HARDWARE WAREHOUSE OPTIMIZATION

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Executive Summary

Wispeco is a growing company and has reached the point where their GS (Gauteng Stockist) storage warehouse does not possess enough storage space to keep up with the growing demand for Wispeco products. They have now acquired an additional storage warehouse, where all their hardware products will be stored.

The processes in the hardware warehouse (or GC warehouse) is currently relatively unstructured, with no standard operating procedures, information management systems or warehouse management systems in place.

In order to improve the operations of this warehouse, an analysis of the current operations have been done, along with an investigation of the current available best practices for similar warehouses. In the investigation of available best practices the following warehousing techniques were investigated: Setting up stock levels, ABC analysis, flow within a warehouse, order picking techniques, layout design, and storage assignment. From the investigation of best-practices the techniques that will best fit the goals of the GC warehouse are a picker-to-part system, with a forward-reserve storage allocation approach. The GC warehouse already operates with a forward-reserve storage allocation approach and picker-to-part system, but the current location of the main areas in the warehouse, namely the small store, bulk store, receiving and dispatch areas, are increasing the average travel distance of pickers. These areas need to be located according to the amount of movement between the areas.

The best storage policy for the GC warehouse is a combination of dedicated storage and full-turnover storage, items with a high turnover rate are located in dedicated location close to the dispatch area.

When conducting an ABC analysis it was found that locating items according to their relative impact on sales value, will be the best strategy for reducing the average picking distance. The relative impact of an item is determined by multiplying the value of an item with the annual number of sales. When drawing a Pareto-graph for the relative impact of sales it was discovered that roughly 16.07 % of the items are responsible for 80% of GC warehouse's value of sales. The following 15% of the sales value is comprised from the next 20.54% of items. The final 5% of sales value is from the final 63.39% of items. These three groups will be known as groups “A”, “B” and “C”.

The proposed receiving process, along with the use of an inspection sheet will ensure that incorrect products or in accurate quantities are not accepted into the warehouse. The proposed dispatch process, along with a picking slip, which indicates the product code, quantities and location of the item that needs to be picked, the amount of incorrect picks will decrease, along with inaccurate shipments to customers.

It was determined that proposed layout 3 is the best layout for the GC warehouse, because It fulfils the most important criteria of the warehouse.

When comparing the available storage space in the GC warehouse with the required storage space, it was determined that the warehouse does consist of sufficient space for all the Hardware products.

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Chapter 1: Overview

1. Background

1.1 Company Background

Wispeco Aluminium is the largest aluminium extruder and supplier in Africa. The company encompasses factories and distribution centres nationally. (Wispeco, 2016) Figure 1 below displays the operations at Wispeco, the process starts with scrap metal being delivered, and then the scrap is sorted into usable and un-usable metal. The usable metal is bailed into a cube for effective handling, after which it is transported to Remelt. When the usable metal bails are melted, the liquid metal is cast into logs and cut into smaller usable lengths (known as billets). Die shapes are received from die manufacturing for specific extrusions. Billets are pressed through die shapes to form extrusions at Profiles. Extrusions can be distributed and sold without any surface finish, or it can be sent to anodising or powder coating for surface finishing.

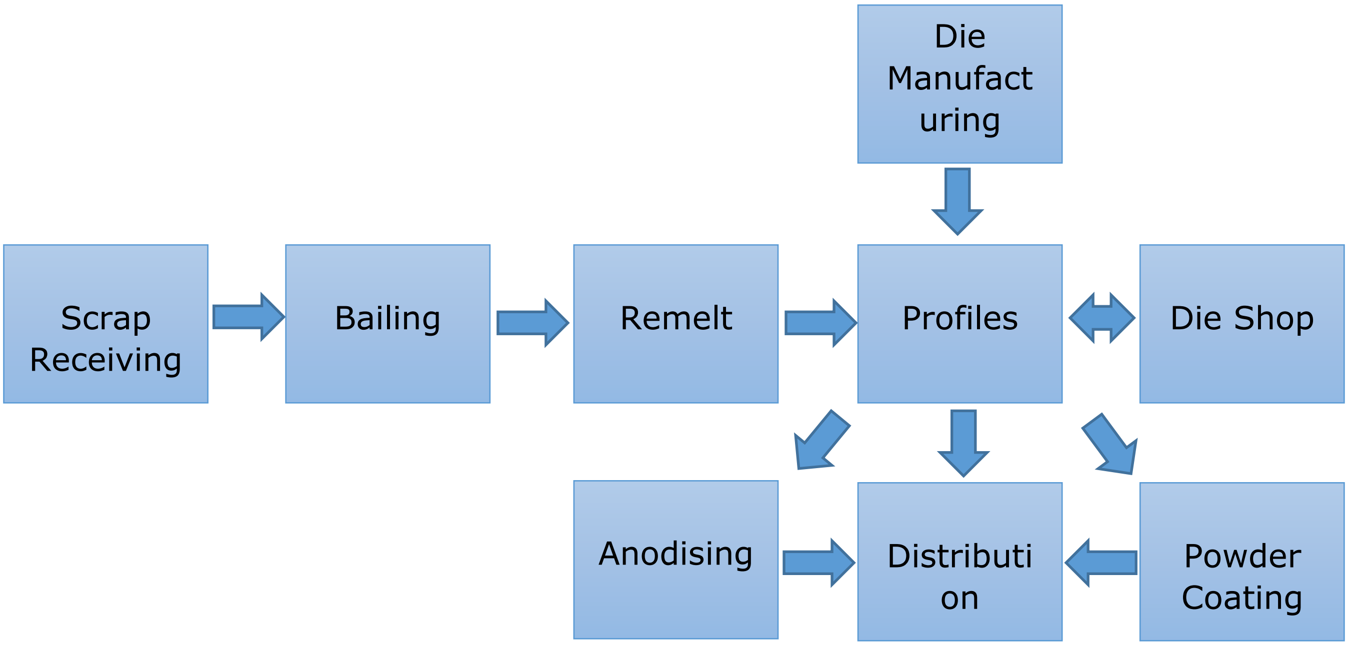

Figure 1: Wispeco operations (Wispeco, 2011)

1.2 Problem Background

The products sold by Wispeco are stored in the GS warehouse before they are distributed to stores nationwide. With the growing demand for Wispeco products, the GS warehouse had to start carrying a larger variety and amount of products in order to keep up with the demand. Wispeco decided to acquire an additional warehouse (known as GC) for their hardware products. Hardware products are items used along with the extrusion products in order to form a complete product, examples of hardware products include, window handles, silicone, roller locks and hinges. Hardware products are not manufactured by Wispeco, they are sourced locally, as well as internationally.

1.3 Investigation of current operations

The main operations in the Hardware warehouse can be classified under three categories, namely: Small Store Replenishment, Picking and Receiving.

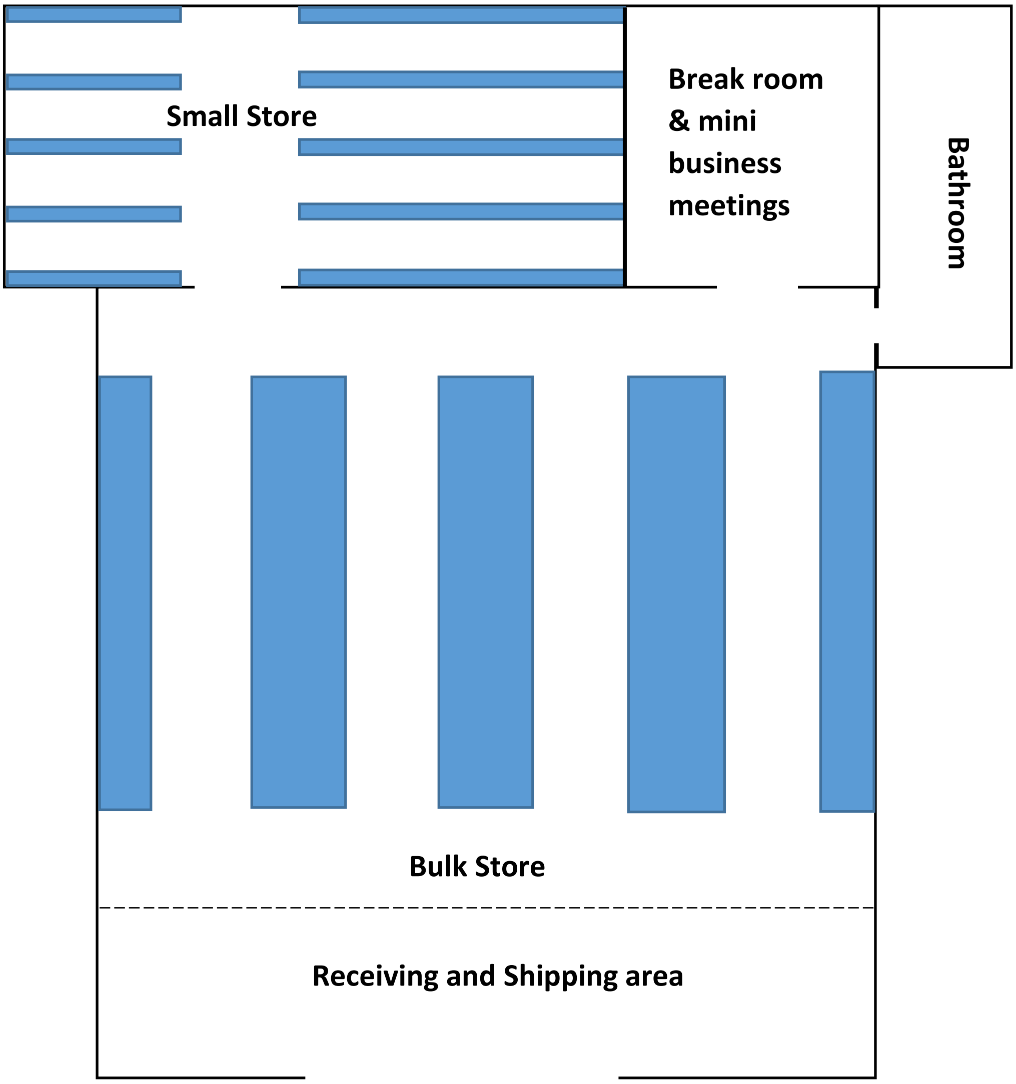

Figure 2: GC warehouse layout

1.3.1 Small Store Replenishment

This is where the GS and the GC warehouses differ. The GC warehouse is divided into two sections for ease of picking, bulk store (Figure 3) and small store (Figure 4), while the GS warehouse only has one store where picking takes place. In the GC warehouse the bulk store carries the same products as the small store, only in bulk quantities and packaged in larger amounts. The small store inventory is replenished by the bulk store, when stock levels are low.

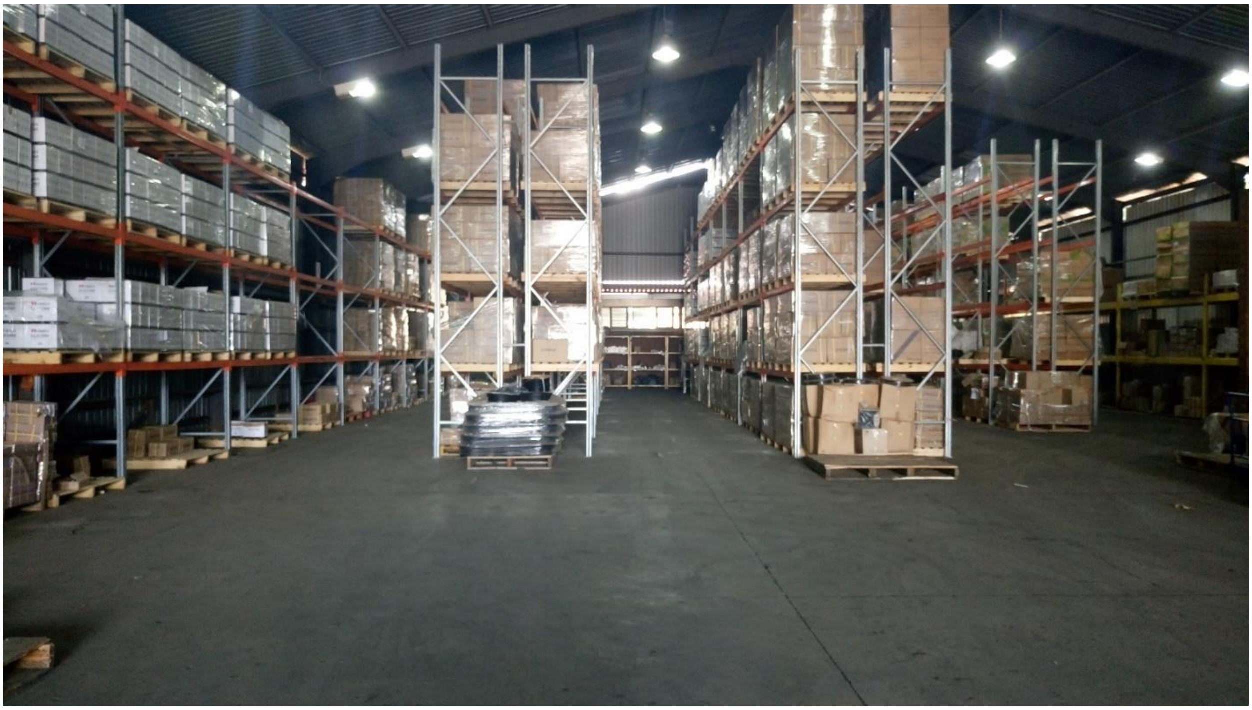

Figure 3: Bulk store

Figure 4: Small store

The current process for replenishing the small store stock is relatively unstructured. When an invoice slip is received and an amount of a certain product needs to be picked from the small store, two problems continuously occur with the current unstructured process:

1. The picker goes to the small store and discovers that there isn't enough of the product, he then returns to the bulk store to fetch a box of the product to replenish the small store, and only then can he finish his pick.
2. The picker does not check if there is enough product in the small store for his order and immediately fetches a box of the product from the bulk store. When taking the opened box to the small store there might already be more than one opened box of this specific product. This results in an overload of products in the small store, while the bulk store might have a shortage of products.

1.3.2 Picking

Throughout the day the warehouse receives invoices from customers, these invoices currently function as picking slips. On the invoice the product code and the amount of each product is displayed. The order in which the products are displayed on the invoice is the same as the order in which the products were selected. Pickers currently need to rely on their knowledge of the warehouse to locate items and to know whether to pick from small or bulk store. Pickers make use of forklifts and hand-pallet-lifts to retrieve items. As items are picked throughout the warehouse, the order is staged in the receiving area in the front of the warehouse on a pallet, the checker then checks the load before it leaves the warehouse.

1.3.3 Receiving

When receiving stock, the shipment is brought to the entrance of the warehouse, where the delivery is checked and matched to the invoice. The shipment is then brought into the warehouse where it waits to be stored. When the shipment is packed away, the workers need to rely on memory to know where to store the different products.

Figure 5: Receiving and Shipping area

2. Problem Statement

The new facility has no warehouse management- or information management processes in place. A lack of these processes makes it difficult to keep track of stock and it increases the difficulty of order picking. With no information management system in place, workers have to rely on memory to find the storage location of items.

The GC warehouse does not at present have any standard operating procedures in place, which allows every worker to have his own method of completing work. Without any standard procedures for completing work, there are a lot of inconsistencies with how long certain tasks take to be completed.

In order to get the new warehouse in line with the company's mission of one-day-delivery, the above mentioned problems will have to be addressed.

3. Project Scope

3.1 Project Aim

The aim of this project is to increase the ease with which workers find a specific product's storage location, optimal storage assignment for attaining maximum space efficiency and to create efficient flow through the warehouse, in order to get the warehouse in line with the company's mission of one-day-delivery.

3.2 Project Approach

Chapter 1: Analysis of current operations

The project will be approached by first conducting an analysis of the current operations, this will be achieved by investigating the following:

- Receiving processes
- Picking processes
- Warehousing
- Storage policies
- Management of inventory
- Material Handling equipment

The deliverables that are expected after the completion of phase 1 are:

- Requirements of current operations
- Material handling methods
- Constraints of current operations

Chapter 2: Information Gathering

In the second phase an investigation of available best practices for the following will be done:

- Warehouse layout
- Demand forecasting
- Optimal warehouse flow
- Information management systems
- Tracking of stock movement

The deliverables that are expected after the completion of phase 2 are:

- Summary of current best practice solutions for the above mention problems.
- Through evaluation of best practice techniques to find the techniques that will best help solve the problems at Wispeco's GC warehouse.

Chapter 3: Solution Design

Part 3 will be an investigation on the actual requirements of the GC warehouse, this will be completed by investigating and calculating the actual and optimal amount for the following:

- Annual product demand
- Minimum stock level

- Actual storage space required

In the third phase there will also be solutions generated and evaluated, in order to address the following problems:

- Optimal warehouse layout
- Optimal flow through the warehouse
- Demand forecasting
- Tracking stock movement

The deliverables that are expected after the completion of phase 3 are:

- Optimal solution documented
- Optimal solution presented
- Optimal solution poster completed

After the analysis of the operations at Wispeco's GC warehouse the annual demand of each product must be determined, along with how much space each product requires. With this information it will be determined whether the GC warehouse consists of sufficient space for all the Hardware products or whether additional space is required.

4. Conceptual Design

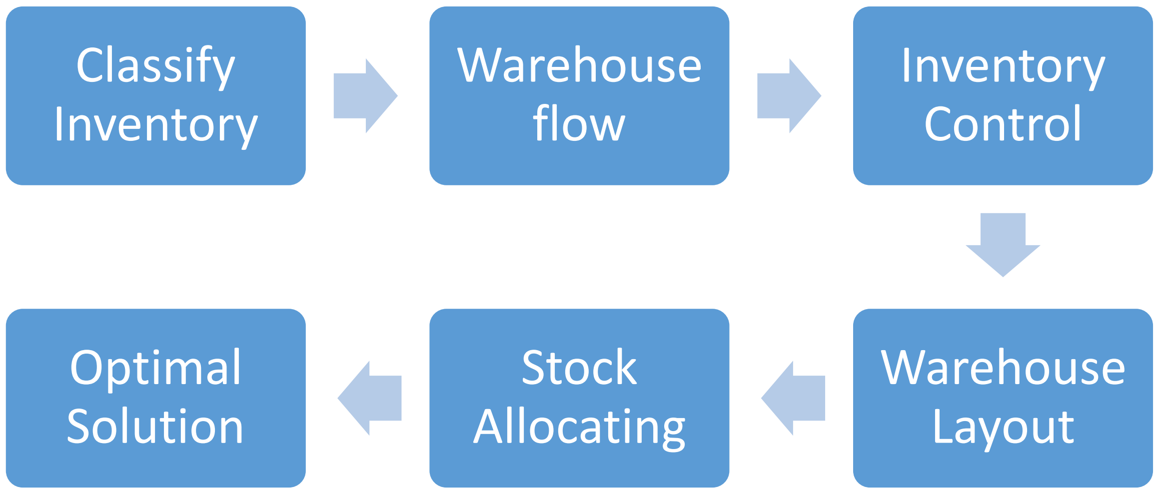

Figure 6: Conceptual Design

Chapter 2: Information Gathering

1. Information Gathering Aim

The information gathering phase is an important phase. This phase will provide the foundation from which optimal solutions and strategies will be derived, in order to potentially solve the inefficiencies experienced at Wispeco. The information gathered from literature will be used to formulate an effective solution.

2. Inventory Control

If inventory levels are not properly managed, it could have an effect on cash flow, increase holding cost, increase holding time, and will eventually result in disappointed customers. (De Koster, 2007) (Chand, 2011)

2.1 Setting up various stock levels

In order to avoid under-stocking and over-stocking of inventory, there has to be a maximum inventory level, a minimum inventory level, a re-order point, danger point and average level of inventory. (Chand, 2011)

(a) Re-order point:
This is the point at which an order for replenishment of inventory should be made.
The re-order point is a fixed point, which will be located between the maximum- and minimum inventory level. The quantity of inventory that is located between the re-order point and the minimum level will be sufficient to cater for the customer's demand, until the inventory levels are replenished. (Chand, 2011)

Re-order point is calculated as follows:
Re-order point = Max Rate of consumption x Max lead time

(b) Maximum Inventory Level:
This is the level above which inventory should never reach. The maximum inventory level prevents the unnecessary use of capital on inventories, extra overheads, obsolescence and deterioration of inventory and temptation of thefts. (Chand, 2011)

Maximum Inventory Level is calculated as follows:
Max Inventory Level = Re-order point + Re-order quantity – (Min Consumption x Min re-order period)

(c) Minimum Inventory Level:
This is the level under which inventory should never reach. The minimum inventory level prevents lost sales due to shortage of inventory. (Chand, 2011)

Minimum Inventory Level:
Min Inventory Level = Re-order point – (Normal rate of consumption x Normal delivery period)

(d) Average Inventory Level:
When determining the average inventory level it is necessary to determine the average of the Minimum-and Maximum Inventory Level. (Chand, 2011)

Average Inventory Level:
Average Inventory Level: ½(Min Inventory Level + Max Inventory Level)

(e) Danger Level:
The danger level is located just under the Minimum Inventory Level, inventory should never be allowed to fall below this level. (Chand, 2011)

Danger Level:
Danger Level: Average rate of consumption x Emergency supply time

2.2 ABC analysis:

The ABC analysis can be used to exercise control over inventory. By using this method inventory is classified under three categories, according to their values, rate at which items sell or relative impact of the items. Group A can consist of expensive items, fast moving items or a combination of both, which is known as the relative impact of the items. Group A usually consists of 10 – 20% of the total items, but usually accounts for about 50% of the items sold, value of the items sold or relative impact of the items sold. There needs to be a greater amount of control exercised on these items, in order to regulate stock. (Chand, 2011)

Group B usually consists of 20 – 30% of the total items, but usually accounts for about 30% of the items sold, value of the items sold or relative impact of the items sold. There needs to be a reasonable amount of control exercised on these items, in order to regulate stock. (Chand, 2011)

In the final group, Group C, is where the last 70 – 80% of the items are located, making up about 20% of the items sold. (Chand, 2011)

This technique has the ability to ensure a reduction in storage expenses, when applied with care.

3. Warehouse order picking

Order picking – *The process in which items are retrieved from storage, as a reaction to a customer request.*

In warehouse operations, order picking is known as the most expensive and labour-intensive activity. The order picking in some warehouses have been estimated to be as high as 55% of the total warehousing cost. In order to provide satisfactory service and keep operational costs to a minimum, any underperformance of order picking must be avoided. (De Koster, 2007)

3.1 Warehouses and order picking

There are certain situations (e.g. cross-docking, lean manufacturing and ‘virtual inventory’), where storage functions can be minimised, but in most supply chains, products, raw materials and parts still need to be buffered or stored. This implies that warehousing is required and plays crucial role in the supply chain success of the company. (De Koster, 2007)

3.1.1 Warehouse flows

The fundamental zones and movements within a warehouse are shown in figure 7. These typical warehouse activities are: cross-docking, shipping, order picking, receiving, put away and accumulation. (De Koster, 2007)

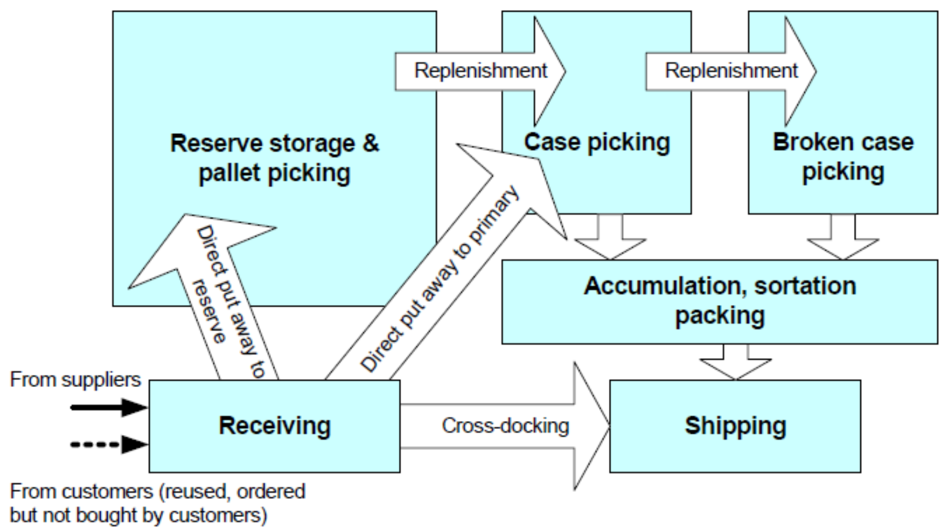

Figure 7: Typical warehouse zones and movements (De Koster, 2007)

The *receiving* process can be summed into three steps: 1. receiving items from the supplier. 2. Updating the item inventory records. 3. Inspecting the items received to find quality or quantity discrepancies. *Order picking* consists of the process of locating the correct amount of the correct items for a set of orders. *Cross docking* is used when received items are directly transferred towards the customer, with short stays, but almost no order picking required. (De Koster, 2007)

3.1.2 Order Picking

There exists a variety of order picking systems for warehouses, it is possible for a single warehouse to operate with more than one order picking system in place. In Figure 7 order picking systems are divided into automated or human order picking systems. A larger amount of warehouses make use of human order picking systems, of which the picker-to-parts system is the most common system. This is where the picker drives or walks through the warehouse and picks items. We can identify between two types of *picker-to-parts* systems: high- and low-level picking. In high-level picking, high storage racks are employed; pickers travel to the storage location of the item to be picked on board a high reaching order-pick truck. The truck stops at the pick location and allows the picker to complete the pick. In low-level order picking systems the picker travels along the storage aisle picking items that were requested from bins or storage racks. (De Koster, 2007)

The *parts-to-picker* system consists of an automated retrieval and storage system. This system mostly makes use of aisle-bound cranes, which retrieves an entire unit load and takes it to a pick location. When the load arrives at the pick location, the picker picks the required amount of items, after the pick is completed the remaining load returns to its storage location. (De Koster, 2007)

A *put system* consists out of two processes, a retrieval process and a distribution process. The first step in a *put system* is to retrieve the items, this can be done with a *picker-to-parts* or *parts-to-picker* system. The second step is for a picker to distribute the pre-picked items over customer orders. This type of system is very useful when a large number of customer's orders need to be picked. (De Koster, 2007)

Figure 8 shows that there are variants of the picker-to-part system.

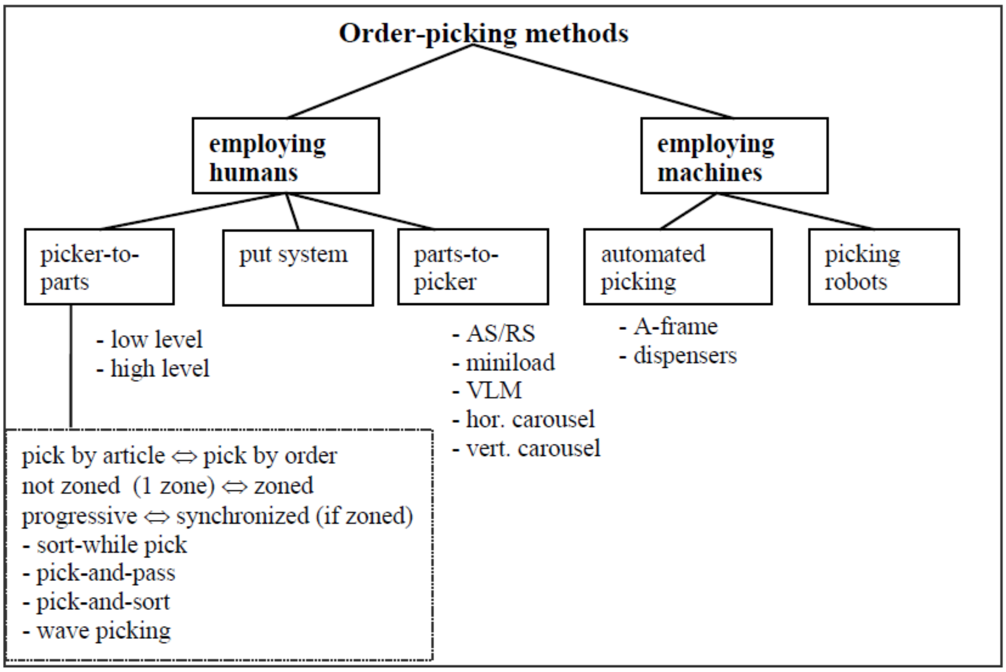

Figure 8: Order picking systems (De Koster, 2007)

3.1.3 Order picking objectives

Maximising the service level is the most important objective of order picking systems. Labour, capital and machines are only some of the constraints that need to be overcome to reach this objective. Factors that fall under service level, include delivery time, accuracy of order and order integrity. (De Koster, 2007)

In Figure 9 a typical *picker-to-parts* picking time components are shown. There has been a variety of case studies showing that other activities, other than travel do sometimes have a great impact on the total picking time, but travel is repeatedly the activity that takes up the largest amount of time in a pick. (De Koster, 2007)

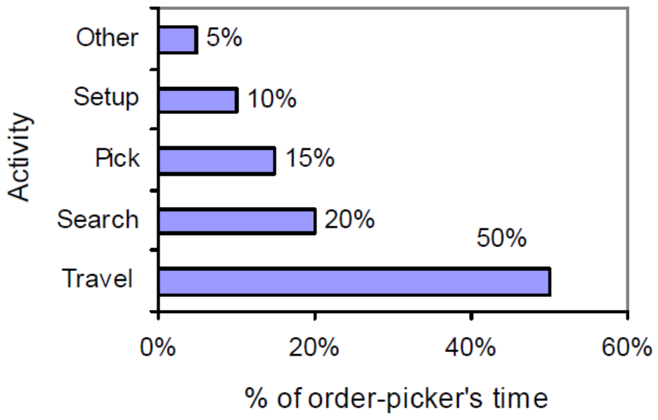

Figure 9: Typical picker's time distribution (De Koster, 2007)

In manual order picking systems, travel time is a function of travel distance. Therefore the travel distance is considered to be the main objective in warehouse optimisation.

3.2 Layout design

Order picking is concerned with two layout problems: the layout of the order-picking system and the layout of the facility. The first problem is concerned with the length, width and number of aisles in each block and the number of blocks. The second problem is concerned with where each department will be located, in respect of each other. The optimal layout can be determined by taking the activity relationships between departments into account. The objective is to minimise handling cost. (De Koster, 2007)

3.3 Storage assignment

Items need to be placed in storage locations, before picking can take place. There are storage assignment methods that can be used to allocate items to an ideal storage location. (De Koster, 2007)

3.3.1 Forward – reserve allocation

There has been cases where the bulk stock and the pick stock have been separated, in order to increase picking speed. It is ideal to restrict the size of the pick stock area, because the size of the pick area is proportionate to the average time of a pick. Two important decisions that need to be made are, how much of each item should be located in the pick area and where in the pick area must these items be located. When splitting bulk stock and pick stock regular internal replenishment is required from bulk stock to pick stock. (De Koster, 2007)

It is important to balance extra replenishment efforts with pick time savings. Another possibility is to store some items only in the bulk store, for instance where demand quantities for certain items are very high or when demand frequencies for certain items are very low. A disadvantage of the forward-reverse allocation method is that replenishment needs to take place at times when there are no order picking. (De Koster, 2007)

3.3.2 Storage assignment policies

There are five frequently used storage assignment types: closest open location, full turnover, random storage, dedicated storage and class based storage. (De Koster, 2007)

With random storage each incoming load is assigned to a storage location, which is randomly selected from all the available empty storage locations, with each empty storage location having the same probability of being selected. This method results in a high space utilisation, but also has an increased travel distance. Random storage can only be utilised in a computer controlled environment. (De Koster, 2007)

Closest open storage will most probably be applied when order pickers are given the opportunity to choose the storage locations of items themselves. This would most likely result in a system where the first empty location which the picker encounters is used. (De Koster, 2007)

Dedicated storage is where each item has a fixed storage location. Some of the disadvantages of dedicated storage, is that storage locations are reserved even if items are out of stock, another disadvantage is that sufficient space need to be reserved for the maximum amount of items to be stored. This method has the lowest space utilisation of all the storage policies. Order pickers do get familiar with the storage locations of items, which is one of the advantages of dedicated storage. (De Koster, 2007)

Full-turnover storage distributes items throughout the warehouse according to turnover. Items with the highest turnover rate are located in the most accessible areas. Items with low turnover rates are usually located more to the back of the warehouse. The use of full-turnover storage works best when combined with dedicated storage. The main concern is that the demand for each item changes constantly, this would mean that the item locations would need to change frequently. A solution can be to restock the warehouse once every chosen period. (De Koster, 2007)

3.3.3 Class-based storage

A Typical class-based storage method is Pareto's method (or ABC analysis), the goal is to group items in classes, so that all the fast moving items are grouped together, which should make up about 15% of the total items stored in the warehouse, but which contributes to about 85% of the sales. The warehouse is then arranged according to classes. (De Koster, 2007)

There are numerous ways of positioning different classes in a warehouse, McDowell and Jarvis (1991) recommend having only one class in an aisle, which is known as within-aisle storage as in Figure 10; while De Koster and Le-Duc (2005) claim that across-aisle storage is the closest to an optimal method. In the across aisle storage method items of each class are located in each aisle, with the fast moving items located closest to the depot and slow moving items located to the back of the warehouse, the across-aisle storage method is depicted in Figure 10. (De Koster, 2007)

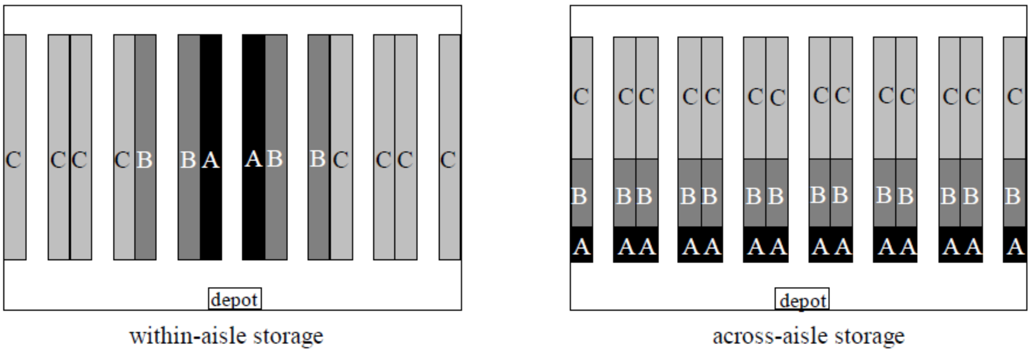

Figure 10: Two ways of implementing class-based storage (De Koster, 2007)

3.3.4 Family grouping

This method is ideal for when certain items are always ordered together, it might be ideal to locate these items close to each other, this is known as family grouping. (De Koster, 2007)

4. Warehouse Management System

4.1 Benefits of a Warehouse Management System

A full warehouse management system will optimize the workings of any business, by focusing on the following functions:

- Receiving – A warehouse management system will improve the amount of information regarding which shipments have been received, but not yet placed into storage and which shipment must be placed into storage first in order to avoid stock-outs.
- Put-away – A warehouse management system knows the location of each item in a warehouse, and can therefore route workers to where each received item needs to be stored.
- Picking – Picking takes place with the use of a mobile device, which provides workers with their picks. A warehouse management system knows the location of each item in the warehouse, and can therefore determine the optimal route to follow during picking, in order to minimise travel time.
- Shipping – A warehouse management system keeps track of when and to where loads need to be shipped, the system will therefore ensure that the right load was shipped on time. (Barcoding, 2015)

4.2 ROI

The initial cost associated with installing a full warehouse management system can be high, but the system will improve the workings of the warehouse from the moment it is fully functional. The system will provide real-time visibility into stock, increase knowledge about when shipments need to be made and when shipments need to be received. It will reduce the time required to invoice and receive payments, it provides mobility to each person in the warehouse and it equips the warehouse with the capabilities to meet future demand. (Barcoding, 2015)

4.3 Problem Solving

When relying on people to manually enter data for the management of the warehouse, it compromises information accuracy and worker productivity. In manual warehouse management systems, orders need to be printed, picked, packed and shipped to the customer, with a paper trail documenting the whole process. These documents then need to be manually entered into the system and filed. When a mistake is discovered in an order or invoice, data from the system and the filed documents need to be compare in order to find the mistake. (Barcoding, 2015)

With a warehouse management system the following can be avoided:

- Struggling to find information about a specific order or invoice.
- Inaccurate data being entered into the system
- Miss-shipments
- Late invoices
- Not being able to locate stock that is moved within the warehouse.

Warehouse management systems can be combined with mobile computers, voice picking applications, a wireless network and radio frequency identification technology (RFID), to significantly improve the performance of any manual system. (Barcoding, 2015)

Chapter 3: Design considerations

1. Classifying Inventory

Multiple inventory items and product lines, are compelling organizations to focus more on important inventory items and to utilize more effective approaches to inventory management.

1.1 ABC Analysis

When using the ABC analysis, inventory is assigned into groups according to the value of the items, the relative impact of the items or according to the inventory turnover ratio of the items. Items in group “A” are viewed as the most important items in the warehouse, items in group “B” are viewed as moderately important items and group “C” items are viewed as less important.

The criteria according to which the ABC analysis is performed will influence whether an item is placed in group “A”, “B” or “C”. The objective of the project will determine which criteria is used for the ABC analysis.

1.1.1 ABC analysis – sales volume

An analysis was conducted on the sales of the products stored in the GC warehouse, over a period of 12 months (Feb 2015 – Feb 2016). The aim of the sales analysis was to discover what items can be classified as fast-movers and what item can be classified as slow-movers. This information would then be used to decide on a storage policy.

The items were compiled from the item of which the most was sold in this 12 month period, to the item of which the least was sold in the 12 month period. When drawing a Pareto-graph it was discovered that roughly 7% of the items are responsible for 80% of the items sold from the GC warehouse. Graph displayed in figure 11.

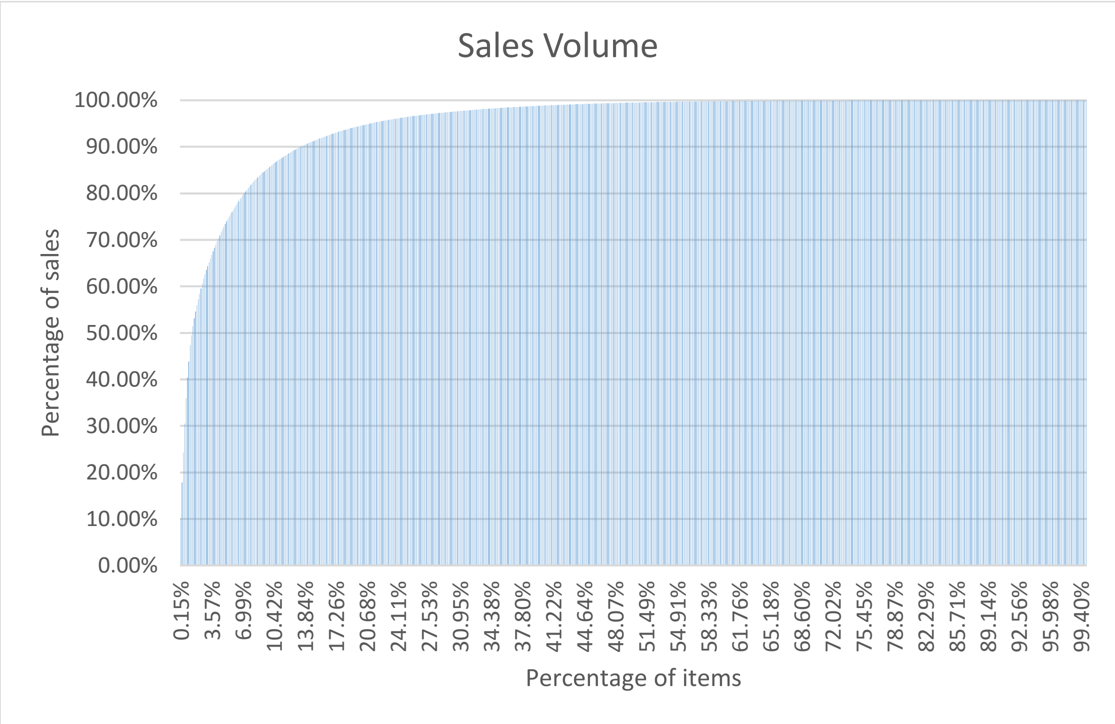

Figure 11: Percentage of item sales

The average value of all the items in the GC warehouse is R129.83 per item, where the average value of the items that make up 80% of the warehouses item sales, are R12.00 per item. This shows that most of the fast movers are small items, with very low values; these items are sold in boxes containing a number of these items. This discovery implies that the amount of items sold from the GC warehouse can be misleading, because the picker does not travel to the storage location for each individual item, but that at least one box of items are transported each order.

1.1.2 ABC Analysis – sales value

It was decided that compiling the items according to annual amount of sales was not the best way to organise the warehouse. A more appropriate method would be to compile the items according to their relative impact on sales value. The relative impact of an item is determined by multiplying the value of an item with the annual number of sales. When drawing a Pareto-graph for the relative impact of sales it was discovered that roughly 16.07 % of the items are responsible for 80% of GC warehouse's value of sales. The following 15% of the sales value is comprised from the next 20.54% of items. The final 5% of sales value is from the final 63.39% of items. These three groups will be known as groups "A", "B" and "C". Graph displayed in figure 12.

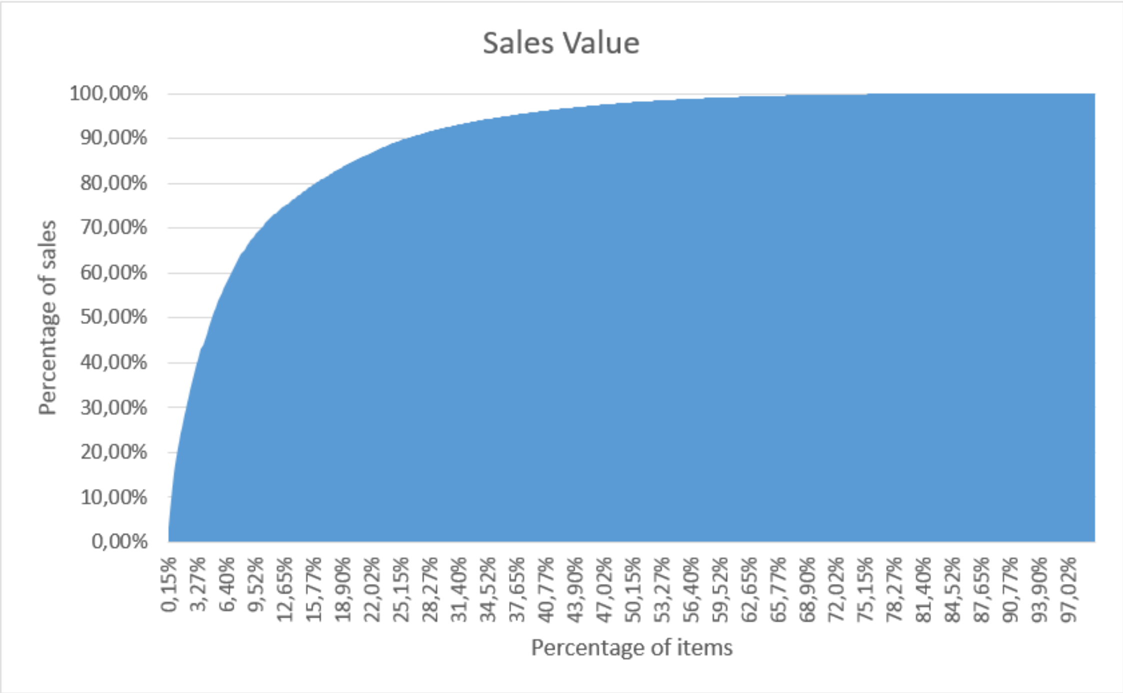

Figure 12: Relative impact on sales

1.1.3 Classifying Inventory

The products in the warehouse will be arranged according to the three groups identified in the Sales Value ABC analysis. Products classified under Group A, which are seen as the most important items in the warehouse, will be located closest to the dispatch area, for ease of picking. Products classified under Group C, which are viewed as the least important items in the warehouse, will be located the farthest away from the dispatch area, because these items have the smallest relative impact on sales. Products classified under Group B will occupy the area in between Group A and Group B.

2. Design Requirements for New Facility

The objective of the redesign of the warehouse is to have an optimal warehouse layout, which will help to decrease the average picking time. By changing the warehouse layout in such a way that the average travel time in a pick is reduced significantly, will result is faster and more picks a day. It is also important for the space in the warehouse to be utilised, to account for any future growth.

2.1 Proposed receiving process flow

The proposed receiving process starts with the vendor shipping the items to the warehouse. The items are then physically received by the warehouse, at which time the invoice is compared to the Purchase Order (P.O.), if there are any discrepancies the items are placed on hold and the matter is referred to the purchasing department (Buyer). If the invoice and the Purchase Order matches, then the load is inspected to ensure that the right quantities of each item is received and that all the items are in an acceptable condition. If there is anything picked up during the inspection, the matter is referred to the purchasing department, who will contact the vendor. When the items pass inspection they are put into storage and the system is updated with the new item quantities.

An illustration of the receiving process is displayed in figure 13.

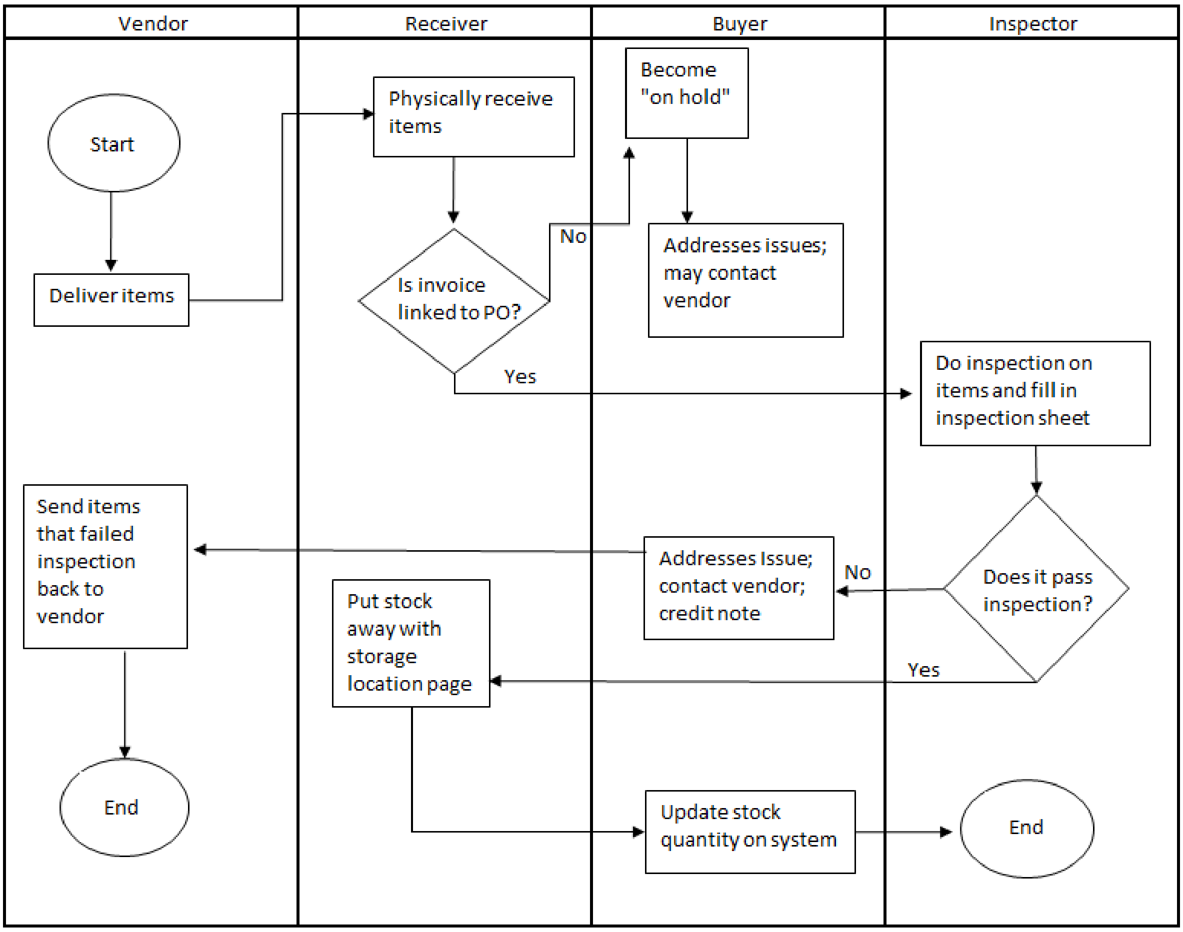

Figure 13: Proposed receiving process flow

2.2 Proposed dispatch process flow

The proposed dispatch process starts with the sales department creating a picking slip, which is sent to the picker who picks the items on the slip. If there are items which are not available to be picked, the matter gets referred to the sales department who will investigate the matter and produce a new picking slip. If all the items on the picking slip are available, the load has to go through inspection to ensure that the right items and quantities have been picked. If items are missing from the load, the picker needs to go and pick the missing items. If all the items on the picking slip has been picked and are in an acceptable condition, the load is prepared for dispatch. After dispatch the system needs to be updated with the new item quantities.

An illustration of the dispatch process is displayed in figure 14.

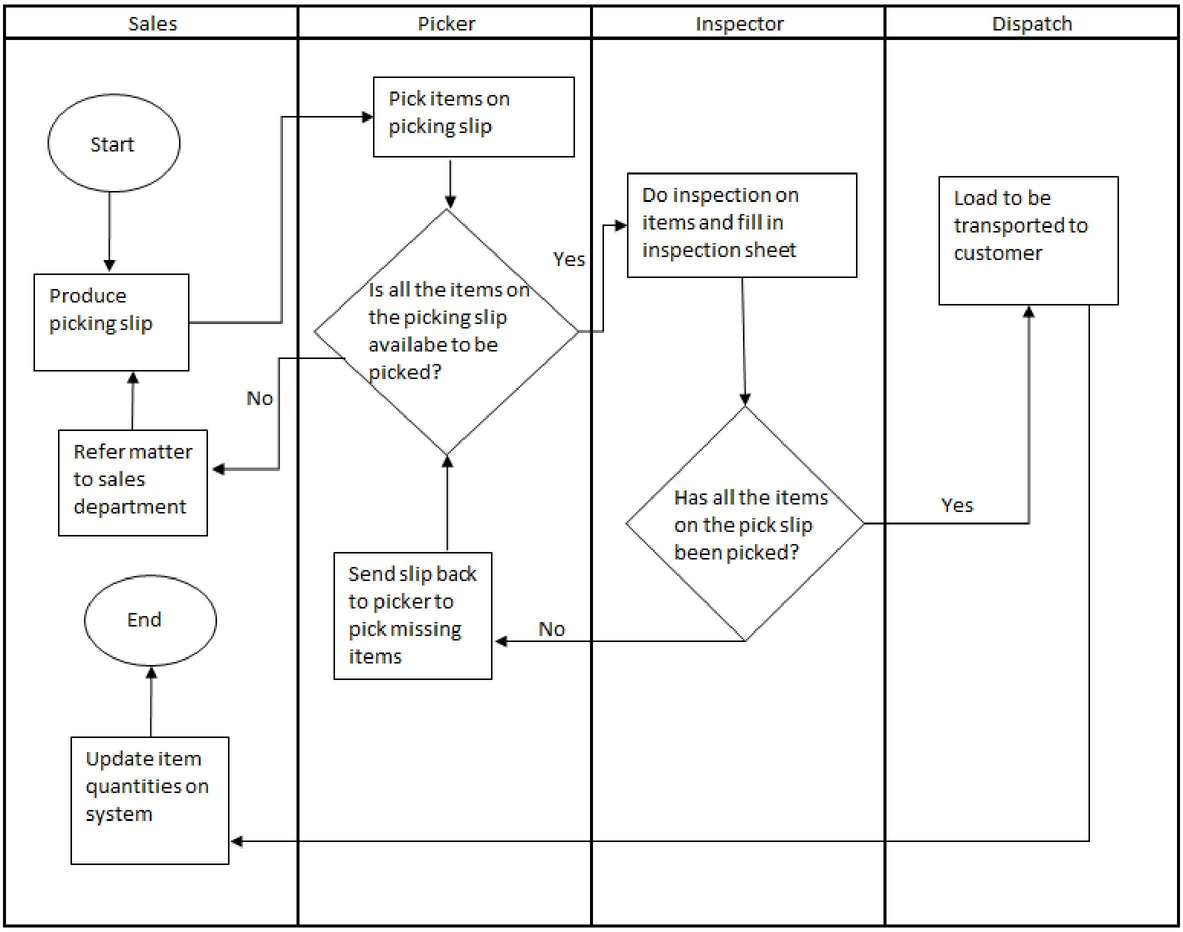

Figure 14: Proposed dispatch process flow

3. Inventory Control

3.1 Sales

In order to avoid under-stocking and over-stocking of inventory, there has to be a maximum inventory level, a minimum inventory level, a re-order point, danger point and average level of inventory. These levels were determined for the 2104 types of products that are to be stored in the GC warehouse, below are the 10 product types in the GC warehouse who have the highest total amount of sales in the year 2015.

Table 1 contains the sales of the 10 items with the highest total amount of sales.

Table 1: Sales

Product	January Sales	Febuary Sales	March Sales	April Sales	May Sales	June Sales	July Sales	August Sales	September Sales	October Sales	November Sales	December Sales	Average Sales
1. B01O	919	982	1100	951	1077	1051	1339	932	1107	1163	1244	716	1048.417
2. CLEATINGMACHINE	10	25	20	21	24	16	26	24	29	23	25	5	20.66667
3. WP48500FG	148	407	401	263	245	458	445	451	510	403	496	221	370.6667
4. FS406FG	2437	3534	2559	1395	565	3707	3050	2655	2921	2577	2962	1088	2454.167
5. ROLL650FG	2146	10953	29822	3526	6631	4683	6287	2391	5726	25055	2568	3598	8615.5
6. HND004RHB	1566	5364	6871	10501	11100	17771	15036	8866	5919	31304	29897	8258	12704.42
7. BS067500PR	84	116	109	87	104	158	116	129	136	141	117	61	113.1667
8. FS600FG	683	1303	1351	434	539	728	703	635	1291	904	1112	266	829.0833
9. FS304FG	1233	1440	1379	1557	1412	1644	1725	2411	1931	2448	1702	1261	1678.583
10. W01G	288	508	555	396	460	686	555	605	615	738	884	527	568.0833

Table 2 contains the inventory levels that need to be considered when any inventory orders are placed. The formulas for determining the inventory levels are located in Chapter 2, section 2.1.The average lead time that was used is dependent on whether the item is locally sourced or internationally. Local items have an average lead time of 2 weeks, while imported items have a lead time of 12 weeks, while the maximum lead time is 4 weeks for locally sourced items and 16 weeks for imported items.

Table 2: Inventory levels

Product	Re-order point	Max Level	Min Level	Avg Level	Danger Level
1. B01O	2678	4640	1105	1028	1048
2. CLEATINGMACHINE	58	111	27	17	21
3. WP48500FG	1020	1892	464	329	371
4. FS406FG	7414	14263	3733	2136	2454
5. ROLL650FG	59644	117142	46721	15984	8616
6. HND004RHB	62608	123650	43551	16435	12704
7. BS067500PR	316	571	146	110	113
8. FS600FG	2702	5138	1458	809	829
9. FS304FG	4896	8559	2378	1841	1679
10. W01G	1768	3248	916	586	568

The determined maximum amount of items of each product type, will be the highest number of each item stored in GC warehouse, by using the amount of each product that can be stored on a pallet, the required number of storage spaces can be determined for the warehouse.

3.2 Stock Allocating

All the stock that is to be located to the GC warehouse will be divided into three groups; bulk stock, small-store stock and both. Products that are classified under "bulk" will be stored and picked in bulk quantities. Products classified under "small-store stock" will only be located in the additional warehouse space, located at the entrance/exit of the GC warehouse and will be picked in small quantities. Stock classified under "both" will be stored in the bulk store for bulk picking purposes, along with the quantity of a case that will be stored close the corresponding bulk stock, for small quantity picking purposes.

There will be no storage space reserved for products of which nothing was sold in this 12 month period. These products that are not in demand any more will be stored in Wispeco's dead stock store; and will be retrieved when an order is received. Once this stock is sold-out new stock will not be ordered.

The number of each of the three storage groups (bulk, small-store and both) that are required was determined by using equation 1. This equation uses the maximum amount of each product that should be kept in the warehouse, which was determined in section 3.1, this amount is divided by the amount of each product that fits in a specific storage location (whether a bulk or small-store storage location). The result is the number of storage location of each type of storage location that is required.

Equation 1: Storage groups

Product name	Max storage level	/	Amount of items that fit on a storage area	=	Number of storage areas required

The results from equation 1 indicated that the GC warehouse requires 109 bulk storage location, 132 small-store storage locations and 307 storage locations that are classified under both, which implies that another 307 bulk storage locations and 91 picking level location are required; one picking level location for each product type.

Table 3: Required Storage Area

Required storage areas	
Bulk	416
s/b	91
Small	132

In total 416 bulk storage locations, 132 small-store locations and 91 picking level location are required in the GC warehouse.

4. Warehouse Layout

4.1 Current warehouse layout

The current facility layout is displayed in Figure 15. The main areas of the facility consists of the bulk store, the small store, receiving, dispatch, break room and bathrooms.

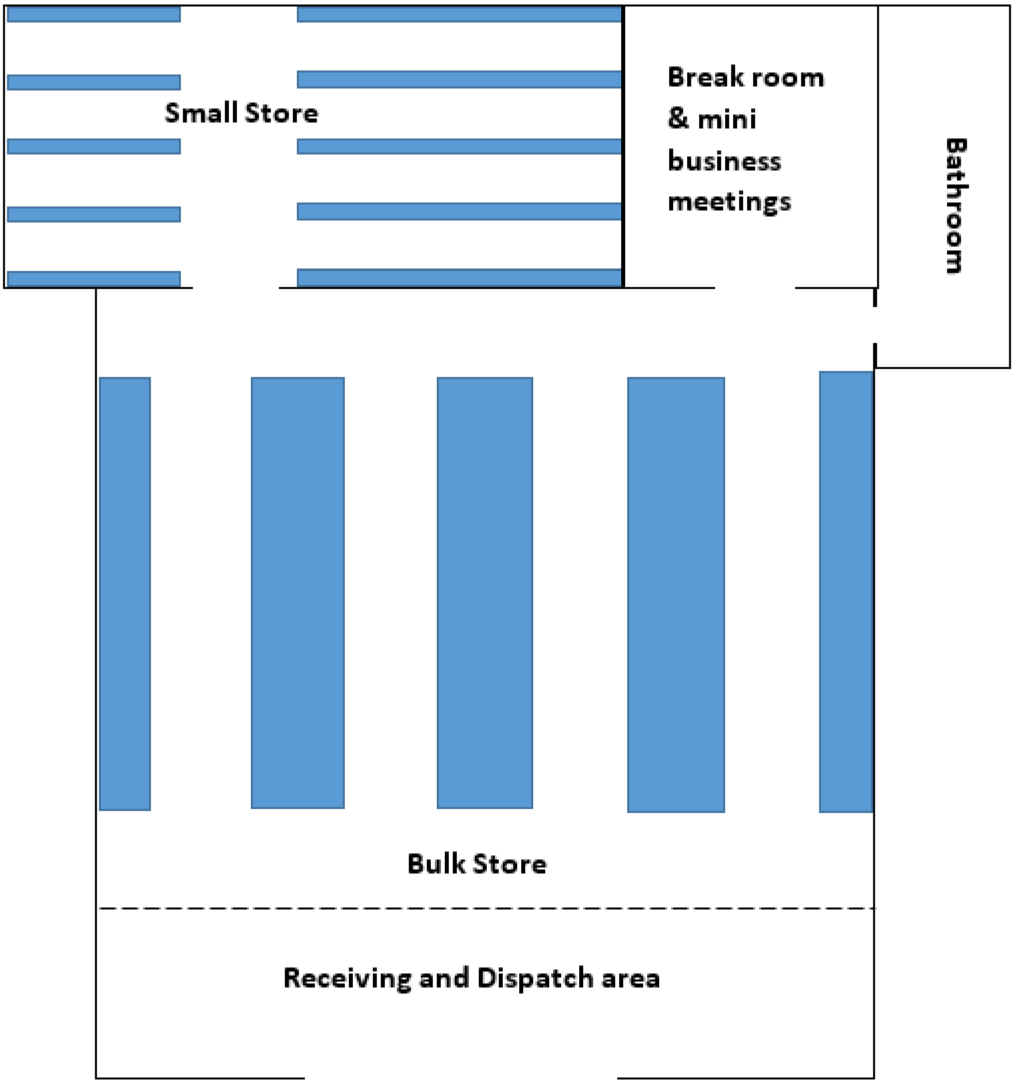

Figure 15: Current warehouse layout

4.1.1 Main areas within the warehouse

Small store - The small store is where items are stored in smaller packaged quantities than in the bulk store, this is ideal for picking smaller orders.

Bulk store - In the bulk store items are stored in large quantities, which works well with large orders. For example if an order for 120 of a certain item comes in, and this specific item is stored 60 items in a box in the bulk store, it is necessary for the picker to only pick 2 boxes in the bulk store, instead of picking 120 items in the small store.

Receiving area - The warehouse also has a receiving area, where shipments from suppliers (or vendors) are received and placed into storage.

Dispatch area – The dispatch area is where loads are taken after being picked, loads are then prepared to be dispatched.

4.1.2 Space relationships

The space relationships between different areas in a facility indicate the importance of these areas being located close to one another. In the GC warehouse there are four main areas, small store, bulk store, receiving and dispatch. The space relationships of the items are shown below. The relationship between these areas are indicated in figure 16.

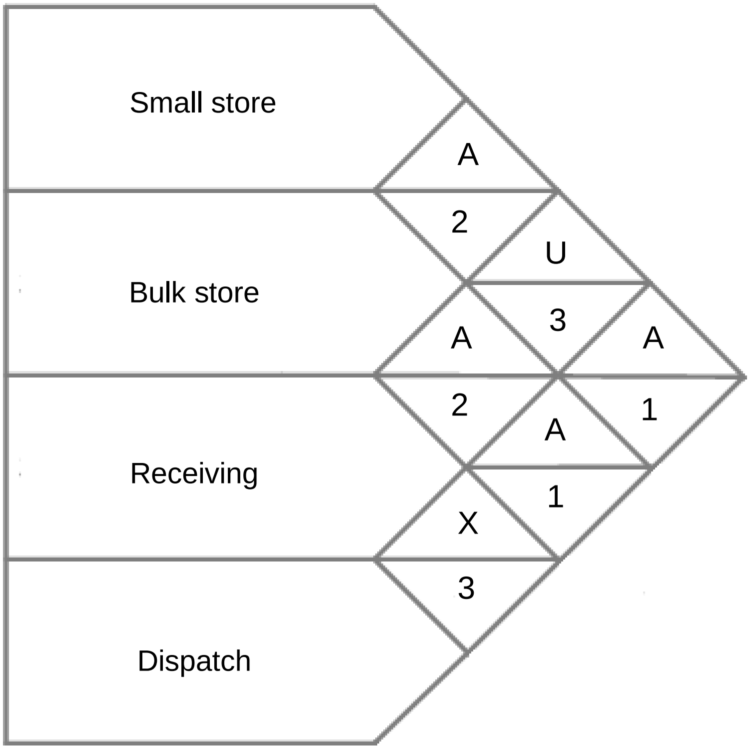

Figure 16: Space relationship

Table 4: Importance of closeness

Value	Closeness
A	Absolutely Necessary
E	Especially Important
I	Important
O	Ordinary Closeness Okay
U	Unimportant
X	Not Desirable

The “Closeness” table contains the measures for how important it is that certain area are located close to one another.

Table 5: Frequency of use

Code	Frequency
1	Frequency of use high
2	Frequency of use medium
3	Frequency of use low

The “Frequency” table contains the measures for how often there is travelled between two areas.

4.2 Current warehouse analysis

In the current warehouse layout the dispatch- and receiving areas are located in the same space, this can get confusing when there are loads that need to be received and loads that need to be dispatched at the same time. Wispeco would like their GC warehouse to carry stock more in bulk form than in pieces, but that some item pieces still need to be stored for small orders. This means that it is necessary to decrease the size of the small store, which would imply that there are more available space for additional bulk stock.

4.3 Proposed Layout 1

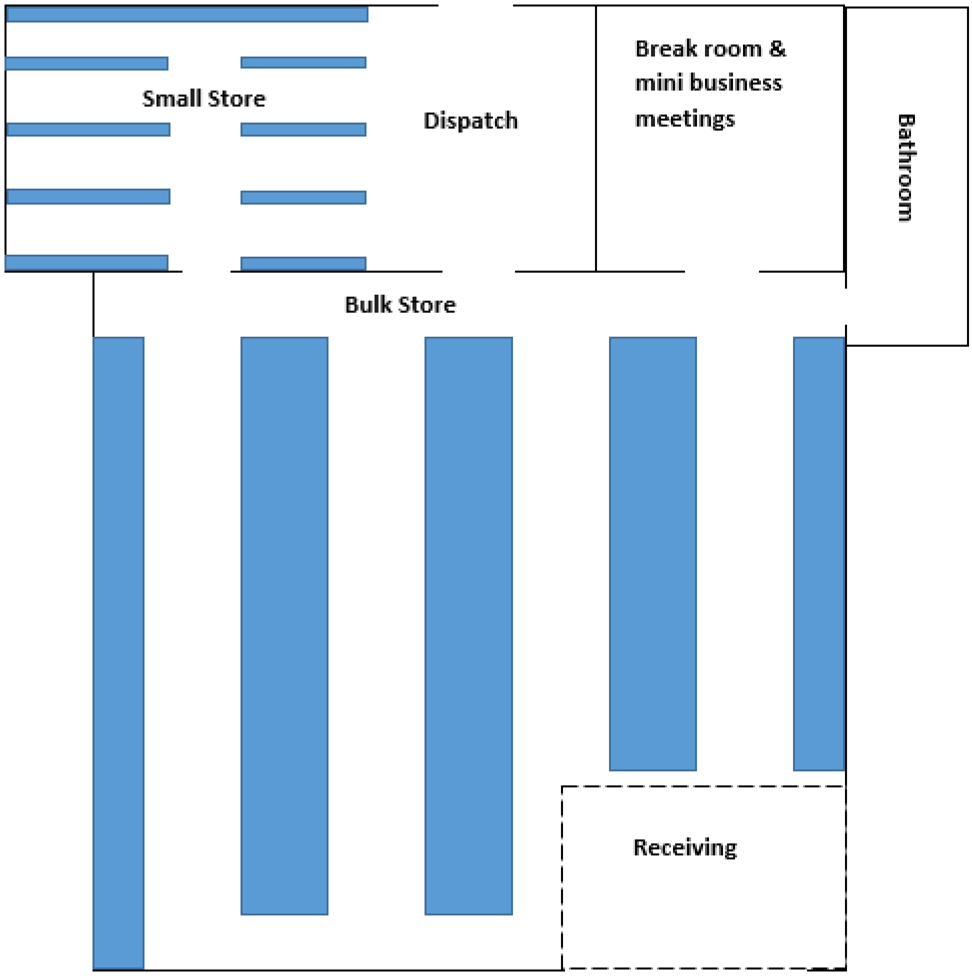

Figure 17: Proposed layout 1

In this layout the dispatch area was moved to the back of the warehouse, in order to reduce confusion between loads being delivered and loads being dispatched. This will also reduce the size of the small store and increase the available space for the bulk store. As indicated by the space relationship diagram it is important for the bulk store to be located near the receiving area, because the bulk store is replenished by the receiving area. It is also important for the bulk and small store to be located near each other, because the small store is replenished by the bulk store.

4.4 Proposed Layout 2

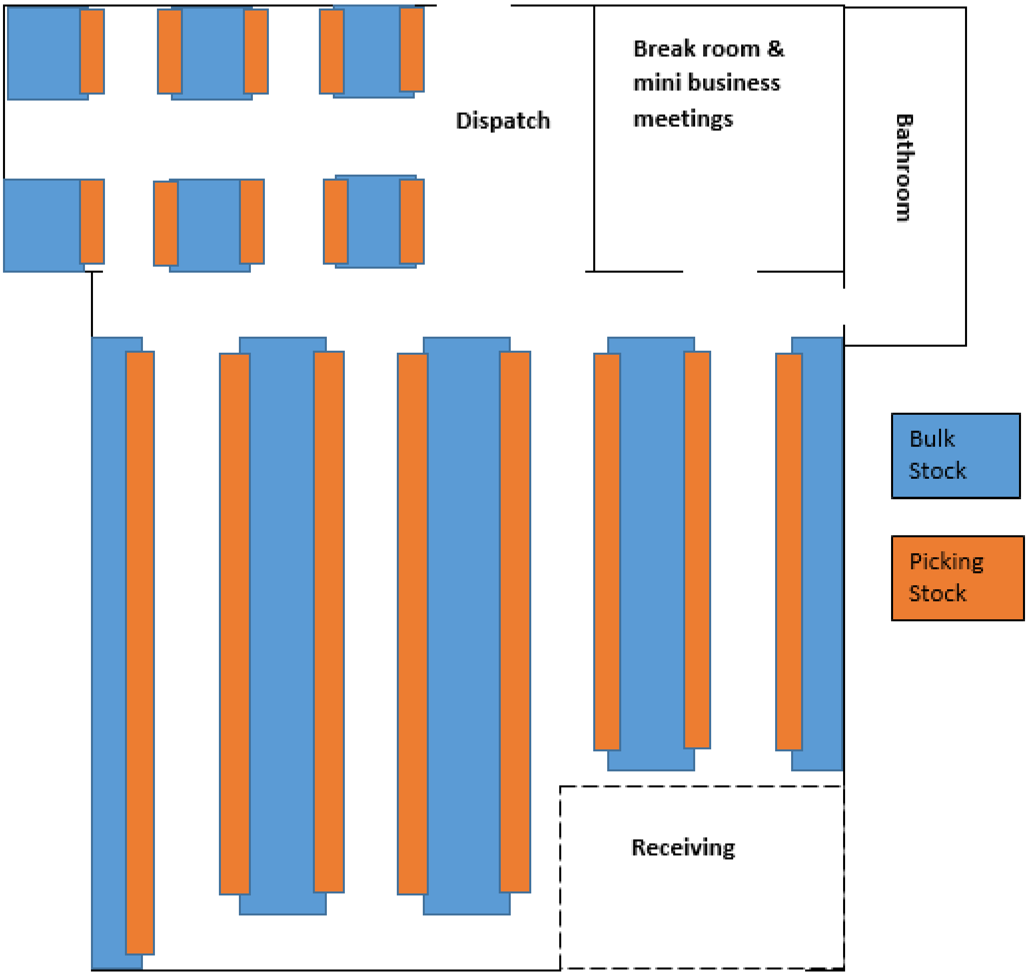

Figure 18: Proposed layout 2

In this layout the bulk- and small stored items are located together, the small stored items are in picking containers, which are attached to the racks in which the bulk stock is stored. In this layout the bulk- and small stock are located close to each other, with the dispatch and receiving areas located on opposite sides of the warehouse, in order to avoid confusion between received loads and dispatch loads.

4.5 Proposed layout 3

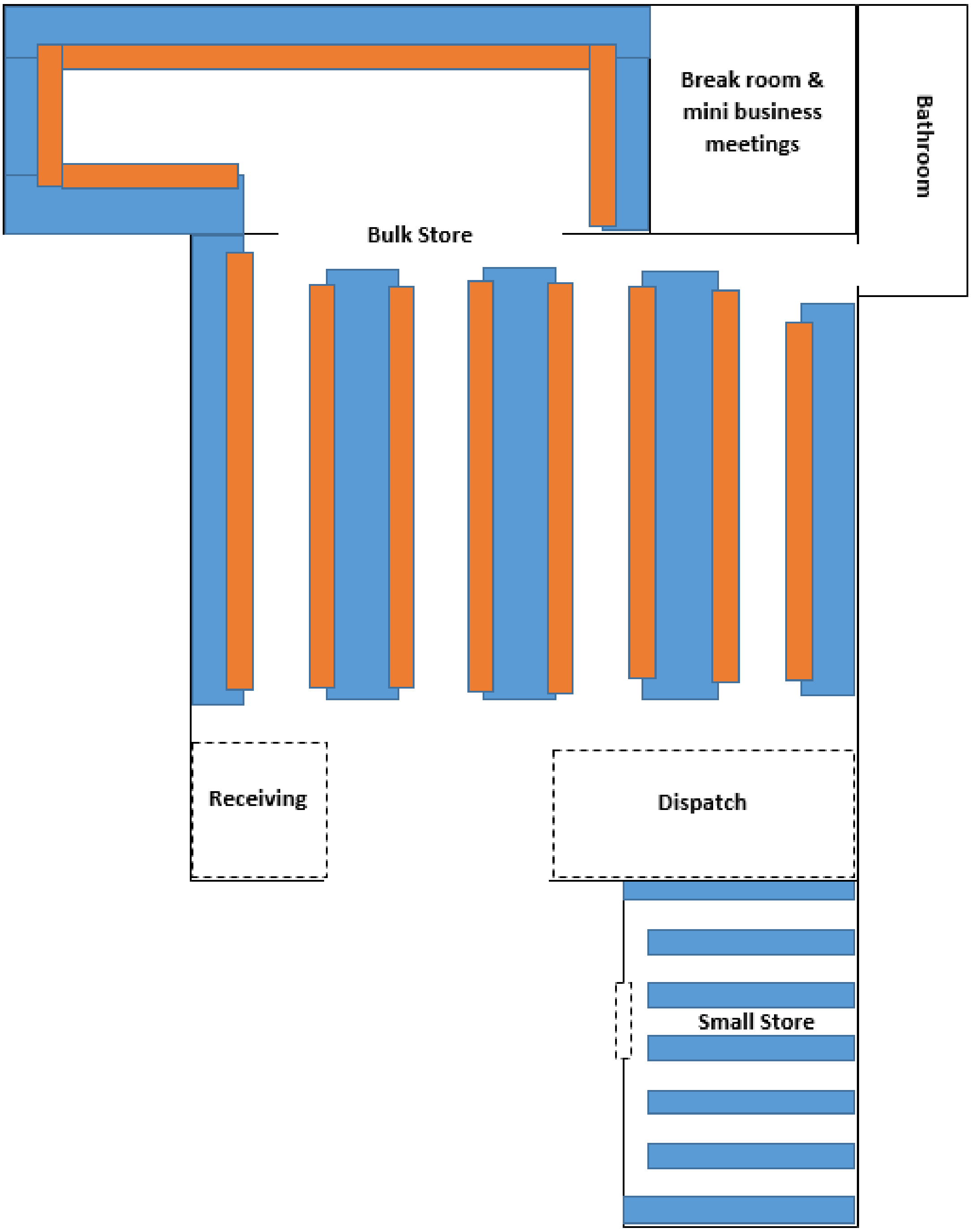

Figure 19: Proposed Layout 3

The layout of the Bulk store was chosen to ensure that the forklift will have full mobility throughout the warehouse. The bulk- and small stored items are located together, the small stored items are located in picking racks, which are normal bulk storage racks which have been divided into smaller picking racks, this racking system for the GC warehouse will consist of three bulk storing levels and one picking level; this racking system is displayed in figure 13. In this layout the bulk- and small stock are located close to each other, the dispatch and receiving areas are also located close to each other, in order to have only one point at which stock can enter and exit the warehouse. Apart from the main warehouse, there will be another storage area located next to the entrance/exit of the warehouse, this will be where small individual products are collected. The invoice which the picker uses to complete his pick, must be handed to the worker stationed at the counter of this storage area, who will then fetch the corresponding items from the invoice and have the picker sign for then. The worker stationed at the counter of this storage area will be the only person allowed to be inside this storage area, in order to be able to hold him accountable for stock that go missing.

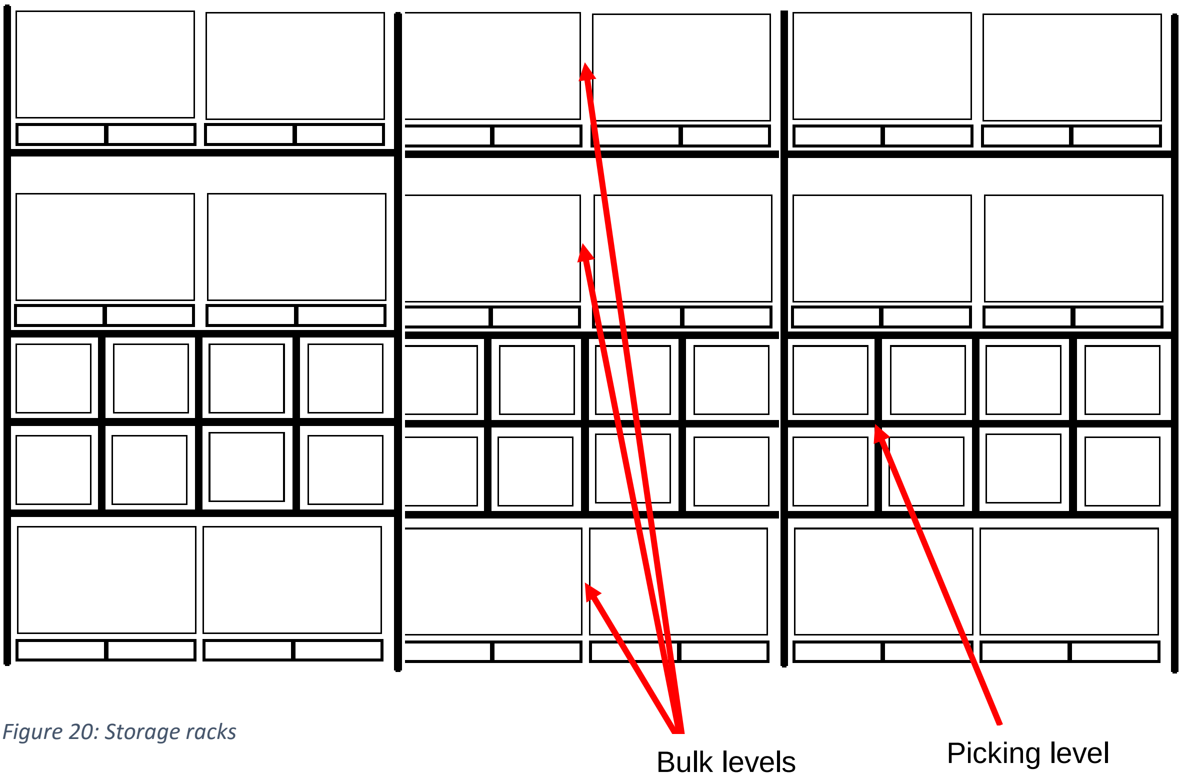

Figure 20: Storage racks

4.6 Proposed warehouse analysis

Table 6: Proposed warehouse analysis

Facility: GC warehouse	**Alternatives**	**Current**		**1**		**2**		**3**	
Project: Warehouse optimization									
Date: 16 Mei 2016									
Factor/ Considerations	**Wt.**	**Ratings and Weights Ratings**							
		1		**2**		**3**		**4**	
Allows for expansion	8	4	32	5	40	6	48	5	40
Ease of supervision and control	4	2	8	3	12	2	8	4	16
Installation cost and maintenance	10	10	100	8	80	7	70	6	60
Utilization of space	10	5	50	6	60	8	80	8	80
Material flow	8	3	24	7	56	8	64	8	80
Personnel Movement Distance	8	4	32	6	48	6	48	7	56
Storage capacity	9	5	45	8	72	9	81	9	81
Ease of layout change	3	3	9	2	6	2	6	2	6
Totals:	498	300 60.24%		374 75.10%		406 81.53%		419 84.14%	
Remarks: Layout 2 was calculated to be the best suited.									

In table 6 the criteria by which the different layout were analysed are listed. The rating for each criteria is, the score for each criteria for each layout alternative multiplied with the weight of the respective criteria. Proposed layout design 3 has the highest rating, because it fulfils the most important criteria.

4.7 Available Storage Space of Proposed layout 3

The bulk store consists of 8 one-sided rows, along with the 2 levels of 30 bulk storage racks located in the small-store from the original layout. In total there will be 416 bulk storage locations.

Table 7: Available Bulk Storage Space

Bulk								
Row	1	2	3	4	5	6	7	8
Racks	18	16	16	16	16	16	16	14
Levels	3	3	3	4	4	3	3	3
Storage areas	54	48	48	64	64	48	48	42
Additional Bulk store with 30 racks and 2 levels = 60								
Total	416							

The small quantities storage locations (or picking level locations) will occupy the second level of the racks in the main bulk store, for ease of picking. This implies that the small quantities storage locations will consist of 8 rows and only one level. The total amount of small quantities storage locations available is, 128.

Table 8: Available Picking Stock Space

S/b								
Row	1	2	3	4	5	6	7	8
Racks	18	16	16	16	16	16	16	14
Levels	1	1	1	1	1	1	1	1
Storage areas	18	16	16	16	16	16	16	14
Total	128							

The small-store consists of 7 rows, each 4 levels high. In total there is 148 small-store storage locations available.

Table 9: Available Small Store Space

Small store							
Row	1	2	3	4	5	6	7
Racks	7	6	6	6	6	6	7
Levels	4	4	4	4	4	4	4
Storage areas	28	24	24	24	24	24	28
Total	148						

4.8 Comparing Available Space with Required Space

In Section 3.2 it was determined that there are 416 Bulk storage areas required, 91 s/b storage areas required and 132 Small-store storage areas required.

Table 10: Required Storage Space

Required storage areas	
Bulk	416
s/b	91
Small	132

When comparing the available space with the required space (in Table 11), it is seen that the warehouse does consist of sufficient space for all the Hardware products.

Table 11: Required Space vs. Available Space

	Required storage areas	Available storage areas
Bulk	416	416
s/b	91	128
Small	132	148

4.9 Storage location numbering

In the proposed solution each product will have dedicated storage location/s, these locations will be stored on Wispeco's TOPP database, along with the name, price and description of each item. This means that the pickers can continue to make use of invoices as picking slips, but that the invoices will have an additional column, providing the location of the product.

If the location of a product needs to change it will be possible to change the location on the database.

The location of each product will consist of 3 identifiers, the first will be the row in which the product is located, which will be indicated by a letter from the alphabet. The second identifier will be to indicate the rack number in the row. The final identifier will be to identify on what level the product is located, this will be indicated by a second letter from the alphabet.

5. Cost-Benefit Analysis

5.1 Cost

The proposed layout consists of three racking systems, from these three racking systems Wispeco already has all the necessary rack quantities for two of the racking systems. The Bulk racking system will remain the same as in the original layout, while the racking system in the small store in the original layout, will now be used in the additional warehouse space located next to the entrance/exit of the GC warehouse. The additional Bulk racking system that will be located in the original small-store will cost R 700 per storage area. The cost to convert one level of the racks in the Bulk store to picking rack will cost R150 per storage area. The total cost of the chosen layout is R 61 200, as determined in table 14.

Table 12: Cost of Bulk Storage Racks

Bulk racks	
Number of storage areas	60
Cost per storage area	700
Cost	42000

Table 13: Cost of Picking Storage Racks

Picking racks	
Number of storage areas	128
Cost per storage area	150
Cost	19200

Table 14: Total Cost

Total cost	61200

5.2 Benefit

The 5 pickers in the GC warehouse were each presented with a list of 10 items which they had to find, they were only presented with the name of the item. The time each picker took to locate all 10 the items on his list was recorded in table 15, from this the average time to locate one item was determined.

Table 15: Current picking time

Item	Picker 1	Picker 2	Picker 3	Picker 4	Picker 5
1	PL1/CP4	HPT-CWPHR-BLK	HRA1040NATFG	JCC001G	FBH477S
2	FS304FG	JCC1910	PEX-CMPS-BLK	BPCAP	JCE4623
3	FS600FG	EHROLL	PL1/CP4	VS001P	T56AR
4	HPT-CWPHR-BLK	PL1/CP4	FS304FG	VR315FG	VR3165FG
5	JCC1910	JCC001G	FS600FG	WP48500FG	PL1/CP4
6	EHROLL	BPCAP	FBH477S	HRA1040NATFG	FS304FG
7	JCC001G	VS001P	JCE4623	PEX-CMPS-BLK	FS600FG
8	BPCAP	VR315FG	T56AR	HPT-CWPHR-BLK	JCC001G
9	VS001P	WP48500FG	VR315FG	JCC1910	BPCAP
10	VR3165FG	VR3165FG	WP48500FG	EHROLL	VS001P
Total picking time	13:06 min	12:37 min	14:45 min	11:57 min	12:29 min
Average time per item	1:19 min	1:16 min	1:29 min	1:12 min	1:15 min
Total average time per item	1:18 min				

The pickers were asked to re-pick their list of items, now that they know the location of each item. The average time it takes to locate a single item was again determined.

Table 16: Possible picking time

Item	Picker 1	Picker 2	Picker 3	Picker 4	Picker 5
1	PL1/CP4	HPT-CWPHR-BLK	HRA1040NATFG	JCC001G	FBH477S
2	FS304FG	JCC1910	PEX-CMPS-BLK	BPCAP	JCE4623
3	FS600FG	EHROLL	PL1/CP4	VS001P	T56AR
4	HPT-CWPHR-BLK	PL1/CP4	FS304FG	VR315FG	VR3165FG
5	JCC1910	JCC001G	FS600FG	WP48500FG	PL1/CP4
6	EHROLL	BPCAP	FBH477S	HRA1040NATFG	FS304FG
7	JCC001G	VS001P	JCE4623	PEX-CMPS-BLK	FS600FG
8	BPCAP	VR315FG	T56AR	HPT-CWPHR-BLK	JCC001G
9	VS001P	WP48500FG	VR315FG	JCC1910	BPCAP
10	VR3165FG	VR3165FG	WP48500FG	EHROLL	VS001P
Total picking time	11:47 min	11:04 min	12:11 min	10:26 min	10:57 min
Average time per item	1:11 min	1:07 min	1:13 min	1:03 min	1:06 min
Total average time per item	1:08 min				

Through this experiment it is shown that on average 10 seconds can be saved with each item that needs to be picked. Pickers work 12 hour shifts, with 1 hour break, which leaves 11 hours for work. If assuming that pickers are only productive for half the time they are working, this still leaves 5.5 hours of productive work. 5.5 hours is equal to 19800 seconds, when dividing the amount of seconds available in a day for productive work with the average time it currently takes to make a pick (1:18 min), this gives 253 picks that can be made by a picker in a shift.

When doing the same calculation with the average time a pick takes when the picker knows the location of the item (19800 divided by 1:08 min), makes it possible for the picker to pick 291 items in a shit. This is a 15% increase in items picked.

Chapter 4: Conclusion

The order picking system that will best fit the GC warehouse is a Picker-to-part system, where the picker can retrieve the items required in an order and stage the order in the dispatch area. The forward-reserve allocation approach increases control over stock, due to the fact that Reserve (bulk) stock should never be opened to pick from, in the reserve store, items should only be picked in large boxed quantities. The GC warehouse already operates with a forward-reserve storage allocation approach, but the current location of the forward- and reserve areas are increasing the average travel distance of pickers.

When assessing the available storage assignment policies, random storage was immediately ruled out due to the high capital expense in acquiring a warehouse management system, which is required to get this policy working at its best. Closest open storage is ruled out for the same reason as random storage. The best storage policy for the GC warehouse is a combination of dedicated storage and full-turnover storage, items with a high turnover rate are located in dedicated location close to the dispatch area.

The ABC analysis that was conducted on the relative impact on sales, grouped items into three groups, A, B and C. With Group A containing the items that have the largest impact on the sales value and group C's items having the smallest impact on the sales value. The items in Group A need to be located closest to the dispatch area, in order to decrease the travel distance a picker needs to travel. Products classified under Group C, which are viewed as the least important items in the warehouse, will be located the farthest away from the dispatch area, because these items have the smallest relative impact on sales. Products classified under Group B will occupy the area in between Group A and Group B.

The proposed receiving process flow needs to be implemented, along with the use of an inspection sheet to ensure that incorrect products or in accurate quantities are not accepted into the warehouse. By implementing the proposed dispatch process, along with a picking slip, which indicates the product code, quantities and location of the item that needs to be picked, the amount of incorrect picks will decrease, along with inaccurate shipments to customers.

The calculated inventory levels balances the chances of a stock-out, with the cost of carrying excess inventory.

It was determined that proposed layout 3 is the best layout for the GC warehouse, because it fulfils the most important criteria of the warehouse.

The additional Bulk racking system that will be located in the original small-store will cost R 700 per storage area. The cost to convert one level of the racks in the Bulk store to picking rack will cost R150 per storage area. The total cost of the chosen layout is R 61 200.

When the products in the GC warehouse have dedicated storage areas, along with the picker making use of a picking slip with the location of the products indicated on it, it is possible for each picker to increase the amount of items picked in every 12 hour by 15%.

Wispeco should implement the best practices into their day-to-day workings, this will significantly improve the operations of the warehouse.

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Appendix B: Industry Sponsorship form

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Identification and Responsibility of Project Sponsors

Final Year Projects may be published by the University of Pretoria on *UPSpace* and may thus be freely available on the Internet. These publications portray the quality of education at the University, but they have the potential of exposing sensitive company information. It is important that both students and company representatives or sponsors are aware of such implications.

Key responsibilities of Project Sponsors:

A project sponsor is the key contact person within the company. This person should thus be able to provide guidance to the student throughout the project. The sponsor is also very likely to gain from the success of the project. The project sponsor has the following important responsibilities:

1. Confirm his/her role as project sponsor, duly authorised by the company. Multiple sponsors can be appointed, but this is not advised. The duly completed form will considered as acceptance of sponsor role.
2. Review and approve the Project Proposal, ensuring that it clearly defines the problem to be investigated by the student and that the project aim, scope, deliverables and approach is acceptable from the company's perspective.
3. Review the Final Project Report (delivered during the second semester), ensuring that information is accurate and that the solution addresses the problems and/or design requirements of the defined project.
4. Acknowledges the intended publication of the Project Report on UP Space.
5. Ensures that any sensitive, confidential information or intellectual property of the company is not disclosed in the Final Project Report.

Project Sponsor Details:

Company:	Wispeco Aluminium
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