Design of a New Binning Area to Improve Space Utilization

for

Nissan South Africa

by

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EXECUTIVE SUMMARY

This project design could be used to determine whether more space can be created within the Nissan Parts Distribution Centre by changing the way parts are binned as well as the binning layouts. It factors in the sizes of parts as well as the demands.

When designing a warehousing system, the following needs to be addressed:

- Space utilization
- Equipment utilization
- Accessibility and traceability of all parts
- Protection and security of all parts

However, there are various other factors that also need to be considered, such as good housekeeping, implementation of newer technologies that in the long run, would prove beneficial to the warehouse as well as classification of parts into groups.

When parts have been classified into appropriate groups based on sizes, demands and values, the warehouse can be designed as such as to promote the quick distribution of these groups. Parts that are of high demand and high value, such as Group A parts need to be located in the warehouse in such a manner that travel distances and picking times are kept to a minimum.

Keywords: *Facility Design, Storage Methods, ABC Classification, Space Utilization*

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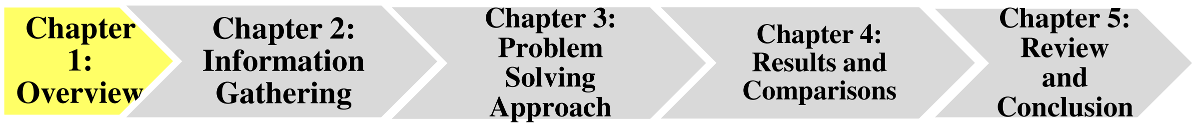


1. COMPANY HISTORY AND BACKGROUND

Jidosha Seizo Co, Ltd. Nissan's predecessor was established in Yokohama, Kanagawa in December 1933. In June 1934 the company name was changed to Nissan Motor Co, Ltd. Within 2 months after construction of the Yokohama plant was completed, the first 44 units of Datsuns were exported to Asia and the Americas.

Over the next 50 years export units surpassed the 20 million mark. In the 1980's Nissan stretched out its world class technologies to the USA and the UK, establishing more production facilities. But as more international motor companies were established, the market for motor vehicles became saturated. This led to numerous alliances of different companies in order to reduce the risk of being eliminated out of the automotive industry.

In 1999 an alliance was formed between the Nissan Motor Company and Renault. The Renault Nissan Alliance has now led to the establishment of a joint manufacturing project to ensure the growth of synergies between the two companies. Current plans born from the Alliance is to open a joint parts warehouse in Rosslyn, South Africa. The Nissan South Africa Ltd assembly plant was established in Rosslyn in 1963.

In 2007, 43,702 vehicles were manufactured. The major vehicles produced by the Rosslyn Plant include the Nissan Hardbody NP300, NP200, Renault Sandro, Livina and the Tiida. Nissan South Africa provides employment for 1890 people. The Nissan Parts Distribution Centre provides efficient and reliable supply of high quality Nissan automotive parts to dealers throughout the Sub Sahara areas. At the end of 2008, the Nissan enterprise has an expanded global manufacturing network in 16 countries including South Africa.

2. PROJECT BACKGROUND

The Renault Nissan Alliance has now led to the consolidation of the Nissan and Renault warehouses in Rosslyn, South Africa. This will hopefully enable both companies to reach their 2 shared goals: improving customer services and reducing costs throughout the supply chain. The synergy of the alliance in one warehouse will enable quicker distribution of parts, shared costs and minimization of the risk being carried by each individual company.

The goal is to place both Nissan and Renault parts into one warehouse in later stages of the alliance. Currently there is not enough space available in the Nissan Distribution Centre to accommodate both companies' parts. This problem can be approached in two ways:

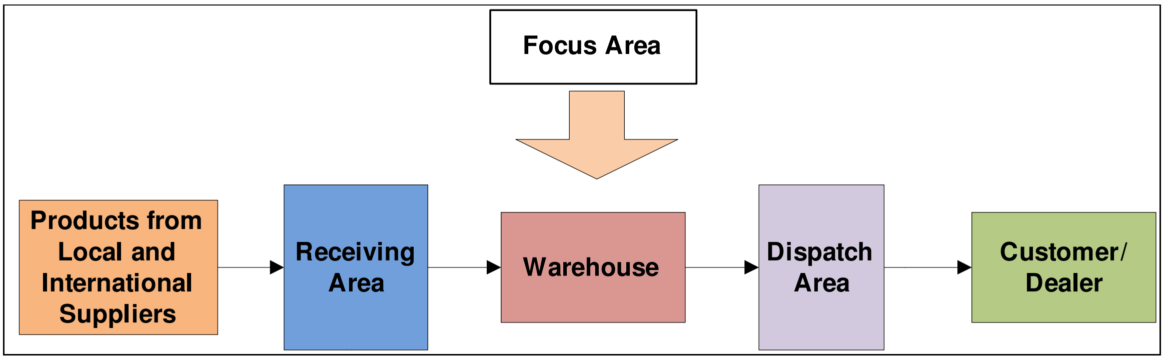
- To design and construct a brand new warehouse that can accommodate both Nissan and Renault parts.
- Investigate whether or not more space can be created within the Nissan Distribution Centre

3. PROBLEM STATEMENT

Nissan have considered it essential to determine whether more space can be created within the warehouse that will enable it to accommodate more parts, whether it is more Nissan or Renault parts in the future.

4. PROJECT AIM AND SCOPE

Figure 1 Focus area of the project



4.1 PROJECT AIM

The original idea for the project was to design a new warehouse where both Nissan and Renault parts can be stored, however, through thorough investigation; it was found that a large amount of space is lost by improper binning of medium sized parts. By allocating parts to bins more suited for its storage requirements, such as its volume and its required stock on hand quantities, and by allocating these bins to racking configurations and rows, space can be made for the addition of either more Nissan parts, or Renault parts in the future.

The aim of this project is to determine whether more space can be created within the Nissan Parts Distribution Centre, by redesigning how certain sized parts are binned, racked and sorted into rows. By placing parts in better space utilized bins, space can be better utilized, and costs can be saved.

4.2 SPECIFIC OBJECTIVE/SCOPE

The following important actions will need to be performed in order to provide an appropriate warehouse design for the new parts distribution centre.

1. Appropriate project planning of the project (Gantt Chart, etc).
2. Obtain data and information on the current warehouse requirements.

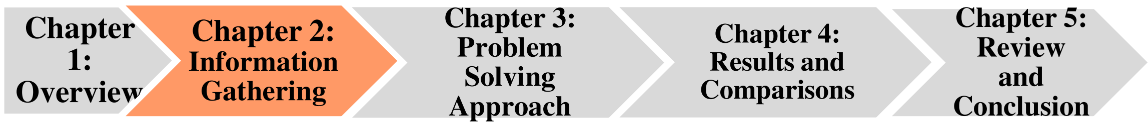
- Identify potential improvements in current warehouse which could increase productivity.
- Obtain classification of parts information.

3. Design of Microsoft Excel spreadsheet to enable parts allocations within the Nissan Parts Distribution Centre. The design should consider the following:
    - Area allocation of parts based on classifications.
    - Utilization of warehouse space by redesigning the floor layout and selection of appropriate storage equipment and parts carousels.
    - Detailed allocation of medium sized parts to bins, allocation of bins to racks and finally allocation of racks to rows.

4.3 DELIVERABLES

1. Project report which will include the following:
    - Information on the current warehouse requirements
    - Identification of potential improvements in the current warehouse
    - Allocation of parts to bins, racks, rows and columns
2. Obtain data and information on the current warehouse requirements.
3. Physical layout design of the areas in which parts are binned within the Nissan Parts Distribution Centre
4. Excel Spreadsheet that can be used by Nissan South Africa to allocate parts to correct bins, racking configurations, user defined rows and columns.

CHAPTER 2: INFORMATION GATHERING



1. INFORMATION GATHERING AIM

"A literature study can be defined as a systematic, comprehensive search for published material on a specific subject" (Botha & Du Toit, 1999).

The literature study can be described as the information gathering phase of the project. The information that was researched for this document will act as a foundation for the improved layout of the Nissan Parts Distribution Centre. The information will be used to help formulate and plan the different phases of the layout planning.

2. FACILITY DESIGN

2.1 WAREHOUSE ROLES IN THE SUPPLY CHAIN

Warehousing can be defined as the link in the supply chain that is responsible for receiving inventory from suppliers, safekeeping (storing) thereof, and shipment of inventory to customers on request. Warehouses also conduct inspections to ensure that products that are received from suppliers are correct in quantity and quality. The quality of the items is checked in terms of correct packaging and obvious damage. Items that are damaged that cannot be detected by warehouse staff will unfortunately flow through the supply chain to the customer. If customers are unsatisfied with a product, it will be sent back to the warehouse and the warehouse will send it back to the supplier. This could be eliminated to a large extent with the implementation of a Total Quality Management System (TQM).

2.2 THE FACILITY PLANNING PROCESS

In order to design a facility layout that would satisfy the requirements of the warehouse, a plan needs to be developed. Typically, a facility planning life cycle consists of the following phases and steps:

Figure 2 Muther's Systematic Layout Planning (SLP) Procedure

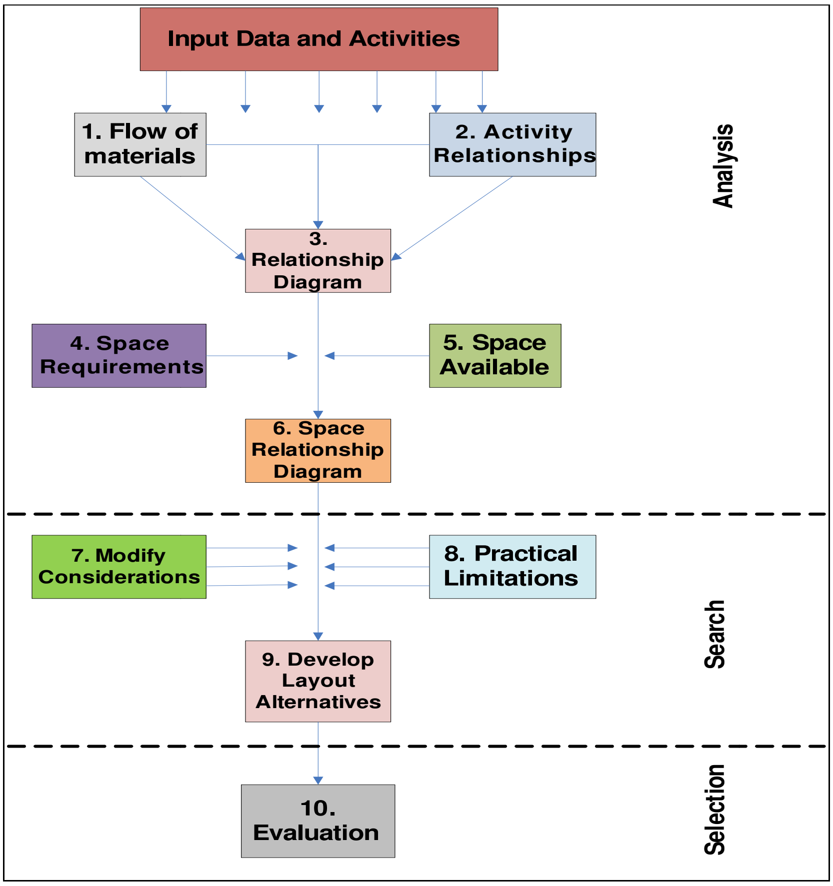
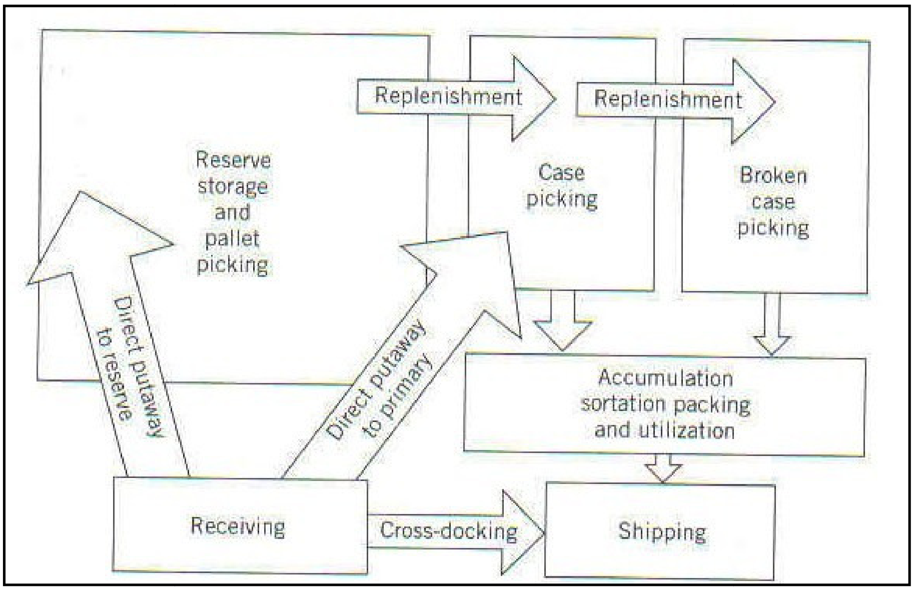


Figure 3 Basic Warehouse Functions and Flows (Coyle et al, 2003)



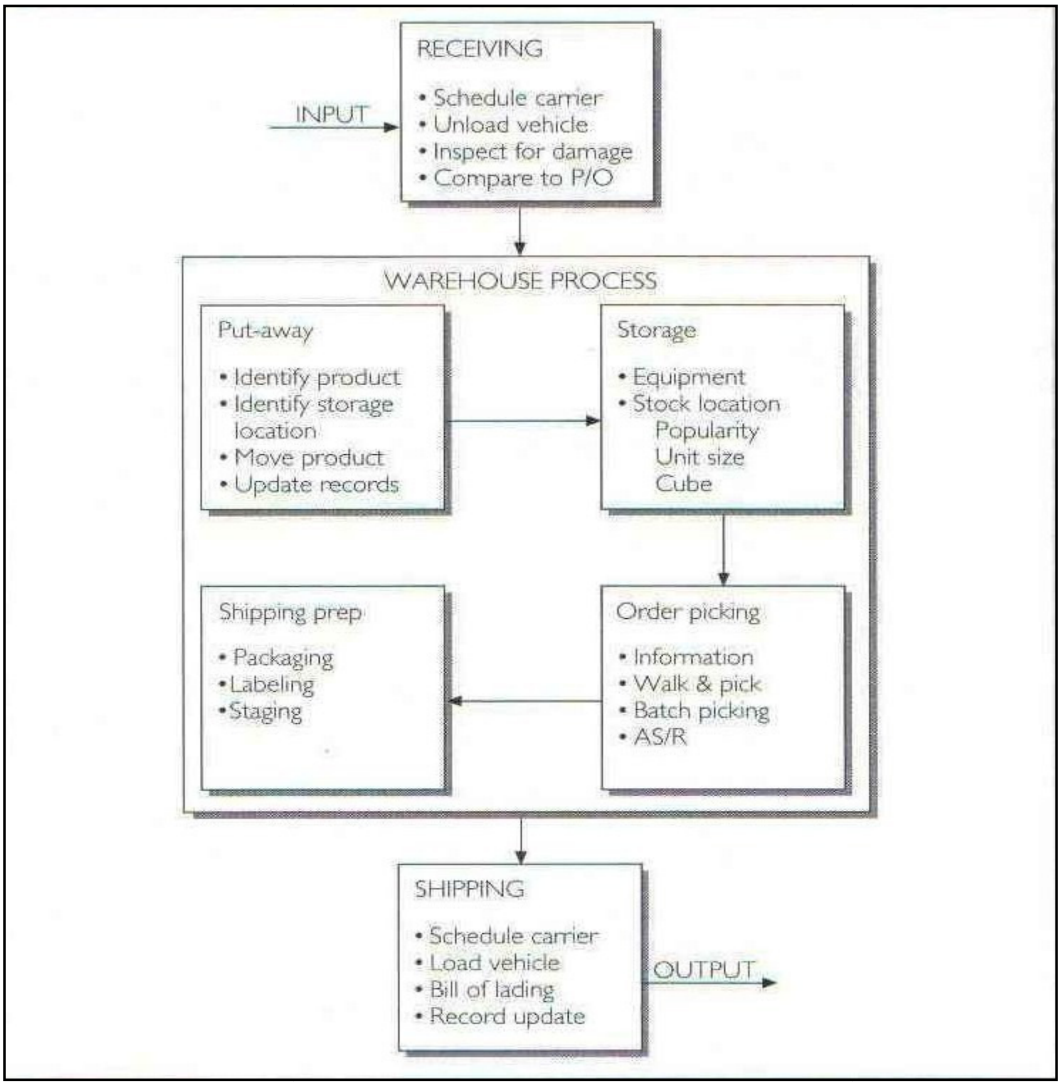
2.3 BASIC DATA TO SUPPORT WAREHOUSE DESIGN

Jenkins (1990, p92) lists 3 basic data and information requirements that need to be collected in order to design a warehouse efficiently:

- Reliable forecasts of every department that will influence the warehouse functionality. These forecasts should be of the receiving and shipping areas, order picking activities, etc.
- Material handling equipments, tools and methods that are needed in order to execute the warehouse functions.
- Establishing warehouse objectives.

2.4 BASIC WAREHOUSE OPERATIONS

Figure 4 Basic Warehouse Operations (Coyle et al, 2003)



All warehouse operations have an effect on the warehouse layout. For example, if order picking is done by hand, the layout should be planned as such as to reduce unnecessary travel distances. Shorter distances will improve productivity.

1. *Receiving*

   In the receiving area, goods are delivered from the suppliers at a specific time. These times should be known in order to improve productivity and enable quicker unloading of goods.
2. *Identification, incoming inspection and sorting*

   Here, items received from suppliers need to be checked for obvious damage and should be compared with the P/O to ensure that the correct type and quantity of goods are received from the suppliers. Items are also sorted into their relative SKU groups and are labelled with bar codes. The bar codes are then scanned and the goods are entered into the warehouse database system.
3. *Put Away*

   Put away is the operation that involves physical movement. The items are physically removed from the receiving area of the warehouse and transported with material handling equipment to the storage area.
4. *Storage*

   The storage operation is the actual safe keeping of the items until the warehouse receives orders for specific items.
5. *Order Picking*

   Order picking is the most expensive and time consuming warehouse operation. It requires warehouse staff to physically retrieve items that have been ordered by customers from the storage area, and to bring these items back to the packaging department where it will be packaged and labelled for shipment. AS/RS systems can be used to reduce order picking time as well as increase order accuracy.

6. *Packaging, labelling and/or pricing*
   Customer ordered items retrieved from the storage area by the warehouse staff, are now packaged into protective packaging, and are labelled with the customer and package content details into shipment containers.
7. *Shipping*
   After packaging the items are transported at certain times to the customers.

3. FACILITY LAYOUT

3.1 OBJECTIVES OF A WAREHOUSE LAYOUT

Salvendy (1994, p 1777) states that the following points are objectives for the facility layout:

- Effective utilization of material handling equipment.
- Effective utilization of warehouse space.
- To promote good housekeeping.
- To provide ease of maintenance and operations efficiency and flexibility.

3.2 SIZE AND LOCATION

The size of the warehouse will be determined by the new facility layout. The facility should be adaptable and flexible, because it should be able to accommodate more parts, should the demand for Nissan parts grow. The ideal warehouse is a multi level storage facility, rather than a single floor warehouse. A single floor warehouse requires a larger area that results in longer travel distances when compared to a multi level facility. Receiving and Dispatch areas should ideally be located on the ground floor of the warehouse and offices on elevated levels. Advantages and disadvantages of these level allocations will be determined later in the project.

3.3 STEPS IN ESTABLISHING A FACILITY LAYOUT

Salvendy (1994, p 1778) describes the following 8 steps that are required to establish a facility layout.

1. The objectives of the warehouse layout should be defined.
2. The primary activities of the warehouse that are needed to achieve the warehouse objectives should be specified.
3. Define the relative activities that are required to support point 2.
4. The space requirements of all activities should be determined.
5. The interrelationships between all activities should be determined.
6. Develop alternative layouts.
7. Evaluate and analyze alternative layouts.
8. Finalize and implement the chosen layout.

3.4 PARKINSON'S LAW

Even though new facilities can be planned to the finest detail, ensuring that there is sufficient space within the warehouse for the future, Parkinson's Law states that even this extra available capacity space will soon be occupied with little delay.

3.5 THE DISTRIBUTION CENTRE

When designing a warehousing system, the following needs to be maximized:

1. Space utilization
2. Equipment utilization
3. Accessibility and traceability of all parts
4. Protection and security of all parts

If one of the above aspects is neglected in a warehousing system, the warehouse will not be able to run efficiently. Warehouses need to be planned to the finest detail, such as which and how much of a part to place in which bin, in order to minimize total space used. In order to accomplish success when planning a distribution centre layout, the following objectives must be considered:

- Maximize distribution centre space utilization
- Maximize efficiency of material handling equipment
- Maximize the efficiency of labours
- Ensure proper protection of products
- Enable efficient product flow throughout the distribution centre
- Creating a safe working environment for labourers

3.6 ANALYSIS OF THE DCMEL (DISTRIBUTION CENTRE MANAGEMENT EVALUATION LIST)[1]

A comparison was made between the Nissan (Japan) and the Nissan (Rosslyn) distribution centres. It was determined that the Nissan (Rosslyn) distribution centre operates at a much less efficient rate than the Nissan (Japan) distribution centre. It would thus be wise to determine what changes should be made to the Nissan (Rosslyn) distribution centre, in order for it to operate as efficiently as the Nissan (Japan) distribution centre.

Based on the scores allocated during the evaluation of the distribution centre, the following opportunities for layout improvement were determined in the different departments/areas of the distribution centre:

[1] Due to confidentiality, the warehouse management evaluation list cannot be included in the report

RECEIVING AND BINNING AREA

- Parts are sorted in the binning area, but are not properly binned in the repackaging area. This might cause damage of parts, or parts might even be misplaced.
- The receiving area only has time schedules for delivery trucks (Inbound) with important containers. This can create problems in delivery bays if more trucks arrive than planned. Adequate planning should be done to establish the correct amount of delivery bays for trucks.
- There is not enough space in the receiving and sorting area. This forms an integral part in this project. The space utilization of the distribution centre is very important and will be focussed on later in the report.

PICKING

- Parts are currently picked based on customer regions. Nissan (Japan) also picks its parts based on customer regions, but it also packs the parts in that order. Proper space should be allocated for picking and packing of parts. Proper signage should also be put up to indicate where each region's container is.

STORAGE

- Only some part locations are managed by part size. This needs to be rectified that all part locations be managed based on part sizes.
- The parts moving code helps to decide the parts location, currently the mezzanine area 1st floor is fast moving parts. The question should be asked whether or not the mezzanine area is the best possible location in the distribution centre for fast moving parts and where the new mezzanine area should be placed in the distribution centre.
- Parts are hanging out of bins. The question is whether this is because the bins are too small, the parts are too big for the bins, or that the bins are over capacity. Proper sized

bins should be used for the parts and proper planning (Economic order quantity study) should be done as not to over order parts.

- Long parts are stored lengthways. Some of these parts, such as bumpers, should rather be stored standing against walls such as the irregular size parts. This can reduce the amount of floor space taken up by these parts.
- Only some of the irregular size parts, such as muffler's are stored standing against walls.
- When storing general parts, the label should be in the front, which is not always the case. This minimizes identification efficiency on parts.
- The proper density of parts should be kept in all areas. In the H area, the parts are kept in high density, but not in the Mezzanine area, which is where the fast moving parts are currently kept.
- Blocks and rows should be shown at each area.
- One part per location should be stored, except dead stock. Currently the distribution centre has a space problem, preventing this from being done.
- Each parts information such as dimensions, packaging and weight should be known. This is important when determining the optimal location for parts.
- Bins are not fully utilized, as parts are placed in the first available bin, without consideration for the stock that should be on hand at all times, thus in most instances a bin is only utilized at most 15%.

DISPATCH

- Each process of picking, sorting and dispatching is managed by using different colour pick slips per region. This provides the picker with a visual indication of where the part should go.
- The dispatch area only has time schedules for pick-up trucks (Outbound) for important containers. This can create problems in pick-up bays if more trucks arrive than planned.

Adequate planning should be done to establish the correct amount of pick-up bays for trucks.

MANAGEMENT

- Standard Operating Procedures should be put in place for all distribution centre operations.
- By completing a work study on all the processes, standard times can be set for all processes. This can also help identify problems with the layout and determine whether more material handling equipment is needed.

5 S ACTIVITIES

- Parts are sometimes just placed among the aisles. Good housekeeping forms part of creating an efficient distribution centre.
- Carts and machines should be kept in the designated areas for which they were purchased. The equipment should not just be placed wherever there is a space available for it.
- Lines should be marked on the floor of the distribution centre between different areas.

3.7 FACTORS THAT INFLUENCE THE DISTRIBUTION CENTRE SYSTEM

It is quite trivial to determine what the distribution centre objectives are, but there are various components and activities that influence the performance of the distribution centre:

- Material Handling Equipment
- Inventory Control Strategy and Control Logic
- Material Zoning
- Distribution centre Layout

MATERIAL HANDLING EQUIPMENT

Material handling equipment is used to store and retrieve materials within the distribution centre. These equipment ranges from forklift trucks to fully automated equipment such as AS/RS. All the different material handling equipment has different characteristics and effects on the efficiency of the distribution centre. They also differ greatly with cost. An important aspect of the distribution centre layout is to dedicate adequate zoning for these materials handling equipment. It should be kept in mind that some material handling equipment does not only utilize horizontal, but vertical movement as well. An example of this is the AS/RS. Two components should be considered when utilizing material handling equipment:

Proper scheduling should be considered to reduce the operator waiting times for the use of the equipment and the implementation of a well balanced maintenance schedule to reduce breakdowns.

INVENTORY CONTROL STRATEGY

It is important that the distribution centre bases its inventory control strategy on due dates set forth by customers and dealers. Inventory should be stored and controlled appropriately to reduce put and pick times without operators having to search for items. An adequate inventory control system would also improve the performance of the distribution centre and minimize the damages and losses of products.

MATERIAL ZONING

Large varieties of products, each with different characteristics, storage requirements and demands need to be stored safely in the distribution centre. Products differ with dimensions such as height and width as well as weight. This may create limitations to the areas in which these products can be stored. Some products may be flammable, and need to be stored in a designated enclosed area, equipped with a sprinkler system, away from other products which might be damaged if a fire were to start. Products that are fast moving items should also be allocated a certain storage location, to reduce the order picking times of these items, and to minimize the movement of the material handling equipment that were ordered to pick the products.

DISTRIBUTION CENTRE LAYOUT

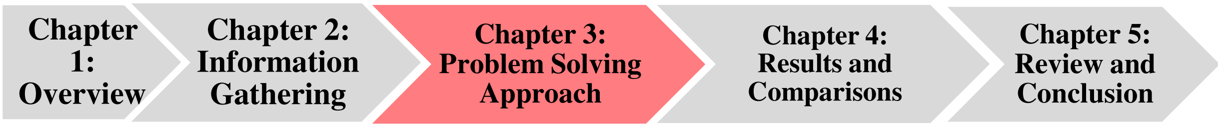
The layout of the distribution centre itself is a factor that can create numerous problems for the warehousing system. If the physical sizing factors of the material zoning areas are not properly determined it would be difficult to rectify once the new layout has been implemented. These factors include:

- The number of aisles
- The height of the distribution centre that can be utilized
- The number of material handling equipment
- The product zoning requirements
- Employee requirements, such as amount of restrooms, locker rooms, etc.

CONTROL LOGIC

Control logic is the mechanism that drives the distribution centre operations. It is based on algorithms that can determine, based on a number of criteria, such as, the position of the material handling equipment, the number of bin locations available, and the priority of the product, what, where and when products should be stored and retrieved.

CHAPTER 3: APPLICATION AND PROBLEM SOLVING APPROACH



1. BASIC DESIGN APPROACH

1. Determine optimal facility location

It is assumed that the current location of the Nissan Distribution Centre is the optimal location for the improved layout. Further research can be done to determine whether or not the current location is suitable, but it is outside the scope of the project.

2. Data Grouping

Data grouping has to do with the sorting of large amounts of data into usable formats and sizes. The data gathered from the parts will be sorted into part sizes that will enable the choice of bin sizes.

3. Specify Storage Containers

Once the parts are sorted and grouped based on size and weight, decisions can be made on the amount and sizes of bins that are required to store the parts. In order to assign a part to a bin, the decision algorithm in Appendix A.2 was used. There are 13 bin types available for storing parts. See Appendix A.1.

4. Specify Racking Requirements

When the amount of bins required has been determined, the quantity, length, height and type of racking configuration needed to support the bin containers need to be selected.. There are 14 racking configurations available. See Appendix B.1.

5. Determine Rows

Based on the amount of racking configurations in each area, as well the user specified row lengths, racking configurations are allocated to a row.

6. Allocate Aisles and Columns

Aisle requirements will have a great influence on the selection of material handling equipment in the distribution centre. However, for the purpose of this project, only the binning area for medium parts will be considered. This binning area consists of parts that are easy to carry by order pickers, and thus no special material handling equipment is needed except for a trolley. The trolley enables the order picker to carry more parts.

Rows can be allocated into 1, 2 or 3 columns, each with its own aisle requirements. For each area, the rows will be sorted into each of the three, and the column choice that reduces the amount of space used and minimizes the total volume will be selected.

7. Layout

When the above points have been completed, the layout of the new binning area of the distribution centre can be determined in such a way as to reduce travel time and waste of space.

2. DATA GROUPING

Parts are automatically sorted by the SAP program that NSA uses into ABC Classification type groups. There are currently 10 classes, Classes A – J. However, for this project, the parts will be classified into 4 groups, A, B, C and D. Class A is high demand, fast moving parts, whereas Class D are parts that are rarely ordered, and which is of low value. Parts can be divided into areas based on three possible strategies. These strategies are as follows:

- ABC Classification
- Sizes
- Demand

If parts are stored under the ABC Classification strategy, bins should be stored in areas that are designated for that type of classification. All parts that medium size parts, which is classified as Class A should then be stored in an area only for type A parts. All parts that are special size parts, such as very small and very large parts will be stored in a different way. If this strategy is the successful candidate, then the distribution centre will have 4 major areas, A, B, C and D. The ABC Classification strategy also enables pickers to pick fast moving parts quicker instead of having to walk long distances, since the fast moving parts class A area can be placed closer to the dispatch area.

If Size is chosen, the warehouse will consist of one major area, with parts ranging from small to very parts. This strategy can be seen as a total strategy, where all parts are allocated to one area.

If Demand is the chosen strategy, parts will be stored from high demand to lower demand products. Further investigation will be needed to determine if there will be designated areas, or just one very large area.

Parts will be stored under the ABC Classification Strategy

3. SPECIFY STORAGE CONTAINERS

For the purpose of this project, only parts that are middle sized[2] will be allocated to bins. This is because it has been observed within the warehouse that the most space is wasted in the binning areas, because parts are incorrectly binned. It is assumed that all parts that are grouped as small parts are of such a quantity that they can be allocated to a Linpic Carousel. Each area A, B, C and D has 3 Linpic Carousels available for use.

The following step is to allocate these medium parts to properly selected bins. The bins should be of the correct type, strength and size to accommodate the parts. Only 1 unique part number will be allocated to a bin. It is assumed that bins can only be 50% volume filled. The following bin sizes of 13 different bin types are available can be seen in Appendix A.1.

Once the parts are sorted and grouped based on size and weight, decisions can be made on the amount and sizes of bins that are required to store the parts. In order to assign a part to a bin, the decision algorithm in Appendix A.2 was used.

- If the total volume of a part

  $$volume_{part} = length \times height \times width \times demand^3$$

  is less than the maximum allowable volume for small parts, then the part will be allocated to the small parts area.
- If the total volume of a part is larger than the minimum permissible volume for a part to be classified as medium parts, or if either a parts length[4] (mm), height (mm), width (mm) or weight (g) exceeds the maximum allowable values for parts that are permissible to be carried then allocate the part to the large parts area.

[2] Middle sized part: a part having either dimension (length, width or depth) at a value of 0.5m or less, and a volume of less than 2.38m^3. If part weighs more than 3.5kg, it is considered a large part that required specialized material handling equipment. These values can be user-specified

[3] The words demand and stock on hand (required) are used interchangeably

[4] The words length and width are used interchangeably

- If the total volume of a part is less than the utilizable volume of a bin,

$$volume_{bin} = length \times height \times depth \times utilization\ factor,$$

  starting at Bin 1, then allocate the part to that bin. If the volume of the part is not less than the utilizable volume of a bin, then compare the volume of the part to the following bin until a suitable bin is found.
- The parts (medium parts) that were binned is sorted into areas A, B, C or D of the warehouse based on its classification of either A, B, C or D.
- The total amount of parts that are allocated to each bin is added up as well as the total of all the parts that were allocated to each area.
- Now the binned parts can be allocated to specific racks.

4. SPECIFY RACKING REQUIREMENTS

When the amount of bins required has been determined, the quantity, length, height and type of racking configuration needed to support the bin containers need to be selected. There are 14 fixed racking configurations available. See Appendix B1.

A great amount of space is wasted between storage racks as well as between and in shelves. Racks are not stacked appropriately and gaps are left between bins. By just adjusting the distances that racks are stacked back to back, moving the bins closer to each other and utilizing the entire rack space, the space needed to store parts will be minimized.

Space is also wasted on racks by placing bins of smaller size on racks that can accomodate larger sized bins. To keep the picker from having to reach deep into the racks in order to pick the part, the bins are normally placed in the front of the racks. Thus a large space is left open behind the bin. This can be rectified by either utilizing larger bins, or by using narrower storage racks.

The amount of bins that are allocated to each area is now sorted into 14 racking configuration types until all bins are allocated to a specific rack type. The easiest way to explain the logic behind the racking configurations is by means of an example.

Example:

The following is an example of the amount of bins of each type that has been allocated to Area A.

Table 1 Amount of Bins of Each Type Allocated to Area A

Bins Located to Area A					
BINS	**Amount of Bins**	**BINS**	**Amount of Bins**	**BINS**	**Amount of Bins**
B1	370	B6	123	B11	29
B2	483	B7	301	B12	53
B3	799	B8	396	B13	13
B4	52	B9	372	**Total**	**3618**
B5	418	B10	209		

The amount of bins for Area A is now first allocated into Configuration1. Configuration 1 consists of Bin types 1, 2, 3, 4 and 5. Bin types 2, 3, 4, and 5 all have 2 bins in the configuration and there are 6 bins of type 1 in the configuration. First the amount of bins of type 5 available in total is compared to the amount needed for the configuration. There are 418 bins available and for 1 rack, 2 is needed.

Thus

$$\frac{Amount\ of\ bins\ available}{Amount\ of\ bins\ needed\ for\ 1\ rack} = \frac{418}{2} = 209\ racks$$

can be made from this amount of bins. However, bin type 5 is not the only bin type needed for 1 rack of configuration 1. Thus, the same logic is applied for all the bins, and the minimum amount of racks that can be created is selected. In this case, 26 racks can be created from the data.

Table 2 Example of Bin Allocation to Racking Configurations

Configuration 1	**Bins needed for 1 Rack**	**Bins needed**	**Bins Left for Area A**
B5	2	209	366
B3	2	399	747
B4	2	26	0
B2	2	241	431
B1	6	61	214
Minimum Possible Racks		26	

The amount of bins left after creating the 26 racks is calculated by using the following formula:

$$Amount\ of\ bins\ available - \ Amount\ of\ bins\ needed\ for\ 1\ rack\ \times$$
$$Minimum\ amount\ of\ racks = 418 - 26 \times 2 = 366.$$

The amount of bin type 5 that is left will now be carried over to Configuration 2 and the same procedure will follow. This procedure is applicable to all bins and configurations. Once all bins have been allocated to racking configurations, the total amount of racks of each type and each area is added up.

5. DETERMINE ROWS

Based on the amount of racking configurations in each area, as well the user specified row lengths, racking configurations are allocated to a row.

There are 3 types of rows that can be generated due to the groupings of the racking configurations. The racking configurations are grouped because the depth of the racks differs and to place a rack with a depth of half the next racks depth would create a loss of a lot of space. This means that only racks of each group type can be placed next to each other.

The three row types based on the racking grouping are as follows:

- Type 1: Configurations 1, 2, 3, 4, 5 and 12
- Type 2: Configurations 6, 7, 8, 11, 13 and 14
- Type 3: Configurations 9 and 10

Racking configuration number 4 is left out of the determination of rows, because the probability that a racking configuration will fall under this classification is so small, it can be neglected.

Based on the user input for row lengths, racks are added based on length and grouped types until the user input row length is met. Once the row is full, or the amount of racks of that specific type is finished, a new row is started. See results in Appendix F.5.

6. ALLOCATE AISLES AND COLUMNS

Aisle requirements will have a great influence on the selection of material handling equipment in the distribution centre. However, for the purpose of this project, only the binning area for medium parts will be considered. This binning area consists of parts that are easy to carry by order pickers, and thus no special material handling equipment is needed except for a trolley which enables the order picker to carry more parts.

Rows can be allocated into 1, 2 or 3 columns, each with its own aisle requirements. For each area, the rows will be sorted into each of the three, and the column choice that reduces the amount of space used and minimizes the total volume will be selected.

There is a choice to either keep al the rows in one column, or to make muliple colums with aisles in between.

- Rows are grouped together in two's, thus starting the total amount of rows for an area will be divided by two determine the grouped rows.

$$Grouped\ rows = \frac{Total\ amount\ of\ rows\ for\ Area}{2}.$$

- For Columns 1 and 2, the Total Amount of Aisles is calculate by

$$Total\ Aisles\ inbetween\ Rows = \ Grouped\ Rows - 1$$

- For Columns 3, if the Grouped Rows value is more than 0, then

$$Total\ Aisles\ in\ between\ Rows = Grouped\ Rows,$$

  else,

$$Total\ Aisles\ in\ between\ Rows = Grouped\ Rows + 1.$$

- The required spacing between columns, is length of the main aisles allocated in between the columns which is user specified.

The following was done for Area A, to compare the effects that multiple columns have on the area and volume of the area.

Table 3 Comparing for Area A, 1 Columns, 2 Columns and 3 Columns

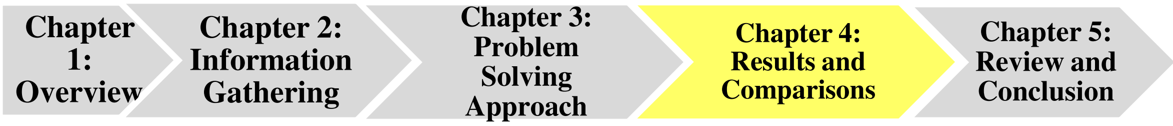
Columns	**1**	**2**	**3**
Actual Rows	22.00		
Grouped Rows	11.00	6	3
Total Aisles	10	5	3
Required Aisle Spacing between Rows (m)	1	1	1
Required Aisle Spacing between Columns (Main Aisle/s) (m)		1	1
Total Length (m)	50	101	152
Total Width (incl. Aisles) (m)	30.21	10.96	6.50
Total Height (m)	2.5	2.5	2.5
TOTAL AREA (m2)	1510.5	1106.96	988
TOTAL VOLUME	3776.25	2767.4	2470

As can be seen from the table above, by placing rows in multiple columns, the total area and volume of that specific area can be reduced. See the figure in Appendix C.1. However, it is not always the case, thus the 3 choices of column numbers need to be compare and the smallest of the three should be chosen.

7. LAYOUT

Layouts of each of the 4 binning areas can now be drawn up based on the results from the above points.

CHAPTER 4: RESULTS AND COMPARISONS



1. RESULTS

For the results of the Excel Spreadsheet output on Storage Containers, Racking Requirements, Rows, Aisles and Columns see Appendix F.

2. COSTING OF THE AREAS

The amount of capital needed to change the warehouse's binning area, depends on the amount of parts that are allocated to bins. Since the rule is one unique part number per bin, the amount of bins needed is directly proportionate to the amount of parts that need binning.

The amount of racks that are required depends on the amount of bins of each type that is needed. In order to keep the cubic space costs to a minimum, the row layouts with the minimum amount of space requirements should be selected.

Generally, since less space will be used to bin the parts, for each m^2 that is needed less than the current situation, money will be saved.

3. COMPARISONS

3.1 COLUMN ALTERNATIVES

Out of 27 different combinations of 1,2 or 3 columns the best alternative is where Area A consists of 2 columns, Area B of 2 columns, Area C of 3 columns and Area D, 2 columns. See Bin Allocation Excel Spreadsheet.xlsx, worksheet *Alternatives*. In this Alternative, the smallest amount of space is used to store the parts in areas A, B, C and D.

Table 4 Area and Volume in Total for Each Area

16	Columns	Length	Width	Height	Area (m^2)	Volume (m^3)
Area A	2	101.00	11.11	2.50	1122.11	2805.28
Area B	2	101.00	8.15	2.50	823.15	2057.88
Area C	3	152.00	6.38	2.50	969.76	2424.40
Area D	2	101.00	1.00	2.50	101.00	252.50
					3016.02	7540.05

3.2 COMPARING OF CURRENT SITUATION WITH NEW DESIGN

When comparing the allocation of 24400 parts to bins, and the overall total area that is a result of that, with the current information of the distribution centre, the following can be seen.

Table 5 Comparing the Current Binning Situation with the New Design

	Current Situation	Binning Design	% Improvement
Total Lines	55 281		
Bins	94 361	24 400	
Floor Area (m^2)	17 229.90	3016.02	
Volumetric area (m^3)	129 224.6	22 620.15	
Lines per m^2	3.21	8.09	
Lines per m^3	0.43	1.08	
Bins per m^2	5.50	8.09	147%
Bins per m^3	0.70	1.08	154%

In the current situation, there are more bins than parts, meaning that there is more than one bin per part. With the Binning Design, each part is allocated to only 1 bin, which is suitable for the parts total volume ($volume_{part} = length \times height \times width \times demand$). Since the amount of parts in the current situation and the binning design differ, the two situations will be compared to each other based on the density of parts and bins per m^2 and m^3. With the Binning Design, it can be seen that parts are stored much more dense together, which leads to a much more efficient utilization of warehouse space.

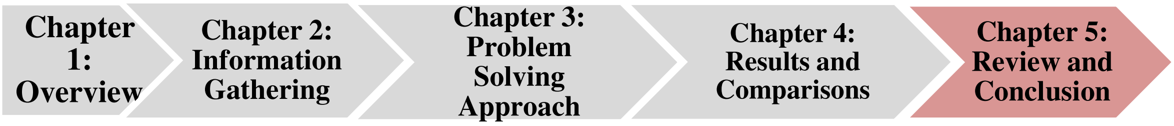
3.3 COMPARING OF DIFFERENT STOCK ON HAND SCENARIOS

The following table enables comparison between the effects different stock on hand scenarios for each part having a demand of any value between 1 and 100, and not fixed as assumed (Area A = 50, Area B = 25, Area C = 10 and Area D = 1).

Table 6 Comparing Random SOH Scenarios with the New Binning Design

	Current Situation	Random Stock on Hand Scenarios	% Improvement	Binning Design for Fixed Stock on Hand	% Improvement
Total Lines	55281	56463		56463	
Amount of Bins	94361	33476		24 400	
Total of Binned Parts	x	33476		33476	
Floor Area	17229.90	5739.45		3016.02	
Volumetric area	129224.6	43045.88		22 620.15	
Lines per m2	3.21	5.83		8.09	
Lines per m3	0.43	0.78		1.08	
Bins per m2	5.50	5.83	106%	8.09	147%
Bins per m3	0.70	0.78	111%	1.08	154%

CHAPTER 5: REVIEW AND CONCLUSION



1. REVIEW AND CONCLUSION

Based on the results of the Excel spreadsheet and comparison of the volumes with current binning volumes, an immense amount of space can be better utilized because more parts are stored per m^2. All unique parts number are also allocated to its own bin, based on its volume and its stock on hand requirements. Thus, more space can be created within the warehouse by applying better binning methods.

The Excel Binning Spreadsheet, enables the user to store parts in predetermined sized bins, racks and rows and even ables the user to decide whether 1,2 or 3 columns are more sufficient for the warehouse's needs.

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APPENDIX

APPENDIX A: BINNING

A.1 BIN INFORMATION

The following table is a list of the 13 different bin types available for storing parts:

Bin Type	**Length** (m)	**Height** (m)	**Depth** (m)	**Volume** (m^3)	**50% Bin Volume Utilization** (m^3)
B1	0.16	0.17	0.46	0.01	0.01
B2	0.39	0.15	0.46	0.03	0.01
B3	0.45	0.42	0.46	0.09	0.04
B4	0.47	0.43	0.46	0.09	0.05
B5	0.96	0.35	0.46	0.15	0.08
B6	0.96	0.42	0.46	0.19	0.09
B7	0.50	0.54	1.00	0.27	0.14
B8	0.86	0.54	1.00	0.46	0.23
B9	1.53	0.58	0.93	0.83	0.41
B10	2.83	0.59	1.01	1.69	0.84
B11	2.40	0.97	0.86	2.00	1.00
B12	2.73	1.10	1.22	3.66	1.83
B13	2.33	1.44	1.42	4.76	2.38

A.2 ALGORITHM FOR THE DESIGN OF A NEW BINNING AREA

NOMENCLATURE

$n = number\ of\ parts\ requiring\ storage;$

$i = index\ for\ part\ i, where\ (i = 1; \dots; n);$

$p_i = part\ i, where\ (i = 1; \dots; n);$

$v_i = volume\ of\ part\ in\ m^3\ i\ , where\ (i = 1; \dots; n);$

$l_i = length\ of\ part\ in\ m, where\ (i = 1; \dots; n);$

$w_i = depth\ of\ part\ in\ m, where\ (i = 1; \dots; n);$

$h_i = height\ of\ part\ in\ m, where\ (i = 1; \dots; n);$

$d_i = demand\ of\ part\ i, where\ (i = 1; \dots; n);$

$m_i = mass\ of\ part\ i\ in\ kg, where\ (i = 1; \dots; n);$

$j = index\ for\ bins, where\ (j = 1, \dots 13);$

$b_j = bin\ \ j, where\ (j = 1; \dots; 13);$

$v_j = volume\ of\ bin\ \ j\ in\ m^3, where\ (j = 1; \dots; 13);$

$l_j = length\ of\ bin\ j\ in\ m, where\ (j = 1; \dots; 13);$

$w_j = depth\ of\ bin\ \ j\ in\ m, where\ (j = 1; \dots; 13);$

$h_j = height\ of\ bin\ j\ in\ m, where\ (j = 1; \dots; 13);$

$\alpha = bin\ utilization\ factor;$

$u_j = usable\ bin\ volume\ of\ bin\ j\ in\ m^3, where\ (j = 1; \dots; 13);$

$k_{max} = maximum\ permissable\ carry\ length, widht\ or\ height\ of\ all\ parts;$

$m_{max} = maximum\ permissable\ carry\ weight\ of\ all\ parts;$

$s_{max} = maximum\ permissable\ volume\ for\ parts\ to\ be\ classified\ as\ small$

$l_{max} = maximum\ permissable\ volume\ for\ parts\ to\ be\ classified\ as\ large$

$a_{ij} = allocation\ of\ part\ i\ to\ bin\ j, where\ (i = 1; \dots; n) and\ (j = 1; \dots; 13);$

$q = other\ area\ types,\ small\ and\ large, where\ (q = 1,2);$

INPUT TO THE ALGORITHM

$n; d_i;\ l_i;\ h_i;\ w_i;\ m_i;\ l_j;\ h_j;\ w_j\ ;\ l_{max};\ m_{max};\ s_{max};\ k_{max};\ \alpha;\ \ t;\ where\ (i = 1; \dots; n) and\ (j = 1; \dots; 13);$

BINNING ALGORITHM PROCEDURE

This algorithm is executed with the complete data for all areas A, B, C and D in one Excel worksheet. An Excel formula is created to summate the amount of parts that were located to which bins for each area as well as the amount of parts that were allocated to the small and large areas. These totals for the medium parts are used to allocate the bins to racking configurations and from there to rows.

Step 1

In this step, some calculations are done from the input data.

1.1 Let the following start with:

$$i = 1;$$

$$j = 1;$$

1.2. Calculate the total volume of the part, by multiplying the part length (mm), part height (mm), part width (mm) and part demand.

$$v_i = l_i h_i w_i d_i;$$

1.3. Calculate the volume of the bin, by multiplying the bin length (mm), bin height (mm) and bin width (mm).

$$v_j = l_j h_j w_j;$$

1.4. Calculate the utilizable volume of the bin, by multiplying the volume calculated in Step 1.3 by the utilization factor, specified to be 50%.

$$u_j = \alpha v_j;$$

Step 2

2.1 If the volume of part i multiplied by the demand for that part is smaller than the maximum allowable volume for small parts, allocate the part to the small part area, q = 1.

$$If\ v_i < s_{max}$$

$$p_i = o_{i1}\ ;\ allocation\ of\ part\ i\ to\ area\ q = 1;$$

Step 3

3.1 If the volume of part i multiplied by the demand for that part is larger than the maximum allowable volume for medium parts, allocate the part to the large part area, q = 2

$$If\ v_i > l_{max}$$

$$p_i = o_{i2};\ \ allocation\ of\ part\ i\ to\ area\ q = 2;$$

3.2 If the length, width or height of part i is larger than the maximum permissible carry length, width or height of all parts, allocate the part to the large area q = 2.

$$If\ l_i,\ \ h_i,\ \ w_i > k_{max}$$

$$p_i = o_{i2};\ allocation\ of\ part\ i\ to\ area\ q = 2;$$

3.3 If the weight of part *i* is larger than the maximum permissible carry weight of all parts, allocate the part to the large area q = 2.

$$If\ m_i > m_{max}$$

$$p_i = o_{i2};\ allocation\ of\ part\ i\ to\ area\ q = 2;$$

Step 4

4.1 If the total volume of part *i* is less than the utilizable volume of bin *j*, then allocate the part *i* to that bin *j*.

$$If\ v_i < u_j$$

$$p_i = a_{ij}; allocation\ of\ part\ i\ to\ bin\ j, where\ (i = 1; \dots ; n) and\ (j = 1; \dots ; 13)$$

Step 5

5.1 If the total volume of part *i* is more than the utilizable volume of bin *j*, then move to the next bin, and return to previous steps.

$$If v_i > u_j$$

$$Then\ j = j + 1$$

Return to Step 4

Step 6

6.1 After part *i* has now been allocate to a bin *j*, return to step 1 and repeat the procedure for $i = i + 1$.

6.2 If $i = n + 1$, then proceed to Step 7

Step 7

7.1 Summate the total amount of parts that are allocated to the small parts area

$$\sum_{i=1}^{n} o_{i1}$$

Step 8

8.1 Summate the total amount of parts that are allocated to the large parts area

$$\sum_{i=1}^{n} o_{i2}$$

Step 9

9.1 Summate the amount of parts that are allocated to each bin.

$$for\ j = 1{:}1{:}13$$

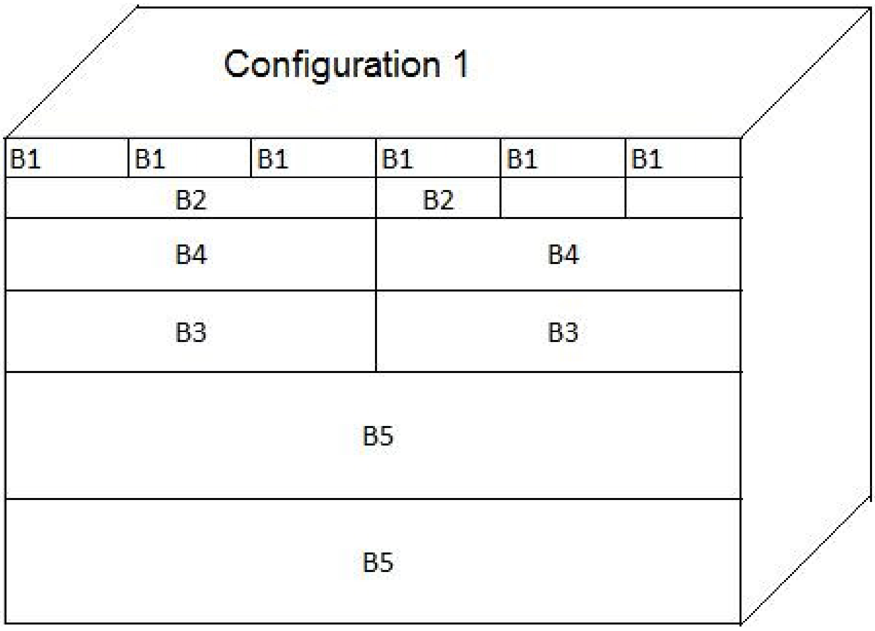
$$\sum_{\mathrm{i}=1}^{\mathrm{n}} \mathrm{a}_{\mathrm{ij}}$$

See Appendix F1 for the results for Binning

APPENDIX B: RACKING CON-FIGURATIONS

B.1 CONFIGURATION DATA AND DIAGRAMS

The following is an indication of the different racking configuration and the different types and quantities of bins they consist of. This is only an example of Configuration 1. The other configurations are sorted based on the same idea.



RACKING CONFIGURATION 1									
	LENGTH (m)	**HEIGHT (m)**	**DEPTH (m)**	**VOLUME (m^3)**	**QTY**	**TOTAL VOLUME (m^3)**	**MAXI-MUM HEIGHT (m)**	**MAXI-MUM LENGTH (m)**	**MAXI-MUM DEPTH (m)**
B5	0.96	0.35	0.46	0.15456	2	0.30912			
B3	0.45	0.42	0.46	0.08694	2	0.17388			
B4	0.47	0.43	0.46	0.092966	2	0.185932			
B2	0.39	0.15	0.46	0.02691	2	0.05382			
B1	0.16	0.17	0.46	0.012512	6	0.075072			
TOTAL VOLUME PER RACK						0.797824	1.87	0.96	0.46

RACKING CONFIGURATION 2									
	LENGTH (m)	**HEIGHT (m)**	**DEPTH (m)**	**VOLUME (m^3)**	**QTY**	**TOTAL VOLUME (m^3)**	**MAXI-MUM HEIGHT (m)**	**MAXI-MUM LENGTH (m)**	**MAXI-MUM DEPTH (m)**
B5	0.96	0.35	0.46	0.15456	5	0.7728			
TOTAL VOLUME PER RACK						0.7728	1.75	0.96	0.46

RACKING CONFIGURATION 3									
	LENGTH (m)	**HEIGHT (m)**	**DEPTH (m)**	**VOLUME (m^3)**	**QTY**	**TOTAL VOLUME (m^3)**	**MAXI-MUM HEIGHT (m)**	**MAXI-MUM LENGTH (m)**	**MAXI-MUM DEPTH (m)**
B3	0.45	0.42	0.46	0.08694	8	0.69552			
TOTAL VOLUME PER RACK						0.69552	1.68	0.9	0.46

RACKING CONFIGURATION 4									
	LENGTH (m)	**HEIGHT (m)**	**DEPTH (m)**	**VOLUME (m^3)**	**QTY**	**TOTAL VOLUME (m^3)**	**MAXI-MUM HEIGHT (m)**	**MAXI-MUM LENGTH (m)**	**MAXI-MUM DEPTH (m)**
B4	0.47	0.43	0.46	0.092966	8	0.743728			
TOTAL VOLUME PER RACK						0.743728	1.72	0.94	0.46

RACKING CONFIGURATION 5									
	LENGTH (m)	**HEIGHT (m)**	**DEPTH (m)**	**VOLUME (m^3)**	**QTY**	**TOTAL VOLUME (m^3)**	**MAXI-MUM HEIGHT (m)**	**MAXI-MUM LENGTH (m)**	**MAXI-MUM DEPTH (m)**
B2	0.39	0.15	0.46	0.02691	10	0.2691			
TOTAL VOLUME PER RACK						0.2691	0	0.39	0.46

RACKING CONFIGURATION 6									
	LENGTH (m)	HEIGHT (m)	DEPTH (m)	VOLUME (m^3)	QTY	TOTAL VOLUME (m^3)	MAXI-MUM HEIGHT (m)	MAXI-MUM LENGTH (m)	MAXI-MUM DEPTH (m)
B1	0.16	0.17	0.46	0.012512	10	0.12512			
TOTAL VOLUME PER RACK						0.12512	1.7	0.16	0.46

RACKING CONFIGURATION 7									
	LENGTH (m)	HEIGHT (m)	DEPTH (m)	VOLUME (m^3)	QTY	TOTAL VOLUME (m^3)	MAXI-MUM HEIGHT (m)	MAXI-MUM LENGTH (m)	MAXI-MUM DEPTH (m)
B8	0.86	0.54	1	0.4644	3	1.3932			
B7	0.5	0.54	1	0.27	10	2.7			
TOTAL VOLUME PER RACK						4.0932	1.62	2.58	1

RACKING CONFIGURATION 8									
	LENGTH (m)	HEIGHT (m)	DEPTH (m)	VOLUME (m^3)	QTY	TOTAL VOLUME (m^3)	MAXI-MUM HEIGHT (m)	MAXI-MUM LENGTH (m)	MAXI-MUM DEPTH (m)
B8	0.86	0.54	1	0.4644	9	4.1796			
TOTAL VOLUME PER RACK						4.1796	1.62	2.58	1

RACKING CONFIGURATION 9									
	LENGTH (m)	HEIGHT (m)	DEPTH (m)	VOLUME (m^3)	QTY	TOTAL VOLUME (m^3)	MAXI-MUM HEIGHT (m)	MAXI-MUM LENGTH (m)	MAXI-MUM DEPTH (m)
B12	2.73	1.1	1.22	3.66366	2	7.32732			
TOTAL VOLUME PER RACK						7.32732	2.2	2.73	1.22

RACKING CONFIGURATION 10									
	LENGTH (m)	HEIGHT (m)	DEPTH (m)	VOLUME (m^3)	QTY	TOTAL VOLUME (m^3)	MAXI-MUM HEIGHT (m)	MAXI-MUM LENGTH (m)	MAXI-MUM DEPTH (m)
B13	2.33	1.44	1.42	4.764384	1	4.764384			
TOTAL VOLUME PER RACK						4.764384	1.44	2.33	1.42

RACKING CONFIGURATION 11									
	LENGTH (m)	HEIGHT (m)	DEPTH (m)	VOLUME (m^3)	QTY	TOTAL VOLUME (m^3)	MAXI-MUM HEIGHT (m)	MAXI-MUM LENGTH (m)	MAXI-MUM DEPTH (m)
B11	2.4	0.97	0.86	2.00208	2	4.00416			
TOTAL VOLUME PER RACK						4.00416	1.94	2.4	0.86

RACKING CONFIGURATION 12									
	LENGTH (m)	HEIGHT (m)	DEPTH (m)	VOLUME (m^3)	QTY	TOTAL VOLUME (m^3)	MAXI-MUM HEIGHT (m)	MAXI-MUM LENGTH (m)	MAXI-MUM DEPTH (m)
B6	0.96	0.42	0.46	0.185472	3	0.556416			
TOTAL VOLUME PER RACK						0.556416	1.26	0.96	0.46

RACKING CONFIGURATION 13									
	LENGTH (m)	HEIGHT (m)	DEPTH (m)	VOLUME (m^3)	QTY	TOTAL VOLUME (m^3)	MAXI-MUM HEIGHT (m)	MAXI-MUM LENGTH (m)	MAXI-MUM DEPTH (m)
B9	1.53	0.58	0.93	0.825282	3	2.475846			
TOTAL VOLUME PER RACK						2.475846	1.74	1.53	0.93

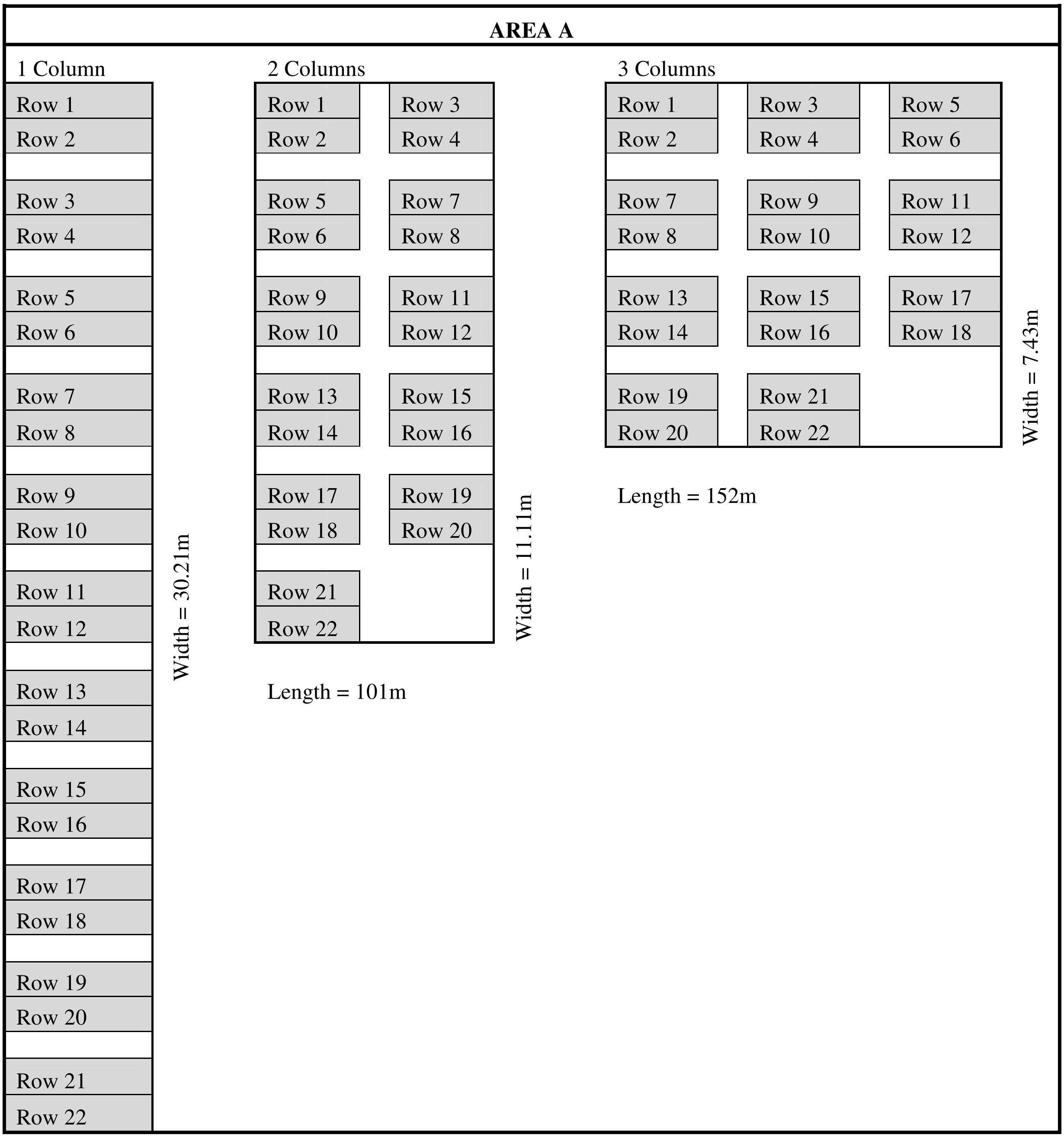
RACKING CONFIGURATION 14									
	LENGTH (m)	**HEIGHT (m)**	**DEPTH (m)**	**VOLUME (m^3)**	**QTY**	**TOTAL VOLUME (m^3)**	**MAXI-MUM HEIGHT (m)**	**MAXI-MUM LENGTH (m)**	**MAXI-MUM DEPTH (m)**
B10	2.83	0.59	1.01	1.686397	3	5.059191			
TOTAL VOLUME PER RACK						5.059191	1.77	2.83	1.01

See Appendix F.2 for the results of the amount of racking configurations of each type that is used.

APPENDIX C: ROWS AND COLUMNS

C.1 COMPARISON OF COLUMNS

The following diagrams are graphical representations of what is meant when the rows are sorted by 1 column, 2 columns or 3 columns.



APPENDIX E: USER MANUAL FOR THE EXCEL BINNING SPREADSHEET.DOC

User Manual for the Bin Allocation Excel Spreadsheet.xlsx

Developed

by

U.O. du Preez,

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at the

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TARGET OF THE SPREADSHEET

This Excel spreadsheet is developed to enable the Nissan Parts Distribution Centre to allocate parts the appropriate sized bins. After parts have been allocated to bins, the spreadsheet automatically allocated parts to predetermined racking configurations. User defined row lengths enables the racks to be allocated to rows accordingly.

USER SPECIFICATION

The user of the Excel spreadsheet is any person who requires that their parts to be allocated to bins, racks as well as rows in a specific area.

GETTING STARTED

BASIC INPUT REQUIREMENTS

The basic input data requirements for the spreadsheet that needs to be fed in manually are as follows:

1. Part information
   - Unique part number, part or material description, part classification
   - Part length (mm), height (mm), width (mm), weight (g)
   - Part demand
2. Maximum volume (m^3) of a part that is permissible as a small part
3. Minimum volume (m^3) of a part that is permissible as a large part
4. Maximum weight (g) that is permissible for a picker to carry
5. Maximum length (mm), height (mm) and width (mm) that is permissible for a picker to carry
6. Required row length (m) into which the configurations will be sorted.

ASSUMPTIONS:

FIXED ASSUMPTIONS:

- Each unique part number can only be allocated to one bin, in order to reduce part mixing.
- There are only 13 types of bins into which part allocation can be done. The data on these bins can be viewed in Appendix A.1
- There are 14 fixed racking configurations into which bins can be placed.
- Rows can be located into 1,2 or 3 columns based on the user defined row lengths and whichever is chosen.
- There are only three types of rows, which are determined based on the depth of each rack. This means that the following groupings of rack configurations can be allocated to the same one sided row.
    i. Racking configurations 1, 2, 3, 4, 5 and 12;
    ii. Racking configurations 6, 7, 8, 11, 13 and 14;
    iii. Racking configurations 9 and 10

FLEXIBLE ASSUMPTIONS FOR GOAL OF THE PROJECT:

- Bins are utilized to 50% of its total volume (m^3). This means that a bin cannot be filled by more than 50%. If a part's is as such that the dimensions of the part satisfy the allocation to the bin, but the total demand multiplied by the volume (m^3) of the part exceeds the bin utilization factor, the part will be placed in a larger sized bin.
- It is assumed that parts classified as A group parts have a stock on hand requirement of 50 parts each (the amount of parts that need to be available within the distribution centre at all times); B groups parts, 25 parts; C group parts 10 and D group parts 1. These values can be changed by the user.
- Parts that can be carried by pickers must not weigh more than 3.5kg. Again this assumption can be user defined.

PROCEDURE

STEP BY STEP

Step 1:

Identify the parts that need to be allocated to bins. Ensure that the classifications of parts A, B, C and D are used and not A-J.

Step 2:

Import all the required parts information into the Excel spreadsheet, pasting it onto the following worksheet:

User Input – Part Data, where the following column heads state:

Column A	*Column B*	*Column C*	*Column D*	*Column E*	*Column F*	*Column G*	*Column H*
Unique Part Number	**Part/Material Description**	**ABC Classification (A,B,C or D)**	**Length (mm)**	**Height (mm)**	**Width (mm)**	**Weight (g)**	**Stock at all times (Demand)**

Step 3:

User must now input the maximum volume (m^3) of a part that is permissible for a small part. This is done on the ***User Input – Part Data*** worksheet in cell: J1

Step 4:

The maximum weight (g) that is permissible for a picker to carry must be filled in the worksheet: ***User Input – Part Data*** in cell: J2

Step 5:

The maximum length (mm), height (mm) and width (mm) that is permissible for a picker to carry must be filled in by the user. This is done on the ***User Input – Part Data*** worksheet in cells K3, 4 and 5 respectively.

Step 6:

Required row length (m) into which the configurations will be sorted. This is done on the ***User Input – Part Data*** worksheet in cell K6.

Step 7:

The required aisle spacing (m) between rows must be filled in the ***User Input – Part Data*** *worksheet* cell K7.

Step 8:

Fill in the required height (m) of the areas, for example 2.5m. This is filled in the ***User Input – Part Data*** *worksheet* cell K8.

WORKSHEETS

Fixed Data

This worksheet can be viewed to see the fixed data for the Excel spreadsheet.

Bin Allocation Calculation

In this worksheet, calculations are done to allocate the parts to bins based on the constraints set forth by the algorithm.

Bin Allocation Output

A summation table of the amount of parts to each bin type and area is given in this worksheet.

Racking Configuration

Calculations are done to allocate bins to racking configurations based on the amount of bin types available for each area. This worksheet can be viewed for the formulations.

Racking Configuration Output

The amount of bins allocated to a rack configuration in each area is given in table form in this worksheet. The amount of bins left that were not allocated to a rack should be kept below 10 bins this will ensure that the margin of error stays as small as possible. If the amounts of bins not allocated to a rack are more than 10, bins need to be allocated manually to a rack, which will not be fully filled.

Row Area A, Row Area B, Row Area C and Row Area D worksheets

In these worksheets, the racking configurations that were calculated in the previous worksheet are now allocated to rows, with lengths specified by the user. These worksheets show the underlying Excel formulas that were used to calculate these rows. The total rows for each area is indicated in Cell A5005.

Row Area A, B, C and D Output worksheets

In these worksheets there are summarized tables for the amount of racks in each area that is allocated to a row. This shows that for example, Row 1 for Area A, consists of 26 racking configurations type 1 and 26 of type 2. The total length of these rows must be less than the user specified row lengths.

Total Dimensions for Area A, Area B, Area C and Area D worksheets

These worksheets are where all the row information is gathered up and the rows can be allocated into 1, 2 or 3 columns. The amount of columns that produce the smallest (minimum) area and volume is selected to calculate the total volume and area of all the areas.

Total Dimensions for Binning

In this sheet the total volume of all the areas together is calculated as well as the area.

Alternatives

In this sheet, different combinations of columns for each area are all compared, and the one that results in the least amount of space (area) is selected for implementation

Comparison

In this sheet, the different scenarios can be compared to what the current status of the warehouse is.

UNDERSTANDING THE LOGIC

The spreadsheet is programmed to pack parts into bins, in such a way that the bin utilization percentage is kept in mind. See Chapter 3 for the logic behind the Spreadsheet, or view the formulas within the Spreadsheet itself.

APPENDIX F: RESULTS

F.1 RESULTS FROM THE BINNING ALGORITHM

The following table is a summation of the amount of parts that has been allocated to a specific area and to a specific bin type.

	Total Parts	Total of Very Small Parts allocated to Linpics	Total of Very Large Parts allocated to Large Area	Bins Located To Area A	Bins Located To Area B	Bins Located To Area C	Bins Located To Area D
Total Parts	56463	18685	13378	3858	5959	12283	2300
Total Parts Allocated to BIN Type 1	4864	x	x	389	1140	2544	791
Total Parts Allocated to BIN Type 2	5019	x	x	441	1103	2349	1126
Total Parts Allocated to BIN Type 3	7158	x	x	864	1577	4354	363
Total Parts Allocated to BIN Type 4	245	x	x	26	87	129	3
Total Parts Allocated to BIN Type 5	2150	x	x	386	854	897	13
Total Parts Allocated to BIN Type 6	1085	x	x	154	137	791	3
Total Parts Allocated to BIN Type 7	1227	x	x	399	326	501	1
Total Parts Allocated to BIN Type 8	1380	x	x	586	314	480	0
Total Parts Allocated to BIN Type 9	713	x	x	272	256	185	0
Total Parts Allocated to BIN Type 10	448	x	x	249	147	52	0
Total Parts Allocated to BIN Type 11	29	x	x	20	8	1	0
Total Parts Allocated to BIN Type 12	66		x	56	10	0	0
Total Parts Allocated to BIN Type 13	16	x	x	16	0	0	0

F.2 RESULTS FROM THE RACKING CONFIGURATION WORKSHEET

The following table is a summation of the amount of each racking configurations type that has been allocated to each area.

Racking Configuration	Area A (m3)	Area B (m3)	Area C (m3)	Area D (m3)	Total
Configuration 1	13	43	64	1	122
Configuration 2	72	153	153	2	381
Configuration 3	104	186	528	45	864
Configuration 4	0	0	0	0	0
Configuration 5	41	101	222	112	477
Configuration 6	31	88	216	78	413
Configuration 7	39	32	50	0	122
Configuration 8	52	24	36	0	112
Configuration 9	28	5	0	0	33
Configuration 10	16	0	0	0	16
Configuration 11	10	4	0	0	14
Configuration 12	51	45	263	1	361
Configuration 13	90	85	61	0	237
Configuration 14	83	49	17	0	149

F.5 RESULTS FROM THE ROW WORKSHEET

The following tables is an indication of the amount of rows that each area consists of, as well as the amount of each racking configuration that is present in that row.

F.5.1 ROW ALLOCATION FOR AREA A

Area A	Row	C1	C2	C3	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	LENGTH (m)	HEIGHT (m)	DEPTH (m)	VOLUME
ROW	1	13	39	0	0	0	0	0	0	0	0	0	0	0	50	1.87	0.46	42.94
ROW	2	0	33	20	0	0	0	0	0	0	0	0	0	0	50	1.75	0.46	39.99
ROW	3	0	0	55	0	0	0	0	0	0	0	0	0	0	50	1.68	0.46	38.25
ROW	4	0	0	29	41	0	0	0	0	0	0	8	0	0	50	1.68	0.46	38.46
ROW	5	0	0	0	0	0	0	0	0	0	0	43	0	0	41	1.26	0.46	23.93
ROW	6	0	0	0	0	31	17	0	0	0	0	0	0	0	49	1.62	1.00	79.09
ROW	7	0	0	0	0	0	19	0	0	0	0	0	0	0	49	1.62	1.00	79.41
ROW	8	0	0	0	0	0	3	16	0	0	0	0	0	0	49	1.62	1.00	79.41
ROW	9	0	0	0	0	0	0	19	0	0	0	0	0	0	49	1.62	1.00	79.41
ROW	10	0	0	0	0	0	0	17	0	0	2	0	0	0	49	1.94	1.00	94.40
ROW	11	0	0	0	0	0	0	0	0	0	8	0	20	0	50	1.94	0.93	89.85
ROW	12	0	0	0	0	0	0	0	0	0	0	0	32	0	49	1.74	0.93	79.23
ROW	13	0	0	0	0	0	0	0	0	0	0	0	32	0	49	1.74	0.93	79.23
ROW	14	0	0	0	0	0	0	0	0	0	0	0	6	14	49	1.77	1.01	87.24
ROW	15	0	0	0	0	0	0	0	0	0	0	0	0	17	48	1.77	1.01	86.01
ROW	16	0	0	0	0	0	0	0	0	0	0	0	0	17	48	1.77	1.01	86.01
ROW	17	0	0	0	0	0	0	0	0	0	0	0	0	17	48	1.77	1.01	86.01
ROW	18	0	0	0	0	0	0	0	0	0	0	0	0	17	48	1.77	1.01	86.01
ROW	19	0	0	0	0	0	0	0	0	0	0	0	0	1	3	1.77	1.01	5.06
ROW	20	0	0	0	0	0	0	0	18	0	0	0	0	0	49	2.20	1.22	131.89
ROW	21	0	0	0	0	0	0	0	10	9	0	0	0	0	48	2.20	1.42	150.80
ROW	22	0	0	0	0	0	0	0	0	7	0	0	0	0	16	1.44	1.42	33.35

F.5.2 ROW ALLOCATION FOR AREA B

Area B		C1	C2	C3	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	LENGTH (m)	HEIGHT (m)	DEPTH (m)	VOLUME
ROW	1	43	9	0	0	0	0	0	0	0	0	0	0	0	50	1.87	0.46	42.94
ROW	2	0	52	0	0	0	0	0	0	0	0	0	0	0	50	1.75	0.46	40.19
ROW	3	0	52	0	0	0	0	0	0	0	0	0	0	0	50	1.75	0.46	40.19
ROW	4	0	40	12	0	0	0	0	0	0	0	0	0	0	49	1.75	0.46	39.61
ROW	5	0	0	55	0	0	0	0	0	0	0	0	0	0	50	1.68	0.46	38.25
ROW	6	0	0	55	0	0	0	0	0	0	0	0	0	0	50	1.68	0.46	38.25
ROW	7	0	0	55	0	0	0	0	0	0	0	0	0	0	50	1.68	0.46	38.25
ROW	8	0	0	9	101	0	0	0	0	0	0	2	0	0	49	1.68	0.46	38.18
ROW	9	0	0	0	0	0	0	0	0	0	0	43	0	0	41	1.26	0.46	23.93
ROW	10	0	0	0	0	88	13	0	0	0	0	0	0	0	48	1.62	1.00	77.14
ROW	11	0	0	0	0	0	19	0	0	0	0	0	0	0	49	1.62	1.00	79.41
ROW	12	0	0	0	0	0	0	19	0	0	0	0	0	0	49	1.62	1.00	79.41
ROW	13	0	0	0	0	0	0	5	0	0	4	0	17	0	49	1.94	1.00	94.11
ROW	14	0	0	0	0	0	0	0	0	0	0	0	32	0	49	1.74	0.93	79.23
ROW	15	0	0	0	0	0	0	0	0	0	0	0	32	0	49	1.74	0.93	79.23
ROW	16	0	0	0	0	0	0	0	0	0	0	0	4	15	49	1.77	1.01	86.83
ROW	17	0	0	0	0	0	0	0	0	0	0	0	0	17	48	1.77	1.01	86.01
ROW	18	0	0	0	0	0	0	0	0	0	0	0	0	17	48	1.77	1.01	86.01
ROW	19	0	0	0	0	0	0	0	5	0	0	0	0	0	14	2.20	1.22	36.64

F.5.3 ROW ALLOCATION FOR AREA C

Area C		C1	C2	C3	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	LENGTH (m)	HEIGHT (m)	DEPTH (m)	VOLUME
ROW	1	52	0	0	0	0	0	0	0	0	0	0	0	0	50	1.87	0.46	42.94
ROW	2	12	40	0	0	0	0	0	0	0	0	0	0	0	50	1.87	0.46	42.94
ROW	3	0	52	0	0	0	0	0	0	0	0	0	0	0	50	1.75	0.46	40.19
ROW	4	0	52	0	0	0	0	0	0	0	0	0	0	0	49	1.75	0.46	39.56
ROW	5	0	9	45	0	0	0	0	0	0	0	0	0	0	50	1.68	0.46	38.25
ROW	6	0	0	55	0	0	0	0	0	0	0	0	0	0	50	1.68	0.46	38.25
ROW	7	0	0	55	0	0	0	0	0	0	0	0	0	0	50	1.68	0.46	38.25
ROW	8	0	0	55	0	0	0	0	0	0	0	0	0	0	50	1.68	0.46	38.25
ROW	9	0	0	55	0	0	0	0	0	0	0	0	0	0	50	1.68	0.46	38.25
ROW	10	0	0	55	0	0	0	0	0	0	0	0	0	0	50	1.68	0.46	38.25
ROW	11	0	0	55	0	0	0	0	0	0	0	0	0	0	50	1.68	0.46	38.25
ROW	12	0	0	55	0	0	0	0	0	0	0	0	0	0	50	1.68	0.46	38.25
ROW	13	0	0	55	0	0	0	0	0	0	0	0	0	0	50	1.68	0.46	38.25
ROW	14	0	0	43	28	0	0	0	0	0	0	0	0	0	50	1.68	0.46	38.35
ROW	15	0	0	0	128	0	0	0	0	0	0	0	0	0	50	0.00	0.46	0.00
ROW	16	0	0	0	66	0	0	0	0	0	0	25	0	0	50	1.26	0.46	28.83
ROW	17	0	0	0	0	0	0	0	0	0	0	52	0	0	50	1.26	0.46	28.93
ROW	18	0	0	0	0	0	0	0	0	0	0	52	0	0	50	1.26	0.46	28.93
ROW	19	0	0	0	0	0	0	0	0	0	0	52	0	0	50	1.26	0.46	28.93
ROW	20	0	0	0	0	0	0	0	0	0	0	52	0	0	50	1.26	0.46	28.93
ROW	21	0	0	0	0	0	0	0	0	0	0	30	0	0	29	1.26	0.46	16.69
ROW	22	0	0	0	0	216	5	0	0	0	0	0	0	0	47	1.62	1.00	76.89
ROW	23	0	0	0	0	0	19	0	0	0	0	0	0	0	49	1.62	1.00	79.41
ROW	24	0	0	0	0	0	19	0	0	0	0	0	0	0	49	1.62	1.00	79.41
ROW	25	0	0	0	0	0	7	12	0	0	0	0	0	0	49	1.62	1.00	79.41
ROW	26	0	0	0	0	0	0	19	0	0	0	0	0	0	49	1.62	1.00	79.41
ROW	27	0	0	0	0	0	0	5	0	0	0	0	24	0	50	1.74	1.00	86.34
ROW	28	0	0	0	0	0	0	0	0	0	0	0	32	0	49	1.74	0.93	79.23
ROW	29	0	0	0	0	0	0	0	0	0	0	0	5	14	47	1.77	1.01	84.50
ROW	30	0	0	0	0	0	0	0	0	0	0	0	0	3	8	1.77	1.01	15.18

F.5.4 ROW ALLOCATION AREA D

Area D		**C1**	**C2**	**C3**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**	**C11**	**C12**	**C13**	**C14**	**LENGTH (m)**	**HEIGHT (m)**	**DEPTH (m)**	**VOLUME**
ROW	1	1	2	45	16	0	0	0	0	0	0	0	0	0	50	1.87	0.46	42.68
ROW	2	0	0	0	96	0	0	0	0	0	0	1	0	0	38	1.26	0.46	22.26
ROW	3	0	0	0	0	78	0	0	0	0	0	0	0	0	12	1.62	1.00	20.22

F.6 RESULTS FROM THE ROW ALGORITHM

The following tables indicate the amount of area and volume taken up if the rows are sorted into 1, 2 or 3 columns. Now the three column types can be compared against each other, and the one that will result in the minimum space used will be selected.

Area A			
Columns	**1**	**2**	**3**
Actual Rows	22.00	0.00	0.00
Grouped Rows	11.00	6.00	3.00
Total Aisles	10.00	5.00	3.00
Required Aisle Spacing between Rows (m)	1.00	1.00	1.00
Required Aisle Spacing between Columns (m)	0.00	1.00	1.00
Total Length (m)	50.00	101.00	152.00
Total Width (incl. Aisles) (m)	30.21	11.11	7.43
Total Height (m)	2.50	2.50	2.50
TOTAL AREA (m2)	1510.50	1122.11	1129.36
TOTAL VOLUME	3776.25	2805.28	2823.40

Area B			
Columns	**1**	**2**	**3**
Actual Rows	19.00	0.00	0.00
Grouped Rows	10.00	5.00	3.00
Total Aisles	9.00	4.00	3.00
Required Aisle Spacing between Rows (m)	1.00	1.00	1.00
Required Aisle Spacing between Columns (m)	0.00	1.00	1.00
Total Length (m)	50.00	101.00	152.00
Total Width (incl. Aisles) (m)	23.25	8.15	6.69
Total Height (m)	2.50	2.50	2.50
TOTAL AREA (m2)	1162.50	823.15	1016.88
TOTAL VOLUME	2906.25	2057.88	2542.20

Area C			
Columns	**1**	**2**	**3**
Actual Rows	30.00	0.00	0.00
Grouped Rows	15.00	8.00	4.00
Total Aisles	14.00	7.00	4.00
Required Aisle Spacing between Rows (m)	1.00	1.00	1.00
Required Aisle Spacing between Columns (m)	0.00	1.00	1.00
Total Length (m)	50.00	101.00	152.00
Total Width (incl. Aisles) (m)	32.61	10.30	6.38
Total Height (m)	2.50	2.50	2.50
TOTAL AREA (m2)	1630.50	1040.30	969.76
TOTAL VOLUME	4076.25	2600.75	2424.40

Area D			
Columns	1	2	3
Actual Rows	3.00	0.00	0.00
Grouped Rows	2.00	1.00	1.00
Total Aisles	1.00	0.00	0.00
Required Aisle Spacing between Rows (m)	1.00	1.00	1.00
Required Aisle Spacing between Columns (m)	0.00	1.00	1.00
Total Length (m)	50.00	101.00	152.00
Total Width (incl. Aisles) (m)	2.92	1.00	1.00
Total Height (m)	2.50	2.50	2.50
TOTAL AREA (m2)	146.00	101.00	152.00
TOTAL VOLUME	365.00	252.50	380.00

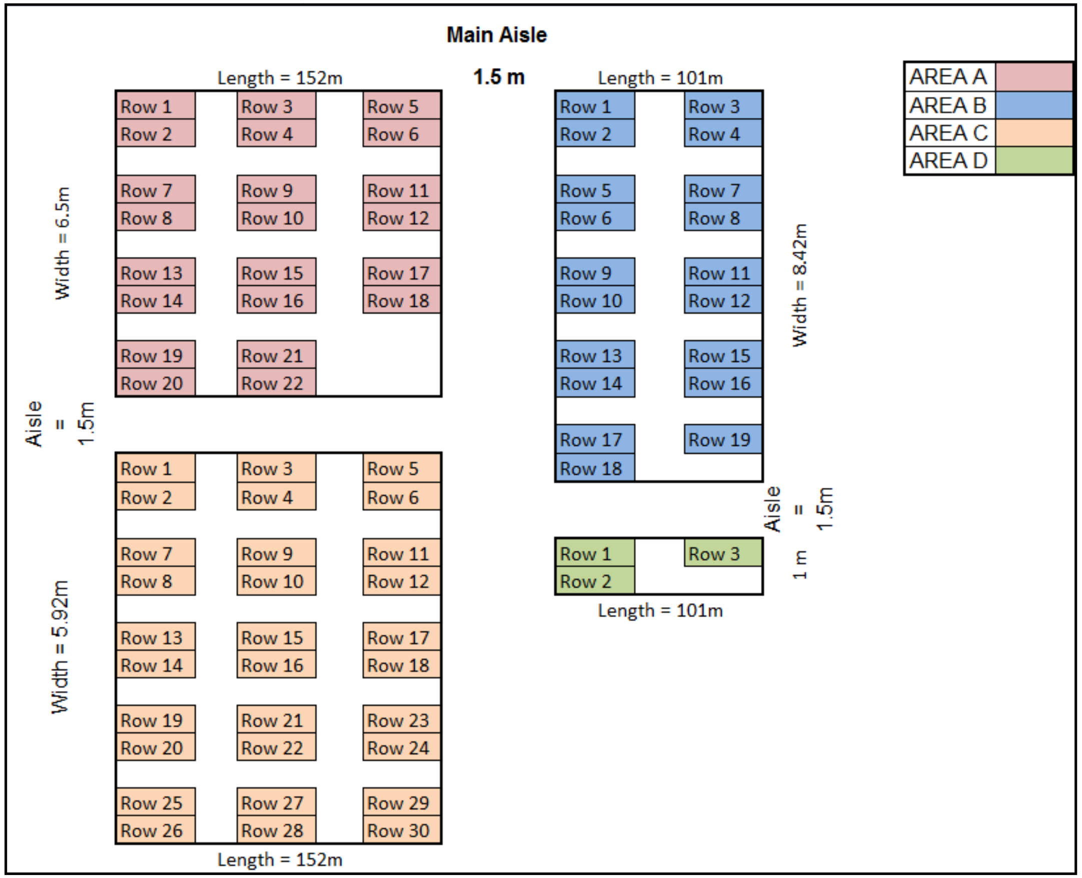
	1 Column	**2 Columns**	**3 Columns**
Total Volume Area A	3776.25	2805.28	2823.40
Total Volume Area B	2906.25	2057.88	2542.20
Total Volume Area C	4076.25	2600.75	2424.40
Total Volume Area D	365.00	252.50	380.00

Area A	2 Columns	2805.28
Area B	2 Columns	2057.88
Area C	3 Columns	2424.40
Area D	2 Columns	252.50
TOTAL VOLUME FOR BINNING		7540.05

	1 Column	2 Columns	3 Columns
Total Area Area A	1510.50	1122.11	1129.36
Total Area Area B	1162.50	823.15	1016.88
Total Area Area C	1630.50	1040.30	969.76
Total Area Area D	146.00	101.00	152.00

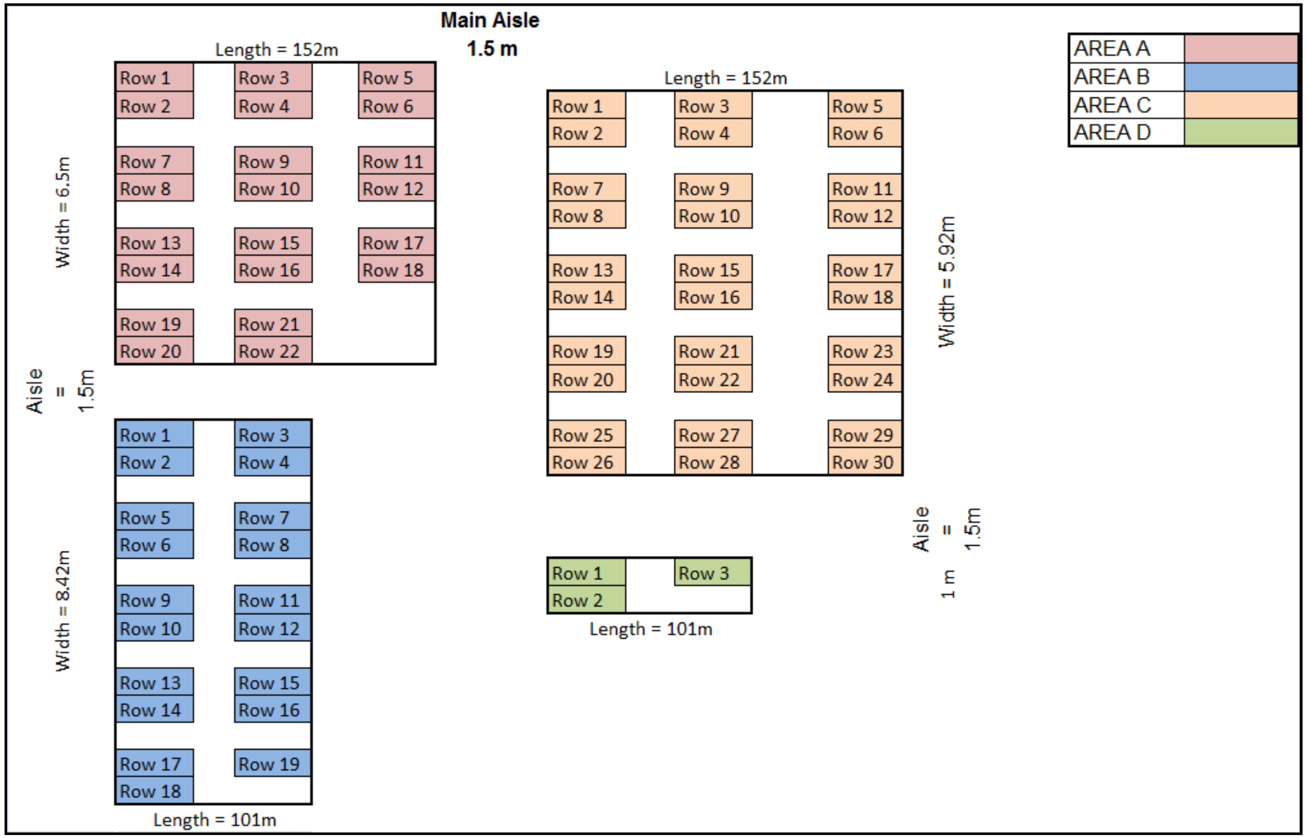
Area A	2 Columns	1122.11
Area B	2 Columns	823.15
Area C	3 Columns	969.76
Area D	2 Columns	101.00
TOTAL AREA FOR BINNING		3016.02

F.7 LAYOUT ALTERNATIVE 1



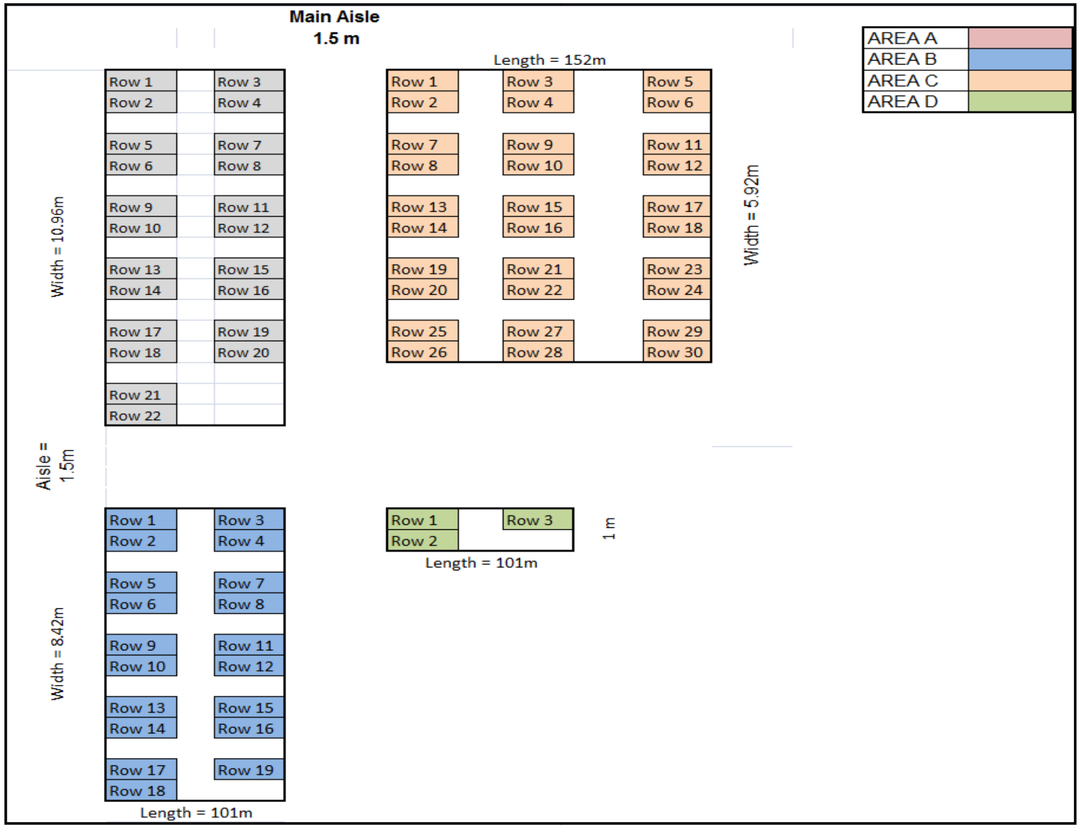
Total Area for Layout Alternative 1 = Length x Width	Total Volume for Layout Alternative 1 = Area x Height
= 254.4m x 13.92m	= 3541.26 x 2.5m
= 3541.26m^2	= 8853.12m^3

F.8 LAYOUT ALTERNATIVE 2



Total Area for Layout Alternative 2 = Length x Width = 305.5 x 16.42m = 5016.31m^2	Total Volume for Layout Alternative 2 = Area x Height = 5016.31 x 2.5m = 12540.78m^3

F.9 LAYOUT ALTERNATIVE 3



Total Area for Layout Alternative 2 = Length x Width = 254.5 x 20.58m = 5237.61m^2	Total Volume for Layout Alternative 2 = Area x Height = 5237.61 x 2.5m = 13094.025m^3