THE DESIGN PRINCIPLES AND SUCCESS FACTORS FOR THE OPERATION OF CROSS DOCK FACILITIES IN GROCERY AND RETAIL SUPPLY CHAINS

by

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Declaration

I, the undersigned, hereby declare that the work contained in this dissertation is my own original work and that I have not previously in its entirety or in part submitted it at any university for a degree.

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SUMMARY

The dissertation reflects the research done on the design principles and success factors for the operation of cross dock facilities in grocery and retail supply chains.

The cross dock is a particular facility in the supply chain where goods are received from suppliers, sorted without storage of the goods, and then efficiently moved to downstream customers.

Cross docks are not a new operation. However, the use in high volume grocery and retail operational capabilities is poorly understood and is not uniquely defined. The problem is that cross docks are often seen as extensions of warehouses. The same personnel, systems and processes are applied and the efficiency potential of the cross dock is not achieved.

Warehouses are orientated towards storing the full range of product and allowing the pick to be done from this storage buffer to provide any or all of these products to a customer. Cross docks will only handle products that are used in larger quantities and that are sent to most, if not all, the customers. The cross dock is therefore distinct and very different from the traditional warehouse.

The published research tends to focus on the technical aspects of the cross dock layout. This research is primarily in the scheduling of the trucks into the yard of the facility; the allocation of trucks to specific doors of the facility; and the allocation of doors to receiving and despatch functions within the facility. Very little information or research reflects the design principles and success factors for the cross dock and its supply chain. The only classification of the cross dock in the literature is whether the barcode is added to the item before or after receipt at the cross dock.

For this research work a literature survey was conducted and five major operations were reviewed, in South Africa and the USA. The research empirically drew logical conclusions, which were tested in the operations and found to be correct. This allowed the design principles and success factors to be determined for a successful cross dock.

The research extends the knowledge of the cross dock operation and design: -

- A new classification for the feasible types of cross docks in the supply chain was developed. Three factors are shown to be of primary importance: -
  - Where in the supply chain the identification of specific items for a customer is done;
  - Where the sort is done for the items to be delivered to a customer; and
  - Whether the supplier is providing one product or multiple products to the sort.

  From these three factors, eight potential classifications could be defined. However, only three practical types of cross dock can be determined from these eight alternatives. These are named in this research as Cross Dock Managed Load (CML); Joint Managed Load (JML); and the Supplier Managed Load (SML).

- The cross dock is far more effective than the warehouse when the total work (excluding inventory) is considered. The earlier in the supply chain the product is identified for the use of the entire downstream supply chain, the more effective will be the total supply chain. Thus the greatest supply chain effectiveness possible is with the SML, then the JML and finally the CML.

- The operation of a cross dock is very similar to a continuous manufacturing process. There is no buffer of stock to decouple the inbound and outbound processes, and the operation takes place in a restricted area. However, in the retail chain, the workload alters with different orders and different days. Daily load differences vary by as much as 90%. This results in vastly different workloads and variations of throughput. This is similar to a batch operation with highly variable workloads between batches. The literature recommends the use of Just in Time (JIT) practice for cross docks. This is inappropriate as its primary requirements are continuous full volume operation and continuous small improvements to achieve a balanced operation. The most appropriate method of process improvement is the Theory of Constraints (TOC) and not JIT.

- The management must have a detailed, disciplined approach. This implies standardised methods of operation, and a high degree of training. Equally there is the requirement for a special type of personnel to operate the cross dock. These operating personnel must be able to operate with precision (i.e. very low error rates) and be able to maintain this capability for continuous periods.

- The systems required for a successful operation must include the capabilities of Yard Management, WMS for cross docking, Order Management with Advanced Shipping Notice (ASN) capability and Track and Trace across the supply chain. The items need to be identified by a barcode. The information required on the barcode will be determined by the information systems capability of the least advanced service provider in the supply chain. If this service provider can receive and transmit all the data required for the supply chain from and to the other members, then the barcode need only be an identification number of the specific item. The data pertaining to the items is then passed from system to system in the supply chain. If data movement is not possible between all the parties in the entire supply chain, then the barcode must contain the information that will identify the item, the origin and the final delivery destination. If the items are delivered as part of a consignment, a further quantum of information is required to identify the total number of items in the consignment and the specific item within the consignment.

- The research shows that the overall capability of the cross dock or its maximum capacity is the combination of the capability of the personnel and the cross dock design. Restrictions on either the personnel capability or the design of the cross dock, or both, severely reduces the effectiveness of the cross dock.

- The previous research on the sequence of allocation of trucks to specific doors within the cross dock can be enhanced with a new sequencing method. The new method allocates the transport, in sequence of arrival, to the open door that either minimises the walk distance in the facility; or maximises the completion of the consignments in order to minimise the area required to build the consignments; or a combination of both. The choice of these will be determined by the constraints imposed by the design of the building. This is an important extension as this ties the supply chain into the cross dock operation, rather than looking at the cross dock in isolation as has been done in this previous research.

- The factors that influence the design of a cross dock as to its size, shape, number of doors, and the specifically required additional areas, is defined in detail. The principles of these factors and their inter-relationships and dependencies are used in a detailed design for a cross dock. The detailed design process is set out from data analysis through to the actual size calculations and layouts. Measurements of walk distance and sort movement are used to determine the most effective design. The design is shown to be considerably more effective than the older designs.

This work has significantly extended the research on the design principles and success factors for implementation of cross docks in retail supply chains. The research derives a unique new classification for cross docks. An improvement is made to existing research on the allocation of the transport to particular doors in the cross dock. The operation, management and personnel are shown to require specific characteristics. The information systems required for effective cross docks is determined and defined. The identification of the individual items by barcode and the information required within the barcode depending on the information sophistication of the service providers in the supply chain is defined. A detail process to design a cross dock is evolved, with the full knowledge of the factors that must be considered and their inter-relationships. Measurements to determine the effectiveness of the design are used to choose the most appropriate design. All these are then synthesised into a new design, which is far more effective than any of the other designs researched. The design process will produce a very effective cross dock as has been demonstrated with a new facility.

DISSERTATION TITLE

The design principles and success factors for the operation of cross dock facilities in grocery and retail supply chains.

CHAPTER 1
INTRODUCTION TO THE RESEARCH

1.1 Cross dock description

A cross dock facility is a facility within a supply chain, which receives goods from suppliers and then sorts these goods into alternative groupings or consolidation points based on the downstream customer or delivery point. No reserve or long term storage of the goods occurs, and staging occurs only for the short periods required to assemble a consolidated, economical load for immediate onward carriage. The inbound transport may be different from the outbound transport in size, mode or type.

The cross dock offers the supply chain an efficient and cost effective means to distribute goods into a local area, without storage costs or inventory costs. The method is particularly valuable for the continual replenishment of lines, and for time sensitive products such as perishable foods.

1.2 Research and methodology

1.2.1 Need for the research

The facility seems to rarely offer the benefits that are theoretically possible when applied in South Africa and, from the literature, even in the USA and Europe there are companies that have struggled to implement cross docks. KLM tried to use their cargo facilities at airports as cross docks. This was not a success. A number of South African companies utilise cross docks, but the majority are struggling to achieve efficient operation and work long periods to perform the required work.

The grocery and retail supply chain incorporating a cross dock is a complex issue for both the operation as well as the design of the supply chain and the facility. There is a need for a clear understanding of the success factors for the effective operation of the cross dock coupled with the design principles for such a cross dock facility and how it integrates into the supply chain. These two aspects of operation and the design of a cross dock in a supply chain are extensive areas for research, but need to be done in conjunction with one another to present a supply chain perspective.

1.2.2 Research methodology

The research was done in three major phases. The first was a review of the existing information from published sources. The second was the review of existing operations and facilities to glean the information pertinent to the design and the success factors for the implementation of these cross docks. The final phase built on this knowledge and extended the research. The factors influencing the operation of a cross dock were researched. The requirements for effective and successful operation are clearly identified in this research. The design principles to design the cross dock facility as an integral part of the supply chain are identified. A detailed design process with the inter-relationships between factors is developed. This design process is then applied to the design of a new facility. Measurements are introduced to determine the optimum layout. This design has been built and is very effective. Where feasible and practical these principles of operation and design, obtained from the research, were applied and tested in the operations under review. These proved to be practical and of value.

1.2.3 Overview of the research

A review of the published literature on cross docks is presented in Chapter 2. The information is summarised in broad headings as used in the research for this dissertation. This provides part of the base on which this research is built. It shows the paucity of work done in this technique from the aspect of a cross dock in the supply chain.

Chapters 3 to 6 reflect the research of the operations of four South African companies that are utilising cross docks in the supply chain. Chapter 7 reflects the operation of two USA companies using cross docks. The work done in the one USA company was very detailed and done as a consultant. The recommendations made during the consultancy work were adopted and have proven to be of value to the operation. Two other operations implemented improvements recommended from this research, and these also proved extremely beneficial.

The expansion of the research knowledge into the grocery and retail supply chain with a cross dock is contained in Chapters 8 to 14. Chapter 8 is an investigation into the types of cross dock. It takes a supply chain view of the critical factors that characterise the cross dock in the supply chain. This leads to the new classification of cross docks in the supply chain. The work measures the relative effectiveness of the three types of cross dock and the warehouse processes.

Chapter 9 looks at the operation of the supply chain and the cross dock. The operation is characterised as equivalent to a continuous process. It reviews the technique that is most appropriate to utilise in analysing the operation. This is the Theory of Constraints (TOC), rather than Just in Time (JIT) as is suggested in the literature. The complexity of handling consignments in the cross dock operation and problems of operator errors are explored.

Chapter 10 looks in brief at the relative value of manual or automated material handling in the cross dock. The decision factors and the process to choose between an automatic or manual process are identified.

Chapter 11 looks at the requirements for systems for a successful cross dock, and the specific types of systems that are required. The information that must be moved along the supply chain is identified and explained. The method of moving the information is set out.

Chapter 12 investigates the personnel and management that are required for the successful cross dock. This includes time constraints that are inherent in the cross dock and the problem of errors and the causes of these errors.

The development of the criteria for the design of the cross dock is produced in Chapter 13. This looks at the supply chain with a cross dock present and then derives the critical factors that make the cross dock and supply chain effective. A detailed design process, from data analysis to the final, practical design, is evolved based on the research.

Chapter 14 develops a design for an actual facility using this process and these principles. The measurements to minimise the distance travelled and the work done were introduced so the most effective design and layout can be determined. This facility has been built and commissioned and has proven to be very effective.

Chapter 15 draws final conclusions. It records the significant improvement this research has introduced in the understanding and definition of the success factors for a supply chain containing a cross dock, as well as the design process for an effective cross dock facility.

1.3 Grocery and retail supply chains containing a cross dock

1.3.1 Benefits

The correctly designed and operated cross dock offers significant advantages in the grocery and retail supply chains. The high value of inventory in the supply chain is substantially reduced. The operation is more effective than that of the warehouse, as fewer activities take place in the facility and the total supply chain. Full loads can be accommodated for the onward carriage of the goods. Fewer staff and the smaller size of the facility reduce the operating costs.

The supply chain with a cross dock is of value for high volume goods or where the goods are of high value and inventory costs represent a high proportion of the supply chain costs. The cross dock can produce an effective, consistent delivery which will reduce supply chain costs, improve customer satisfaction, and enhance the marketing advantage, with its attendant increase in loyalty and potential sales.

1.3.2 Complexity

One form of cross dock is in the courier business where the parcels are brought into the facility and sorted, usually automatically, and then placed into small vehicles for delivery. This is a 'closed' system where the courier company directly controls the entire chain, including inbound and outbound transport and timing. The operation is a simple sort of identified small items.

In the grocery and retail supply chains the system is far more complex. The entire chain is not under the control of one company and this is an 'open' system. The cross dock does not control the orders nor the suppliers that provide these products. The retail supply chain is characterised by multiple suppliers that deliver goods to a facility. The number and range can vary significantly. The complexity of the work to be done can vary considerably from order to order.

1.3.3 Problems

There are a number of areas where problems with the implementation, operation and the design of cross docks impact on the viability of the supply chain.

1.3.3.1 Limited specific information on the operation or design of the cross dock facility

There are no simple and clear references that set out the design process and practice or provide the principles for the effective operation of a South African supply chain incorporating a cross-dock facility. In two of the more widely used logistics text books – Fundamentals of Logistics Management by Lambert, Stock and Ellram [5] and Logistical Management by Bowersox and Closs [6], the only reference is in a note that the company Sears uses "cross docking centres (CDCs) to remote areas".

1.3.3.2 Confusion between warehouses and cross docks

The cross dock operation is not a new concept. Its use in the high volume, time critical, grocery and retail supply chain today is often problematic. The requirements for the successful operation in the supply chain and the efficient or effective design of the facility are not clearly and generally understood. In the retail and grocery chains, the cross dock is often an addition, for time critical goods, to a warehouse. The principles of operation, the systems and the design practice for the warehouse are applied to the cross dock. This has a major negative impact on the capability and effectiveness of the cross dock.

The warehouse is a storage facility. Its inbound and outbound processes are decoupled by the storage. It deals with a vast range of products whether they have low, medium or high volume throughputs. The warehouse receives orders and the products are picked from the goods in storage. The picked goods are then assembled by order for delivery.

Cross docks are not operated in this manner. It has no storage, so the flow of goods into the sort cannot exceed the rate the goods are sorted and assembled for onward carriage. It deals with high volumes of goods or very high value goods. The systems must have the ability to monitor the goods inbound, through the facility and outbound. To achieve the fastest throughput, there must always be inbound transport ready to offload to ensure the sort operates at its maximum capability. The orders are placed on suppliers by other parties in the supply chain, not the cross docks.

A cross dock is distinct and very different from the warehouse operation and design. It is very obvious that the extension of the warehouse concept to a cross dock operation and / or its design is not sensible.

1.3.3.3 Poor operating capabilities

Poorly understood or poorly implemented operating techniques result in the limited use and success of the cross dock. Poor operation may be due to an incomplete understanding of the process, the disciplines required to implement the process, or the co-ordination and controls necessary for the supply chain to operate successfully. This is true in a number of the industry applications reviewed.

Goods must flow through the cross dock facility in a continuous process, as there is no storage available. Enhanced skills in a continuous process operation are required for the operation to be successful. Special systems, not necessarily required in the warehouse, are required for the correct operation of the cross dock.

The supply chain must be co-ordinated to achieve effective operation in the cross dock, as the cross dock facility has a finite capability and capacity. Excess orders in one period will delay deliveries for that, as well as successive periods, until the backlog is eliminated.

1.3.3.4 Poor design of the cross dock facility

In the grocery and retail supply chain the cross dock facility is often incorporated into a warehouse. The design is then based entirely on warehouse principles, including in some cases high roofs for storage not used by the cross dock. The design layout is also done in terms of warehouse concepts. The doors are along one wall generally, and the shape of the facility tends to be approaching a square. These are often not ideal for the most effective cross dock operation.

Fresh foods in the grocery industry are generally handled at 5°C through a cross dock operation. The temperature of chilled products is maintained at 5°C and these products are warehoused. These two facilities have a common temperature zone and are commonly situated adjacent to one another or are totally integrated. The two operations – a warehouse and a cross dock – are very different and often impact negatively on one another.

The design of the facility must incorporate the cross dock into the supply chain so that the facility as well as the supply chain are effective. This design for the supply chain and the facility to suit the cross dock operation is rarely done in South Africa. With the high volume facilities in the USA this is done, but the supply chain aspects are not commonly addressed.

The poor design of the cross dock facility reduces the capacity of the facility and its effectiveness. A poorly operated or designed cross dock directly impacts on the effectiveness of the supply chain, as well as its capacity.

1.4 Origins and development of the cross dock

1.4.1 Origin

The most probable origin of the term cross dock comes from the American railroad usage. Two freight trains parked on either side of a dock at a station could be unloaded and goods moved across the dock. The sort would occur from the one train to the other. The concept may equally be from the shipping era, where the port dock was used for the same purpose.

1.4.2 Development

The cross dock capability developed initially as a means to take goods from one transport party and to sort and assemble these goods into the required groupings for other transport parties to distribute the goods further. For example, this would in simple terms be the transport depot, where a larger truck delivers goods to a central depot and the goods are then sorted and assembled for smaller trucks to deliver locally. This would also be applicable to the collection of goods from many sources to a local depot, where the goods will be assembled into larger loads for movement via larger, more economical transport to further destinations.

The advent of rail and shipping increased the size of the delivered load. The depot on the wharf became the port terminal where the mode changed from sea to land, and the onus was to take goods from the ship and then to distribute these goods utilising both long distance and short distance transport.

The advent of information systems and scanning technology, in the last 15 years or so, has made the monitoring of high volumes of items feasible and promoted the cross dock, which is dependent on this capability. In South Africa the de-regulation of the transport industry allowed the cross dock to become an effective and economical supply chain method of moving goods.

The process has been enhanced in the last decade or so to include the distribution of goods received from suppliers to the retail outlets. The use of the cross dock in this process is ideal for high volume products, short life cycle products and for reduced inventory for high value products. The cross dock service in the grocery and retail supply chains has altered from the initial change of mode focus, to include the aspects of marketing and effectiveness by providing these high volume products more efficiently and high value products with reduced inventory costs.

1.5 Definitions of a cross dock

The range of definitions of the process of cross docking is indicative of both the origin of the capability as well as the growth of the capability in different industries. A representative definition for the transport industry and the transhipment capabilities are given from recognised sources. A definition for the retail industry shows the more complex nature of the capability as it stands today.

The transport aspect can be seen in this definition from the European Logistics Association: Terminology in Logistics [1] –

" freight unloaded from one truck, moved across a loading platform, and loaded into another truck".

An example of a definition reflecting the transhipment and sortation would be that of the Institute of Logistics and Transport: Warehousing and Materials Handling Special Interest Group [2]:

"An operational technique for receiving, allocating, sorting and dispatching product, whilst it remains on the dock of a Distribution Centre, and therefore does not rely upon withdrawing stock from storage".

A slightly more complex definition which reflects the nature of the retail industry more precisely is as follows [3]:

"A cross-dock facility is a part of a warehouse or an independent facility where goods are received, allocated, sorted, assembled and then distributed from the facility without the use of long-term storage (inventory) of the goods"

One of the more comprehensive and modern definitions is [4] " as a process where product is received in a facility, occasionally married with other products going to the same destination, without going into long term storage. It requires advance knowledge of the inbound product, its destination, and a system for routing the product to the proper outbound vehicle." This definition is from the WERC manual on cross docking. It suffers from a number of problems, as in the majority of cases there is no real knowledge of the inbound products. This part of the definition is not a pre-requisite for a facility to be a cross dock. It does, however, supply one of the characteristics of the various forms of the cross dock facility. Obviously, the more information pertaining to the products that are inbound, the better the potential for effective operation.

Further definitions which emphasise the above comments, are contained in the review of literature in Chapter 2.

The definition evolved for this research is as follows:

A cross dock facility is a facility in a supply chain, which receives goods from suppliers and then sorts these goods into alternative groupings based on the downstream delivery point. No reserve storage of the goods occurs, and staging occurs only for the short periods required to assemble a consolidated, economical load for immediate onward carriage via the same mode as the receipt or a different mode.

1.6 Terms used in the dissertation

ASN
The Advanced Shipping Notice is a notification from the supplier to the warehouse of the precise goods that will be delivered and the means of transport that will be used.

Case
This is the generic name for a packaged product, as it is supplied by a manufacturer. For example, there are six cans of cold drink in a plastic shrink wrap, four of these wraps are placed in a cardboard tray and covered with a wrapper. This tray is termed the case for the cold drinks.

Cold box
This is an insulated container of the same base dimensions as a pallet and approximately 2 m high. Dry Ice can be added into these Cold Boxes to maintain the temperature at -25°C.

Consignment
A term used to specify that two or more items must be delivered together as a combined unit or consignment to a customer.

Consolidation unit
A consolidated load can be created using a number of means. The most common is the pallet, but equally rolltainers and cages allow the consolidation of a load into a simple item.

Cross dock
A cross-dock facility is a facility where no reserve storage of the goods occurs, and staging only occurs for the short periods required to assemble loads. The process is the receipt of the goods from one mode and then the sort of these goods into alternative groupings to make economically sized loads for immediate distribution via a different mode or the same mode.

DC
A Distribution Centre is a warehouse where reserve stocks are maintained and is focussed on being able to supply the items necessary to fulfil the items on the orders of the stores or customers it supplies. The reserve stock is obtained from manufacturing warehouses, where the aim is to store larger runs of product and to distribute these in bulk.

Drop shipments
A term used to describe the delivery by a supplier to multiple customers on a route, where the goods are not delivered from a DC to the customers.

EDI
The acronym is for Electronic Data Interchange. This is used generically as a description where data from one system are electronically sent to one or more receiving systems and is utilised by the receiving system.

IS
An acronym for Information Systems. This is used to generically reference any system, usually a computerised one, which takes data and processes it into information. In the context of the research this would include a computer system that facilitated the management of a warehouse or a cross dock facility, or a system that managed the track and trace of goods.

LTL
Less than Truckload is a term used to describe a transport which is not loaded to the maximum capacity.

Lugs
A standard size of plastic (generally) crate which is durable, washable and reusable. (e.g. a base of 600 mm by 400 mm and 340 mm high. The lug area is suitable to fit exactly five on the base of a pallet)

OMS
The Order Management System is a system or part of a system that will place an order on a supplier, allow the supplier to confirm what quantities it will supply, which may be slightly different from the originally requested quantity, and then to confirm the supplier committed quantities to the supplier as a fixed order. Once shipped the supplier advises the supply chain via an ASN of these pre-committed quantities.

Pick
Items ordered need to be picked from the stock in a warehouse. The picker moves through the aisles of the warehouse and picks the correct stock item and quantity. The motion of the picker is used to describe different types of pick sequence. As a picker moves down an aisle, the pick may be done down one side of the aisle and then returns on the other side of the aisle which is called the U pick. Alternatively the pick can be done from either side of the aisle which is called the S pick.

POD
A signed document, which confirms receipt of the delivery or Proof of Delivery.

Rolltainer
This is a consolidation unit that is comprised of a cage on wheels. The cage has a door that can be closed once the loading is complete and sealed.

RF
This is an acronym for Radio Frequency. This is used to describe a system that uses radio frequency to communicate from one device to another. One of the devices is usually a computer system which interfaces to a system WMS or similar system. This includes in the cross dock environment a scanner to read barcodes as a simple one way transmission device to feed information to the WMS. There are also two way communication devices with screens to display information and instructions from the WMS system and capable of having the information captured by keyboard or by a scanner and fed back to the WMS.

RFP
A Request for a Proposal is a formal document which outlines the needs of a client and to which a number of prospective suppliers of services will respond. While it is similar to a tender, the formal nature of the tender process is not adhered to and negotiation and alteration of the terms and conditions are accepted to enable both parties to benefit from the negotiations via clarity of the scope, actions and charges for the services agreed.

SKU
A Stock Keeping Unit is a specific quantity of product which is recognised in the Warehouse Management System as the smallest quantity that can be ordered. This may be one cake of soap, or a pack of six or a box of twelve. This is the primary reference quantity on which all the stock for the item will be calculated.

T&T
Track and Trace system records the position of an item or items at designated locations. These locations are often defined by a scan of the barcode on the item.

VAS
Value Added Services are additional functions or processes that are performed on the items such as adding labels, special packaging and even adding promotional items to existing packs. It is usually done manually and requires the items to be staged where the additional work can be performed. This requires personnel and floor area.

WMS
A Warehouse Management System which manages the data necessary for the operation of the warehouse. In particular the system will record receipt of goods, the location where the goods are stored in the facility and controls the picking of products for orders and their dispatch.

YMS
The Yard Management System is a system which records the arrival of transport, the parking space of the transport and the information pertaining to the origin of the load in the transport.

NOTES

1. European Logistics Association: Terminology in Logistics, 1994
2. Institute of Logistics and Transport: Warehousing and Materials Handling Special Interest Group: Developments in Cross-Docking in Retailing
3. Johnson, Michael. 1998: pp1-9
4. Napolitano, M and Gross & Associates Staff. 2000: pp 6
5. Lambert, D.M., Stock, J.R. and Ellram, L.M. 1998.
6. Bowersox, D.J. and Closs, D. J. 1996.

CHAPTER 2
REVIEW OF LITERATURE

2.1 Introduction

A large selection of literature was reviewed on all the aspects of cross docking. Many of the foremost logistics text books [1, 2] do not have anything more than a small or passing reference. This review highlights the areas where publications have contributed to the understanding and research on cross docks. For the most part the detailed research aspect of the development of cross docks has been done in the mathematical modelling of particular aspects of transport at the dock, or queuing theory applicable to the staging of freight in the cross dock. There seems to be a paucity of work done on the design basics, and the principles that need to be decided for the design to be effective. There is a large amount of literature which covers the cross dock and its problems and the perceived value of the cross dock in specific, successful, applications. This chapter presents the review of the literature with only observations on the literature where absolutely necessary to place it in context, so the work done in this research can be viewed against the existing research and knowledge. To a large extent the work in this research in respect of the classification of cross docks in the supply chain, and the principles and practice of the design of cross docks is unique.

2.2 Definitions

In addition to the definitions contained in Chapter 1 which are used to emphasise the disparity of views of what cross docking constitutes, the following are additional definitions from the literature. These reflect the disparity of views of the role and functions of a cross dock as seen in the literature and in the definitions utilised by various authors. Cross docks are therefore defined as: -

An operational technique for receiving, allocating, sorting and dispatching product, whilst it remains on the dock of a Distribution Centre (DC) and therefore does not rely upon withdrawing stock from storage. [3]

Cross docking is a distribution method of structuring the relationship between suppliers and distributors at any given stage in the supply chain [4].

Method of processing merchandise in a distribution centre [5]. The goods are brought from goods receipt directly to goods issue without being put away. Cross docking does not involve shipping units being repacked between being received and issued from the distribution centre.

Cross docking means to take a finished good from the manufacturing plant and deliver it directly to the customer with little or no handling in between. Cross docking reduces handling and storage of inventory, the step of filling a warehouse with inventory before shipping it out is virtually eliminated [6].

A process where product is received in a facility, occasionally married with other products going to the same destination, then shipped at the earliest opportunity, without going into long term storage. It requires advance knowledge of the inbound product, its destination and system for routing the product to the proper outbound vehicle [7].

2.3 Reasons for using or introducing a cross dock operation: - benefits and drawbacks of cross docks

There are various reasons in the literature for the introduction of a cross dock operation. A number of these are recorded here to show what the industry believes constitutes valid reasons for cross docking. Observations to what has appeared in the literature are added only where necessary to add context to the statements. Thus cross docking is valuable, or not, as follows: -

Companies are cross docking to eliminate [8] : -

- Handling;
- Storage costs;
- Shrinkage;
- Damage;
- Product obsolescence; and
- To reduce cycle time.

While this is true, the storage costs and cycle time work hand in hand. Reduced handling results in less damage and shrinkage is a combination of these two factors.

The move to cross dock can show value for the company or companies undertaking the new method. A study [9] shows that the realised value of cross docking in an industry (USA) can be: -

- Requires only 76% of the space of a traditional facility;
- Requires only 57% of the direct labour; and
- Increases of up to 75% in the cases per man hour measurement.

The study merely claims these figures across a number of industries, and this indicates the potential, without really being an exact measure as these are too vague to be definitive. The base to which these numbers refer is also not known.

In certain of the literature the assumption is made that the demand has to be accurately known [10].This is rarely the case and cross docks can operate successfully without the demand being known. This incorrect conclusion is presumably a result of the need to have supply and demand balanced as no storage occurs in the cross dock, only temporary staging.

A text on cross docks presents a large number of benefits and drawbacks [11]. These are so generic as to be of little specific value, other than as a check list when looking at the option of the cross dock and considering all the potential areas on which the cross dock might impact. For this purpose they are extremely valuable. These are:

Benefits : -

- Speeds product flow and increases inventory turns;
- Reduces handling costs at the cross dock operation;
- Allows the efficient consolidation of products;
- Supports customers' JIT strategy;
- Promotes better asset utilisation;
- Reduces space requirements;
- Reduces product damage because of minimal handling at the facility;
- Reduces pilferage and shrinkage because of faster turnaround;
- Reduces product obsolescence and out of date conditions because product does not stay in the warehouse;
- Accelerates payments to supplier, thus fostering better supplier partnerships and
- Decreases paperwork associated with inventory processing.

Drawbacks : -

- Difficult to determine candidate products;
- Requires supply and demand synchronisation that they cannot support;
- Less than perfect relationships; little or no trust in suppliers; reluctance of suppliers;
- Union fears of losing jobs;
- Inadequate facility and not enough of an investment return to justify purchasing a new one or changing an existing one;
- Inadequate information systems support;
- Management does not have an holistic and supply chain orientation;
- Requirement of fast turnaround causes concerns on the inability to check product quality;
- Fear of being out of stock with no back up inventory and
- Less expensive to buy in truckload quantities and warehouse them.

2.4 Prevalence and use of cross docks

The cross dock operation is not as widely utilised in the supply chain as the value ascribed to the method would lead one to believe. While retailers acknowledge the technique increases efficiency, shortens the cycle time and reduces overall operating costs, few retailers have committed to the method [12]. Other studies have shown that the level of cross dock operation is low in many companies. Studies (1998) show that less than 10% of the retailers in the USA use cross docking for more than 15% of case volume, and the majority use it for less than 5% of the case volume handled. Most cross docking operations, particularly in the supermarket industry, are very small in nature and limited to certain product categories [13]. The current estimates (2002) are that around 5% of the SKU's delivered are being cross docked in America.

2.5 Cost savings in cross docks

Normal distribution channels with warehouses have the warehouse performing four functions – receive, storage, pick and shipping [14]. Of these the most costly are the middle two; that is the storage and pick. These can both be eliminated if a cross dock is used.

Some of the literature is so focussed on a particular aspect of the business that the conclusions that can be drawn from the information could be incorrectly interpreted. For example, a text on the management of warehouses records the benefits of cross docking [15]. The first benefit is that it speeds up the receiving process (this information assumes that all items are pre-labelled and pre-sorted before receipt). The second is a reduction of handling within the supply chain and the third is it removes storage and the time taken to move goods into and out of storage. While the second and third benefits are valid, the first benefit is not common in cross docks and the receiving at the cross dock is speeded up at the expense of the delays in the supplier's processes. This does need to be placed in the context of the supply chain, not just the cross dock, but is a valid advantage in this particular example only, and is often not valid..

The cross dock assists in reducing costs, by making transport more efficient in most cases, and significantly reducing inventory [3]. The need for the supply chain to be integrated is alluded to in terms of the suppliers having to be reliable, as the cross dock has no capacity for correction if a supplier fails; the time and space constraints are just too large to allow a supplier to be anything but totally reliable [3]. The reduction in transport costs comes at a penalty, as the items must be delivered to the cross dock operation, whose cycle time is approximately a day. Thus the transport savings, allied with the inventory savings, must exceed the additional cost of the cross dock operation and the extra day in the supply chain. Where frequent drop shipments are utilised by a supplier, this extra day may become significant.

The handling costs in the cross dock are one of the major factors which determines the economical value of the method [16]. Material handling in the cross dock is labour intensive for three reasons: -

- Freight is often oddly shaped, so automation is difficult;
- Automated systems are not as flexible as manual methods, so seasonality is a problem and
- Automation requires a huge fixed cost, and this means the business must be stable and unchanging for many years to derive the return for this investment.

An example of the value of the cross dock is evidenced by Playtex Products. This company introduced a cross dock operation to replace a problem distribution in the South East of the USA [17]. The area was not adequately covered by the existing distribution network. The solution was a cross dock operated by a specialist company with transport undertaken by another company. The facility cross docks 250 to 300 shipments per day. The operation has reduced damages and reduced the total delivery time by about a day (remember that the original was performing poorly as no DC was in the correct area). There have been cost reductions as well. It is acknowledged that successful cross docking requires advanced knowledge of the inbound product and control systems or measures to ensure it is routed to the correct outbound transport.

2.6 Ideal cross dock

Some authors have tried to record their concept of the ideal cross dock or the conditions for the ideal cross dock.

The ideal cross dock operation has the following elements [18]: -

- Suppliers who have the right processes in place so they can consistently provide the correct quantity of the correct product at the precise time when it will be needed;
- Time accurate, preferably paperless information flow among trading partners and a continuous product flow that is matched to actual demand;
- An appropriate network of transportation, facilities, equipment and operations in place to support the flow of the product from the supplier through the cross dock facility to the customer;
- Personnel who recognise the urgency of moving product rather than storing it. They consistently track performance to determine strengths and weaknesses and
- Accurate data and realistic forecasts.

An alternative way to look at the cross dock is examined in an article, which tries to summarise the cross dock and its use in various industries [10]. It points out that "goods in motion equals value". The description of the Flow Through concept is given to encompass both the cross dock and the merge in transit, which are seen as different parts of Flow Through. Thus Flow Through can be seen as:

- Both a concept and technique;
- Works best where demand is known;
- Retail use predominantly, but valuable for manufacturing;
- Must have visibility into supply and delivery chains and
- Warehouses will have different shapes when Flow Through is introduced.

What is necessary for a cross dock is discussed and can be summarised as follows:

- All the supply chain must be in agreement and focussed;
- Vendor must be reliable, accurate and offer high service levels;
- Buying culture changes significantly – not replenishment but real time buying;
- In larger distribution facilities – only a proportion of the goods is cross docked, generally based on the vendor capability and the item predictability;
- Service levels affect the economic practicality of a cross dock. Where infrequent deliveries are received from a vendor, then the vendor is not suited;
- Multiple products on one trailer or multiple loads, increases the requirement for staging, and can reduce the effectiveness of the cross dock and
- Cross docking is more easily achieved by large companies that ship full trailers at the same frequency that receipts are expected in store.

Some of these issues are particular to this article, which looks primarily at the grocery and retail areas.

One author of an article lists the following to be the essential ingredients for a cross dock [8]: -

- Bar codes for identification;
- EDI;
- Computerised WMS;
- Packaging must be floor ready and
- People.

And this article adds that the critical factor is people.

The European view is somewhat different as reflected in the ILT note on cross docking. The pre-requisites or requirements for a cross dock to succeed are as follows [3] : -

- Teamwork culture – that is the supplier and retailers must work together;
- Information Sharing – online information;
- Confidence in Quality – inspection of goods should not be required and
- Reliable operation.

2.7 Types of cross docks

One attempt at classifying the various forms of cross dock is shown below in entirety[19]. These tend to be simple purpose driven classifications, not rigorous methodologies.

- **Unitized continuous movement: -** The purest form of cross docking – bypasses typical warehouse operations such as put away, picking, or replenishment. This type of cross docking relies greatly on custom pallet building, tightly controlled dock door scheduling, and a high level of information transferring capabilities. Merchandise flows from inbound truck directly into outbound trucks;
- **Consolidated movement: -** Also relies on custom pallet building, but slightly less on dock door scheduling and information transfer. It blends in some traditional warehousing. Merchandise is received and distributed at the partial pallet level to specific stores from the receiving docks. Part of a pallet may be cross docked, the remainder may go into traditional storage. The partial pallet outbound can be married with product from traditional picking to complete an order and
- **Distributed Case movement: -** Depends more on distribution centre capabilities. Merchandise is received and distributed at the case level to specific stores from the receiving docks. Cases often have different destinations, and automatic sortation often supports these operations, driven by smaller, more frequent orders.

An alternative classification scheme for cross docks is proposed [20]. This is based on the segments of the supply chain this type of operation serves: -

- **Manufacturing cross docking** - receiving and consolidating inbound suppliers to support Just in Time manufacturing;
- **Distributor cross docking** – consolidation of multiple suppliers into a consolidated load or consignment for delivery (may include merge in transit), which is scheduled for delivery as soon as the consignment is complete;

- **Transportation cross docking** – consolidation and de-consolidation to make the transport as efficient as possible,
- **Retail cross docking** – consolidation of multiple suppliers into a consolidated load for delivery to a store and
- **Opportunistic cross docking** – transfer of an item across from receiving to dispatch docks.

Another classification separates the types of cross docks based on the point where labels are placed on the items. These are classified into two alternatives, at the cross dock or before the cross dock, called post-distribution and pre–distribution respectively [21, 14]. This is a simple classification based on one dimension.

The view of the cross dock from the grocery industry is reflected in the classification of four cross docking methods [4]:

- Vendor / third party pre-assembled orders method requires a supplier to pre-label store pallets based on the retailer's order;
- Reverse line picking method requires the manufacturer to assemble the pallet in specific layer selection supplied by the customer. The pallets will be deselected as layers at the cross dock facility;
- Flow Through involves the movement of product in pallets or at most half pallets and
- Automated sort for high speed items (the ASN is critical to this method according to the author).

These are based on the functions the operation serves.

In all of these cases, no deductive reasoning or analysis is utilised. As these are all based on observations of the functions the cross dock performs or some form of segment of the supply chain, they are simple classifications and not suitable to generally describe the inherent processes or complexities of the various types of cross dock.

2.8 Cross dock operation

2.8.1 Management of the facility

There are a number of references to the complexity of the operation of a cross dock, and to the pressures on management. It is stated that, from a management perspective, cross docking is a complex enterprise, involving extensive co-ordination between the distributor and its suppliers and customers [14]. The management of the cross dock is characterised by an author as "a very complex enterprise, involving extensive co-ordination between the distributor and its suppliers and customers. The cross dock must know which products are arriving in which trucks at which times for which customers and, if there is an high degree of consolidation, the cross dock must schedule trucks to avoid congestion due to short term storage" [22].

That the reduction in cycle time for the items passing through the cross dock imposes time constraints, is realised with the acknowledgement that the operation is under severe time pressure[3] and the operation of a cross dock requires enormous discipline and great synchronisation in real time[10].

The realisation is that the cross dock is more than a simple operation of physical actions; that it is a complex and integrated operation and process. Behind the physical activity of the movement of the goods is the management of the process which must respond to the strategic needs of the retailers [23] to: -

- Reduce operating costs;
- Increase throughput;
- Reduce inventory levels with increased product lines and
- Increase sales space within the stores.

The grocery industry has some logistics providers that are specialising in the cross dock operation and in some cases these are reaching 30% of their business[24].

2.8.2 JIT and the cross dock

While the improvement of the transport consolidation is obvious with the use of a cross dock, as the loads are dispatched with full transport loads unless the volume is too low to meet a service standard, there is no doubt that the introduction of a cross dock will add costs to the supply chain. Cross docks are of value where this is less than the transport and inventory savings. This balancing of costs, plus the extra time for the cross dock operation, reduces the validity of the principle of considering the cross dock as a JIT delivery process. A number of authors refer to this concept, mainly to convey the reduction in inventory aspect[10]. This is only one small part of JIT.

The cross dock operation is characterised as using JIT delivery to customers [25]. The concept of JIT delivery and its similarity to the operation of the cross dock is emphasised in the Siemens documentation for their materials handling equipment. The concept of linking JIT and materials handling equipment can only be due to the process involving no storage.

A separate emphasis also exists of the cross dock as a JIT process. This is that the rapid response that is associated with JIT suppliers in a manufacturing environment, is also seen in the cross docking operation [20]. While there are suppliers referenced in this concept, the basis for likening this to JIT is the reduction in inventory, as these suppliers deliver only what is required for immediate manufacture, where the manufacturing is at a constant production level.

The usual configuration of the cross dock in the supply chain is as a point of consolidation / de-consolidation before feeding to customers. Only one such point is generally needed, but occasions of multiple levels of cross dock do occur. These are where the cross dock operates in different areas and may have different functions – primarily consolidation and then later primarily de-consolidation. The use of multiple levels of cross dock in the distribution system has been used in the motor car distribution industry[26].

2.8.3 Consignment complexity

While the essence of cross dock is discussed, a separate method is looked at as if it is different from a cross dock – the Merge in Transit process [10]. This is another name for a consignment merge from multiple suppliers. This is a single order composed of multiple parts from many locations married together before delivery. It is usually for high value items, where storage is a significant cost, and speedy delivery is necessary. It improves customer satisfaction as the customer sees one order delivery, not multiple. The Track and Trace capability is emphasised with this consignment, as is the need to communicate to the customer to ensure delivery is effected on time.

2.9 Cross dock – materials handling

2.9.1 Lanes within the operation

Work has been done to mathematically model the staging of freight in the cross dock[22, 27]. The model is predicated on a lane being fed from the sort, and that each destination has one lane. The workers pulling product from the lane solve the problem of the blocking of the lane (fed from one side, and pulled from other side) by moving through other available space to move pallets forward. The queue size is explored for large operation cross docks. The queue length is optimum between 10 and 20 pallets in size. This is chosen purely for operating capability, and doesn't include total movement distance or economic factors. The larger the queue the less the effect of the blocking potential and hence these longer queues support larger throughputs.

2.9.2 Racking

The use of flow or dynamic racking for staging is explored and commented on. In the one article the use for the dynamic racking is recorded as of value, although the caution of the capital cost is recorded [10]. A more detailed, model-based, conclusion is that the throughput is increased by approximately 10% with flow racks for the same facility size[22, 27]. However this model does not take into account the costs of movement and the flow rack equipment. The use of the flow racks introduces increased throughput, but it comes at the expense of: -

- The racks are in fixed locations, reducing flexibility and increasing operational movement distance;
- The size of the racks must be fixed and there will be less than optimal use of the racks, as they are sized for a maximum capacity as an integral entity and
- High capital cost.

The integrated nature of the operation is reflected in the need for multiple disciplines to work together to be efficient. To work efficiently the automated cross dock system demands good system discipline[28]. This is not merely the IS capability, but the physical goods arriving must be compatible, the arrivals must be scheduled, and the personnel must be skilled.

2.10 Requirements for systems in the cross dock operation

The need for systems is evident. The control of the volume of product handled through a cross dock is often impossible to perform manually. The operation is systems intensive [29] and the systems themselves must have a measure of flexibility [30]. This flexibility is required as the processes vary with the type of cross dock as well as the work that is required for the items being received. Where additional steps are added from the basic steps of receive, sort and dispatch, then these steps must be added simply and without changes to the software. This requires the built-in ability of the system to be configurable to handle the different processes. That the reliance on these systems increases the potential for major problems is evident – if the system fails for any length of time and the ability to perform the operation is dependent on the system, then the operation will not function during this period. For this reason, the systems have redundancy and high reliability[3, 10]. In addition, the operation of a cross dock requires information far earlier than a warehouse. To be effective it must have visibility into both the supply and the delivery channels[10].

The need for information on the inbound items is essential. It gives the two advantages that the WMS can allocate the stock to delivery orders before the transport arrives, thereby allowing immediate receipt, and the WMS will highlight whether there are any deviations from the order, which need to be solved before the items are fed to the cross dock[31, 3]. Consignment tracking is highlighted as an important part of this systems capability [3].

The need for a dock yard management system or yard management system is noted in one source, as being a need for the operations in order to position the correct transport to the most appropriate door with the minimum of delay[3].

Track and Trace systems are essential to the operation of the cross dock and this becomes even more critical as the work encompasses consignments[10].

Integration is often addressed between the systems. However this integration is focussed on the internal processes of the company, and not on the supply chain [32]. Where consignment tracking is prevalent, this triggers the need for pre-advice, but not total information integration[3, 32]. This requires integrated software systems, which allow the simple and easy tracking of all the consignments. This needs to be part of the WMS system and not an addition to, where the ease of use and operation is not simple[3].

Reviews of the grocery and food industries in America showed that a key problem was that manufacturers and retailers do not share information describing consumer demand at the store and SKU level [33]. This affects forecasts, and is attributed as one of the factors that contributes to the problem that 'out of stocks' have risen to 7% industry wide. The industry retains the adversarial buyer–seller relationships, and few have moved to the collaboration or partnership view. The need for inbound shipment visibility is required and information is once again highlighted. The impact of decisions by buyers without taking into account the supply chain effect is also highlighted as a source of problems. The need for a co-operative relationship between the manufacturer, distributor and retailer needs to be established to create shipments based on anticipated store requirements.

The need for information in real time is emphasised. These include decision support systems with real time information on transport location, operations and warehousing including cross docking [34]. "The need for such digital aids are clear to retailers who've attempted to solve the complex puzzle of cross docking, for instance, a practice that could save untold shipping miles and man-hours, and improve in-stock situations". To achieve the value of the cross dock "requires pinpoint planning of a number of variables" some of which are the scheduling of inbound and outbound trucks and warehouse personnel.

2.11 Personnel

The requirement for training is evident, as a number of authors repeat the mantra that trained employees are required for effective operation, and only correctly trained operators can be efficient [29].

The cross dock introduces a potential complete culture change [3]. The operator needs to be trained extensively to make this transition simple.

2.12 Design criteria development for cross docking

2.12.1 Truck scheduling

Work was done on the allocation of waiting transport to the receiving doors. The allocation is done based on the information of the load. The general practice is First Come First Served (FCFS). This would allocate the next transport to the first available receiving door. This would result in all the receiving doors handling the same amount of items on average as the transport is allocated without any bias or preference to any door. There are alternative strategies, using the load information. These are termed "look-ahead" techniques [35]. The first is to assign the transport in the queue that has the lowest movement distance for the receiving door that first comes open. The alternative is to allocate to each receiving door (whether open or not) the trailer in the sequence of arrival in the yard that will have the lowest movement distance. The former allocation rule can allow transport to remain in the yard for long periods of time, which the latter does not. The use of allocation rules as discussed above can result in 15% or more reduction in the movement distances in the cross dock.

The use of transport planning systems enhances the ability of a facility to achieve [36]:

- Load balancing;
- Location management (including yard location);
- Cross dock management; and
- Routing for pick up and delivery.

2.12.2 Shape and size of facility

The shape of the majority of the facilities tends to be rectangular and these appear to work well[10]. Mathematical modelling work has been done to determine the optimum shape based on the movement distance of the facility[16]. The distance moved for items, for a fixed width facility, is slightly influenced by the ratio of receiving doors to dispatch doors, and primarily by the total number of doors. The width is fixed to be suitable for the work in the cross dock – staging or VAS – and additional width would be less than optimal. As the distance moved is either along the receiving side of the cross dock, or across the width of the cross dock and then along the alternative side of the cross dock, logic reflects that the shape must be rectangular, with the length increasing as the number of doors increases. Thus with a fixed width the shape will be rectangular until the distance travelled along the dock is so great that amendments to the shape are valuable in reducing the distance travelled. The next shape is a T and then this is expanded to an I (or H) shape with two cross–rectangular additions. The addition of the top cross–rectangular addition to the initial rectangle adds doors with the minimum increase of distance to be moved. The point where the facility must introduce the cross–rectangles is at approximately 160 doors to the T shape, and then at 260 doors to the I (or H) shape. These points of change vary slightly by the ratio of receiving doors to dispatch doors.

There are a number of proposed mathematical models[30, 37, 38] for freight yards that minimise the movement distance of items from the receiving to the outbound doors. The models are run on computers and aim to minimise the distance the items will move from the doors allocated to receiving and to the outbound doors for all items and all doors. This modelling is done on average items and assumes simple sort from receiving to dispatch. These form a basis for the correct allocation of trucks to receiving doors. These are not significantly different from the principles in the paragraph above.

The same work also came up with rules to allocate transport to the most appropriate door for receiving, and the allocation of the receiving and dispatch doors in the facility. The receiving and dispatch are allocated to specific doors for at least a 24-hour period. The rules show a method to allocate the inbound transport to the receiving doors to minimise the movement distance. The receiving doors can be allocated to either side of the facility from the centre out as a block (Block Layout) with the dispatch doors further away from the centre, or, again from the centre, the receiving doors can be alternated with dispatch doors (Alternating Layout). In both cases, the dispatch doors are allocated from the centre out, from the largest to the smallest flows, to the dispatch doors to minimise the distance the items are moved from receiving to dispatch. The Alternating Layout method produces approximately 10% better operations than the Block Layout[16].

The problem of traffic congestion is raised in the cross dock. As the receiving takes place towards the centre of the dock, the doors nearby see all the freight for the one side of the dock pass in front of the door. This can cause congestion if the aisle width is not sufficient[16].

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CHAPTER 3
RESEARCH INTO THE WOOLWORTHS TEXTILES CROSS DOCKS

3.1 Background

Woolworths is a company whose goods are aimed at the upper income market sector. The range includes foods, apparel and home furnishings. The distribution of foods was moved to Tibbett & Britten Africa in the early 1990's, a local company of the Tibbett & Britten Group in the UK. Tibbett & Britten Group in the UK are one of the preferred operators of warehouses for Marks & Spencer, the company to which Woolworths is affiliated. The incentive for Woolworths to use the services of the local Tibbett & Britten Africa company was augmented by the transfer of UK personnel, with Marks & Spencer distribution knowledge, to the South African operation.

Tibbett & Britten Africa extended from the foods distribution and started to perform a portion of the textile movement. This was done with the support of the Woolworths executive in charge of the distribution. The suppliers used a range of other transporters from the mini-containers offered by the national rail transport company – Spoornet – to small companies with empty backhaul legs that could offer the cheapest service. With the advent of Tibbett & Britten Africa into the textile movement, the majority of the distribution occurred via these three larger companies. These companies probably had 80% of the market between them.

The plethora of transporters of different sizes and capabilities led to a long delivery lead time. This was of the order of 8 to 9 days, but there was a large variability between suppliers. There were also major differences in times to urban and rural stores. Some of the distribution capability was effective for the main centre to main centre movements, as there was sufficient volume to be moved. The distribution to the outlying stores was delayed until sufficient stock to make an economic movement accumulated. Alternatively the stock was handed to a third party distributor that specialised in the rural region. This caused further delays, and caused substantial problems with PODs.

The system struggled through the peak in December 1995 and failed to deliver the service required from the stores. Realisation that sales of products were negatively impacted with the lack of goods in the stores came to the fore. Textiles and food products were split into separate units with a new person in charge of the textile logistics operation.

The Woolworths process of payments to suppliers was somewhat complicated. The suppliers received orders on the Monday or Tuesday. Orders that were sent by Friday could be invoiced on Monday and then a special payment run was undertaken on Tuesday after the invoices had been captured. Any discrepancies in cartons delivered or disputes on the amount each carton contained, were communicated from the store to central office. Once these were collated, the shortages were communicated to the supplier. The supplier had a limited time to prove these deliveries of cartons had taken place, and had very little opportunity to query the shortages in the cartons unless a pattern occurred at a few stores where Woolworths staff may not have been vigilant in unpacking or receipting. If these 'potential claims' were not disproved, the costs were deducted from the next payment.

3.2 Suppliers

Woolworths had approximately 220 suppliers of textiles. These suppliers were centred as follows:

Supplier	Percentage
Cape Town	70%
Durban	25%
Johannesburg	5%

The problem was exacerbated by the mismatch of consumers in the country, as these were very different from the above splits. In broad terms these were:

Consumer	Percentage
Gauteng	56%
Western Cape	20%
KZN	18%
Eastern Cape	6%

This imbalance meant that the movement of goods was higher than one would expect. The situation was exacerbated by the distance from the area of the majority of the manufacturers to the area of the majority of consumers, which is over 1 600 km.

Suppliers are contracted to Woolworths to produce one or more products. The products are then produced by the supplier who, in the agreement, is required to maintain stocks in its warehouse to a specific inventory level. This was introduced to ensure the supplier could fill an order within 5 working days as desired by Woolworths. The result of this was that every supplier maintained a reasonably sized warehouse of manufactured goods. Only in exceptional circumstances would a company manufacture goods for the order, and in the time scale only small runs or make up of stock could be produced.

3.3 New beginning

The new management introduced a consulting firm to review and recommend the way forward. The process resulted in a Materials Availability Programme (MAP) being created. This was aimed at putting in place all the building blocks necessary to make inventory move from supplier to store in a much reduced time scale and with visibility of collection and delivery.

The consultants produced a design which utilised the suppliers carrying stock. Three facilities were proposed, one in each of Cape Town, Durban and Johannesburg. The facilities would undertake the collection of the products from the suppliers and cross dock these goods for local delivery or long distance movement to the other two facilities.

The premise to make this feasible was the facilities and transport needed to be under the control of one party. Woolworths did not consider this as core to their operation and a process to choose a long term partner was undertaken. The process was essentially an RFP and resulted in one company, Rennies, undertaking the outsourced operation in what was a true 4th party logistics relationship.

At the time of the tender there were three main parties undertaking the business. The problems came immediately the announcement was made of the chosen operator. One of the existing operators, Tibbett & Britten Africa who were part of the tender process, reacted with the announcement that they would cease textile movement at the end of the week. The other major transporters immediately demanded longer contracts from the suppliers so that they did not lose the Woolworths business until they had a chance to secure additional business.

The withdrawal of the one operation left Woolworths with a major problem as a large number of suppliers were now no longer able to move their goods because of Woolworths appointment of Rennies. To alleviate the problem, Rennies was asked to create the network in 7 weeks, rather than the 7 months that was originally planned. This was done over the Christmas and New Year period and was operational by mid-January. Three facilities were sourced in the time period and staff were obtained. The systems were manual and cumbersome.

The consequence of the closure of Tibbett & Britten Africa was not only a problem that the new 4th party logistics provider had to fill the gap, but also one of this company completing the service contract. The service included the recovery of PODs and, on demand, the delivery of these or copies to the suppliers to ensure payment from Woolworths. A large measure of the PODs for the last 6 months were in dispute and this resulted in poor service and non-payment. This gave rise to further bad feelings between the suppliers and Woolworths over the introduction of a single logistics supplier.

3.4 Implementation

The logistics provider that ceased operation performed approximately 35% of the total business. The new Rennies operation retained about 20% of the total business at its start. The remaining 15% of the business was given to either of the other two remaining logistics providers or new transport companies that were interested in short term business. This left Rennies with only 20% of the volume, but did allow the company to establish more formal systems and introduce improved controls. It added tremendous financial pressure as well, and this would cause different problems in the later stages of the development.

The logistics provider, Woolworths and the consulting company continued with the design of the supply chain. The original concept of the consulting company was centred on the principles of the network and the potential savings. The details of the operation were not addressed. This left a large number of issues that had to be addressed by Rennies and Woolworths while Rennies were doing the initial 20% of the volume. The design of the detailed distribution capability was left primarily to Rennies.

The method of introduction of the one channel caused major problems that were exacerbated by the closure of one of the existing logistics providers. This left suppliers struggling over a peak period, and introduced considerable uncertainty in the minds of the suppliers. The emotional issues caused considerable acrimony between the suppliers and Woolworths and a strong opposition to the one channel and Rennies. This made the acquisition of additional business to add to the initial 20%, very difficult.

3.5 Facilities

3.5.1 Acquisition and initial design

The three facilities that were created in Johannesburg, Cape Town and Durban were very different. Whereas the Cape Town facility was designed and developed specifically for the operation, the Durban and the Johannesburg facilities were placed within existing buildings.

The initial Cape Town facility was acquired near the garment district. It was the original Tibbett & Britten Africa facility. It was far from ideal, but was available immediately following the decision of Tibbett & Britten Africa to pull out of the industry. The lease and rental was taken over from Tibbett & Britten Africa. The lease had approximately nine months to run. This was almost an ideal period, as the Cape Town operation would require a new facility, which it was expected would be brought on line in 7 or 8 months. This would allow an orderly transition from this temporary facility to a new facility.

The Johannesburg facility was an empty warehouse of approximately 5,000 square meters. Its length to breadth ratio was 2.5:1. Initially the induction was done through a 50 meter long roller bed section which was automated. This proved to be far too small to accommodate the large volume trucks that were received from Cape Town primarily, and also from Durban. While a small amount of local receiving was done, the vast majority of goods came from Cape Town and Durban cross dock facilities. Initially these transports were not scheduled and a large amount of queuing occurred. The facility was unable to cater for the full throughput and the staff were working 24 hours a day. The design was altered to provide a 150 meter length of roller bed as the induction into the system. This was adequate to cater for the offloading of a long distance, high volume transport, and was more than sufficient as long as the induction station was operating at a constant high rate. The induction system scanned the parcel into the facility and then determined the mass and physical length, breadth and width measurements. This measuring was done at each facility. This alleviated a vast amount of problems in the internal operation. The sortation was done on a carousel and because of the shape of the facility this carousel was placed against one of the lengthwise walls, where there are no doors. The sort was done from the carousel onto stationary roller beds so that items that were destined for the stores that were sorted by one person, could be pushed onto these spurs. Thereafter items were placed on pallets. Two pallets were allocated per store so that items that were part of consignments were placed on one pallet and items that were one of one or no consignment were placed on an alternative pallet. The advantage of this was that the individual items, which were not part of consignments, could be taken from the sort area immediately and placed in the assembly lanes once the pallet was full. The consignment pallets had to have a secondary sort into consignments. This is the only way that the completed consignments could be separated from those consignments still awaiting one or more items. These completed consignments were then moved to the assembly lanes. One lane was allocated for each store, and for larger stores two lanes were allocated. The secondary sort was a major problem and this simple technique of isolating consignments and items not belonging to consignments enabled far faster creation of full pallets and simplified the assembly and checking process.

The Durban facility was established in essentially the same manner but did not have a carousel. The movement from the receiving door along a length of roller bed that served as the sortation area was automated. Diversion was manual onto diversion roller beds. Instead of a carousel return, the parcels not sorted were accumulated on the end roller bed and were manually sorted from here to the appropriate diversion roller beds. The lower volumes this facility handled allowed this cheaper but very sensible design to work effectively.

The new Cape Town facility was specifically designed for the cross dock operation. Woolworths initially wanted to introduce automated sortation. This turned out to be unnecessary for their throughput, and problematic as a number of the products would not have been able to be handled over the automated sortation system. The range of Woolworths products extended from duvets which are 2 m long and 300 mm in diameter when rolled up, to boxes of lipsticks which are 100 mm long 75 mm high and 25 mm thick. This range precluded the automation of the sort, even had it been a necessity from throughput. Induction was however done with roller beds from the door through to the carousel from which the sort would be done. The induction was made even more effective by the use of telescopic conveyer systems that extended within the transports. The manual sort occurred on a carousel. A diversion roller bed was provided to Johannesburg and a diversion roller bed was provided to Durban. These diversion roller beds were 30 m in length. The sort for local stores was diverted from the carousel onto an automated roller bed and from this into lanes for specific stores. The length of roller bed allowed for the bulk movement to Johannesburg and Durban was far too small. Parcels had to be removed from the roller beds and placed on the floor to accommodate accumulation of a full truck volume. To load a truck then involved replacing these parcels onto the roller beds and moving them into the truck. This was a poor design and could not be altered, as the space did not allow for increased roller bed lengths. A similar problem occurred with the induction roller beds, which were altered to give an additional length for more storage buffer. This was not ideal but was an improvement. The facility itself occupied approximately 6,400 square meters and was nearly square with a length to breadth ratio of 1.2 :1. Other than the bulk movement of goods from Cape Town to Johannesburg and Durban the flow was from one side to the other of the facility.

The design of the Cape Town and Johannesburg facilities, and to a lesser extent the Durban facility showed a number of principles that were necessary for a correct cross dock operation. The Johannesburg facility fed goods onto a long carousel. The length was needed, as there were a large number of stores that were sorted from the carousel. The sort from the carousel directly towards the dispatch doors reduced the distance the pallets of sorted parcels had to move. The receiving was predominantly from large volume transport, and only two doors were required. This made the facility a long rectangular shape. The long induction roller bed enabled a long distance transport to be completed and removed and a new transport brought to the door without the feed to the sort removing all parcels from the induction roller beds. In this way a buffer was created.

The large quantity of parcels received from smaller transporters in Cape Town created a facility that was very different in shape and size and orientation to the Johannesburg facility. The Cape Town facility with multiple smaller trucks doing the highest volume of collections needed greater numbers of induction lanes. This was recognised in the design where eight doors were allocated for receiving. The design was not adequate in that the roller beds with the sorted parcels for Johannesburg and Durban were not long enough. The number of doors also needed to be very different. The Cape Town facility needed to cater for smaller transport and needed more doors to be able to do so. The smaller transport size required more time to prepare to unload, and to remove the transport.

3.5.2 Operating improvements

The operation of all the facilities was initially extremely difficult. The transport was unscheduled and caused major peaks and valleys in the operations. It soon became evident that rigorous scheduling was necessary. The secret for these cross docks was that they had to operate with an effective sort. This meant that a constant flow had to be fed to the sort as the sort fed items onto pallets towards the assembly lanes for dispatch. If excessive quantities of items were fed into the sort, the carousels became clogged and the sort could not be done effectively. If there were insufficient parcels then of course the amount of work done by the sorters on the carousel reduced. While not understanding it at the time, this was the bottleneck for the facility. All other issues upstream and downstream of this were altered to make this work at a constant pace and at the most effective rate possible.

As experience was gained in the operation it became evident that two issues would make or break these facilities. The first was the co-ordination of the transport. The second was the ability to unload transport into the facility without significant delays or clogging of the floor with boxes. The cross docks do not have the space to allow the floor to be utilised to induct transport until the sort was ready for more parcels, and the operation had to be disciplined in placing and moving parcels correctly the first time.

The interaction problem of the facilities was exacerbated by the fact that the entire supply chain was comprised of cross dock facilities. The supply chain had absolutely no storage capability as goods were received from a supplier into a cross dock facility, and transported to a further cross dock facility for onward distribution directly to stores.

The collection process in Cape Town was scheduled for the start of business each morning. Sortation commenced immediately and the large volume, long distance trucks started to leave the facility in the late morning and mid-morning. There were consistently four to seven of these transports leaving every day. With the distance between Cape Town and Johannesburg at approximately 20 hours driving time, these trucks arrived in the early-morning to mid-morning in Johannesburg. The Johannesburg facility struggled to unload the entire distribution for a day in the short period of four or five hours in which the trucks arrived. The arrival of the trucks only in the morning period meant that to accommodate these trucks the effectiveness of the operation was seriously compromised, so deliveries could only commence from these products in the mid-afternoon after the induction and then sortation had cleared. It became very obvious that trucks had to arrive in a scheduled, orderly fashion at the Johannesburg distribution centre so that there was a steady flow of parcels into the facility from early morning until late in the afternoon. The parcels received in the first half of the day would be delivered in the afternoon, and the remainder would be loaded overnight and delivered early the next morning. This was difficult to implement, as it required Cape Town to change its working methods away from its ideal of collections being completed in the morning with local deliveries taking place in the afternoon. However, the change to spread the collections throughout the day allowed the loading of large trucks for Johannesburg and Durban to be done through the day and the evening. The concept of the cross docks being inextricably linked as to the timing of the operation had to be made a priority for the cross docks to be able to handle the parcel volume. Once it became understood that both cross docks would benefit, the entire process became significantly more effective.

At the height of the crisis, people were working 12 hour shifts 24 hours a day, with a catch-up on the weekend. The error rate was fairly significant as these people were tired and working under pressure. The workloads were significantly reduced in both cross docks once these changes to schedule the transport and to balance the flow through the two cross docks were implemented.

The scheduling of the transport allowed time for the internal methods to be reviewed. The cross dock operation was divided into specific tasks, each with clearly defined roles. Operators were trained to do the job correctly the first time. Once this disciplined approach to the operation became effective, the process began to operate far more effectively and with fewer personnel. The improved effectiveness allowed the transport to be loaded quicker and be more effectively utilised.

As the whole process began to be improved, so timing of the outbound transport could also be improved. It was arranged that specific stores would receive loads very early in the morning namely 6.30 am to 7.00 am. This enabled the largest stores to be serviced very early in the morning, allowing the transport to travel prior to the peak in the morning traffic, and to complete its subsequent movement to the next stop just after this peak had subsided. The transport would then either go to the second and subsequent stops or return and load additional items for other stores. This was only feasible if the loads could be guaranteed and that the sort could work correctly. This required a night loading of the transport such that the drivers could arrive at 6.00 am and depart immediately. Once the sort teams had finished the parcels available to sort, these team members then moved from the sort to the loading of transport for the initial deliveries, thereby utilising all the personnel on the shift for the same period.

3.6 Systems

3.6.1 Integration

The systems chosen by Woolworths to effect this were client servers in head office and each cross dock. The cross docks had a WMS system installed specifically for the cross dock operation by Rennies. The Woolworths systems were merely a record of receipt and dispatch at the cross dock. The information for loads moved from one cross dock to the other was transmitted via the Woolworths network to the next cross dock in the process.

Rennies had to add the detailed materials handling information systems, the POD process and billing processes in the cross dock. The system chosen was a centralised one with a strong track and trace capability. Special physical equipment and systems were designed to automatically read the barcodes on the goods, and to measure the mass and physical dimensions of each item. An automated system was installed in Cape Town, the largest volume cross dock. A similar system, but with a manual barcode scan, was developed for the lower volume cross docks in Durban and for Johannesburg. The Rennies system tracked the goods into the cross dock, and out of the cross dock in addition to the capture of the ID, mass and volume details. The system tracked every parcel from pick-up, into and out of the cross dock or cross docks and to the POD issued by the store to prove final delivery.

From the above discussion it is evident that the integration of the systems was from the client to the final store delivery. This total integration for information flow was an absolute necessity in this operation, where the initial stages were fraught with negative attitudes at the very least. The drive may have originally been to achieve this information integration in order to cope with the demands from the dissatisfied suppliers. However, it rapidly became a competitive advantage that not only assisted the suppliers but made a tremendous improvement to the Rennies operation.

The integration was achieved with the acknowledgement that the various suppliers had different forms of sophistication within their systems capability. For this reason a specific barcode label per item was designed, and a new order management process was introduced. The process was fairly simple but very comprehensive. Woolworths would produce an order on the supplier. The supplier would determine that it could fulfil the order required by Woolworths. It would advise Woolworths that it could fulfil the order with or without any amendments. Woolworths would download the information to enable a barcode label to be printed for every box that would be sent. A further sophistication was added that the programme would actually recommend or assume a correct box size for the goods. This was nothing more than a fitting of the goods into predetermined boxes based on parameters entered initially. As most suppliers produced a specific range of goods this was not a major task. The barcode label for every box was then produced as per the commitment to Woolworths from the supplier. With these barcode labels, and on the same barcode label material, a hand over list of the items in the order that were to be handed to Rennies was printed. This was a simple list of the items and the total number of items. The supplier then added the barcode labels to the boxes, prepared the boxes as per this list for hand over and ensured that the quantity of boxes for this specific order totalled the correct total of boxes and therefore labels printed. Hand over was done by a box count between the supplier and Rennies. Rennies would induct these boxes into the cross dock operation. The induction included the scan and record of all the data within the barcode. A reconciliation of the count of the parcels scanned was done against the total quantity of boxes that was handed to Rennies as recorded on the pre-printed label. If the total quantity had been received by the cross dock, then a further reconciliation was done as to the completeness of all of the consignments. All the necessary information was contained within the barcode label and this was simple to do with the WMS system. Once the second reconciliation check was done, the goods were accepted for sortation. A fax with the details of each box was automatically sent to the supplier. Thereafter, at each scanned position, the location of the box was recorded into the system. The delivery either to another distribution centre, where the same process was followed, or to a store resulted in further scans and updates of location. The store scan records the transfer of the parcel to the store, and a code is used to indicate if there was any damage to the box. This store scan information was automatically fed back to the track and trace system in Rennies. In principle every stage of the journey of the goods was tracked into and out of every location. The knowledge of the movement details was therefore known to the system. Physical parameters of mass and volume were known to the system as well. This offered a tremendous ability to track and trace parcels and to effect positive hand over to stores. The operation registered a loss of parcels, where loss implied damage or theft, which was one third the average of the industry.

3.6.2 Barcode

The barcode that was evolved contained the full information that was necessary for the entire supply chain. It was inserted onto the box at the supplier and was used as a positive hand over identification that the box was a legitimate order and destined for Woolworths. Exactly the required quantity of labels was printed. A major process of cancelling a label and recording the reason was actually built into the label printing system, and much the same process was built in for an additional label. The barcode label was chosen specifically because the sophistication varied from a supplier whose systems were at ERP level to the supplier where the secretary had an old PC in order to do correspondence for the Managing Director. This very varied sophistication in systems meant that this label printing process had to cater for all the levels of skill. The barcode label contains within the barcode the Woolworths store number, Delivery Instruction (DI) number, parcel number, supplier number, total number of parcels in the consignment, the type of distribution unit (box or other types of packaging), type of delivery service required, the type of goods supplied, and the destination. In addition to this, as can be seen in the label below, a large amount of information was printed on the label. This included the Woolworths store name and address, the supplier name and address, the date and time the labels were printed, and in large bold writing the store number which in this case is 120 and the final destination cross dock. This large print of the store number 120 enabled a simple and easy manual sort. In addition the number of parcels within the consignment were also printed in large bold characters.

Figure 3.1 Barcode

A refinement was added later as this barcode reflects. This is that the box can contain more than one order (or DI – delivery instruction - in Woolworths terminology). This was done to maximise the box utilisation, and to give Woolworths flexibility to place smaller quantities for their orders. Thus the number of orders that were present in the system could be reflected at the bottom, but they would travel under the main order number as subsidiary orders. While this needed some systems change within both Rennies and Woolworths, so that the supplier systems did not have to be altered, this gave all parties an advantage over their previous methods of distribution and enabled those parties that were interested, to improve their distribution costs.

3.6.3 Proof of delivery

The process of recording the POD was extremely cumbersome with the interlinked cross docks. The PODs were filed in sequence at each of the three main centres. This was a problem for customers who had sent product to one cross dock, and this cross dock had then sent it to another cross dock for final delivery. PODs would be retained at the cross dock performing the final delivery. As every order went to the majority, if not of all the stores, PODs were retained in each of the three cross docks. In the event of a query, the cross dock that did the collections from the supplier was then required to ask for the other two cross docks to copy the PODs and, on receipt, to collate these with its PODs to answer the queries. This was not a sensible arrangement as copies of PODs were moved from cross docks on a regular basis, with teams of clerical personnel in each cross dock dealing with the problem. The work was time consuming and affected the credibility of the Rennies operation.

The consequence of this slow response to POD requests was that customers used this to delay payments. The appointment of Rennies removed from the customers the choice of carrier for their Woolworths business. The appointment was effected by Woolworths, aided by Andersen Consulting, as a fait accompli, and this was not appreciated by the suppliers. A number of the suppliers saw this as an excellent opportunity to not only show disagreement with Woolworths, but to prevent the single channel from working correctly. This negative approach was seen from a number of the suppliers who requested a POD for every parcel, whether Woolworths had any queries or not. This amounted, in the first months of operation, to requests for thousands of PODs every month. These PODs were collated and then sent to the supplier. The supplier of course took a number of weeks to check these PODs. During these periods the suppliers refused payment to Rennies, thereby seriously delaying the cash flow. Rennies sought better methods to handle these PODs. A method to scan the PODs into a database of images was found. A reference number was added to each POD and the document was scanned onto a high volume hard disk. This scan took place at the three major cross docks and the data was consolidated. A central repository of these data images was then delivered weekly to the Head Office in Durban. The reference number from the POD was captured into the track and trace system. As a supplier requested a POD the reference numbers could be looked up and the image located within a few seconds and automatically faxed to the supplier. As the POD response time dramatically reduced from Rennies, the onus passed from Rennies to the supplier to do large amounts of manual work. The suppliers were billed and charged interest for late payments based on the ability of Rennies to deliver these documents quickly and effectively. Underlying this, and of even greater importance, was the double check produced by the reference number entry into the track and trace system. Any entry number that was not in the track and trace system indicated that a POD was not available.

These PODs were strongly managed so that within one week of delivery for local deliveries all PODs were accounted for, and within two weeks for outlying stores. This was reported on Monday of every week to the Managing Director of Rennies Logistics. The Managing Director would not accept any PODs that were not accounted for. Each of the cross docks had to account for every parcel that they received and handled every week. This was imposed without exception each week.

The quantity of PODs, requested by the suppliers, reduced dramatically following the introduction of this new methodology. The methodology itself cost R0.35 per image. However the workload dramatically reduced, the cash flow increased significantly, and the number of people required to perform this task reduced significantly. The number of PODs that were not accounted for were virtually negligible. This was far better service than the suppliers had ever received. As the credibility of the POD management and the speed of delivery became recognised, Rennies began to restrict the number of POD requests, and to charge for PODs above this quantity. This further reduced the POD requests. As a consequence of this work and the strict management control on the PODs, after about 18 months of operation, Rennies gave the assurance that if their track and trace system contained a reference number, a POD was available. These reference numbers were then supplied for queries and only in exceptional cases was a POD supplied. Based on its credibility, Woolworths and its suppliers were willing to accept Rennies' statement that a POD existed. This further reduced the quantity of work.

3.6.4 Data value

The use of this data became a major advantage for Rennies. This data enabled them to measure every supplier's movements and the volume and mass of their movements on a daily receipting basis. Their billing information was produced within one day of a delivery to a distribution centre as it was fully automated. The billing information coupled with this physical data enabled detailed knowledge of the suppliers to be built up. Correct methods of packing to minimise the charges and packaging costs were reviewed with each of these suppliers. This value added work made the credibility of Rennies significantly higher than any other logistic supplier in the Woolworths system previously. The suppliers turned to Rennies for help to set up their own systems and to be able to have sufficient information to deal with Woolworths with regards to pickups and deliveries.

3.7 Conclusions

The research highlights a number of issues pertinent to the knowledge of cross docks and supply chains utilising cross docks. These are summarised as follows: -

- Cross dock capabilities within the supply chain require co-ordination of the entire supply chain as there is no buffering or storage between processes. Where there are multiple cross docks interlinked, the co-ordination effort is increased significantly. The operation of the cross dock facility needs to be a continuous flow as no space or time is available for the accumulation of items or for re-work. This is inherent in the cross dock operation if it is to be successful.
- The operation must have skilled labour, who understand how to do the job and each process or station needs to be carried out by the right number of personnel to support the continuous, and not continual, flow of the goods through the processes.
- The mix of collections to the dispatches and, in each case, the size of the transport will have an impact on the shape and size of the facility. A local collection in small trucks will require more receiving doors than a receipt of the same number of items in a long distance, high volume transport.
- The sort is, unless there is a physical facility constraint, the critical element in the supply chain, and this is exacerbated by the fact that one distribution centre fed another distribution centre. In all cases the sort was seen to be the bottleneck.
- By trial and error the most effective method of operating the combined cross docks was found to be with: -
    - A constant feed onto or into the sort area at the same pace as the sort was being performed.

  - To buffer the receiving from the sort so that there was always sufficient items available to feed to the sort without utilising excessive floor space within the operation.
  - Trained personnel

The unique barcode label was designed by the author of this research and made some significant improvements to be achieved in the supply chain as well as the cross dock: -

- Enabled the manual sort to occur very effectively.
- Allowed all of the suppliers, from those with sophisticated to those with unsophisticated systems capabilities to have full access to the information of the item if they so desired with one scan.
- Facilitated the full knowledge of every item at every scanning point throughout the supply chain. This is critical to the effective operation of the supply chain, and even more important to the control of the items to prevent delays and shrinkage.

CHAPTER 4
RESEARCH INTO THE SPAR FRESH FOODS CROSS DOCKS

4.1 Introduction

The SPAR Group is one of the top three retailers in South Africa, and is the largest retailer in the grocery market in the world based on the number of stores. The concept of the SPAR system is a Guild. The Guild is a region of members who own their own stores and, in a few cases, the stores are owned by SPAR as a corporate entity, but are joined together in the Guild. The Guild will trade with the SPAR name and a SPAR operating company is created as a central function for marketing, buying and distribution to support the Guild. The shop owners may enter or leave the Guild with a short period of notice. The Guild is run as if the store owners have a shareholding in the Guild. This means that at regular intervals a shareholders meeting is held where all store owners, as Guild members, attend with the SPAR operating officers to review performance and strategy. The Guild model guarantees that the SPAR operating company is highly focused on satisfying their customers, who are the store owners as well as the shareholders in their company.

One of the prime functions of the SPAR operating company for the Guild is the provision of a warehouse for the Guild, the purchasing function to maintain correct stocks in the warehouse and the distribution from the warehouse to the stores. In the last four years, with the advent of a new Logistics Director position in 1999, distribution has been a focus for the SPAR corporate office that supports the Guilds in South Africa. This position is a corporate SPAR position and as such is a staff role. It does however have significant influence over the distribution directors in each Guild. It has also provided an impetus to change management and technology necessary to bring these warehouses to a higher level of effectiveness.

SPAR has two Guilds in Gauteng. The South Rand Guild serves members in the Southern Gauteng and Free State regions. The North Rand Guild serves members in the Northern Gauteng and Limpopo regions. Both Guilds have there own Distribution Centres for dry grocery products, but all perishable products for both Guilds were, until late 2003, supplied from a perishable facility located at South Rand. The perishable facility handles frozen, chilled and fresh products. The fresh products are handled through a cross dock operation in the perishable facility and is the major focus of this review.

The chilled and frozen products, with the fresh products, are delivered to the stores in the same transport. To achieve these concurrent deliveries, the three products must be assembled in the perishables facility at the same time. This complicates the operation further. The delivery using one truck for three different types of product requires that the three products must be assembled together in one lane or area so loading and checking can be done effectively. These products need to be delivered during the day and the transport is not available for the sort to take place and the sorted products to be assembled directly into the transport.

4.2 Products

In the SPAR definition, Perishable products are classified into three product types. These are frozen, chilled and fresh products. Chilled and fresh are retained at 5°C. The differentiation between these two products is that chilled has a long shelf life of months, while fresh has a shelf life of two to three days. The frozen products are stored at -25°C and have a shelf life of six or more months. All three products are managed in the facility and assembled in one area for the loading into transport. This area is near the dispatch doors and facilitates the loading of the transport.

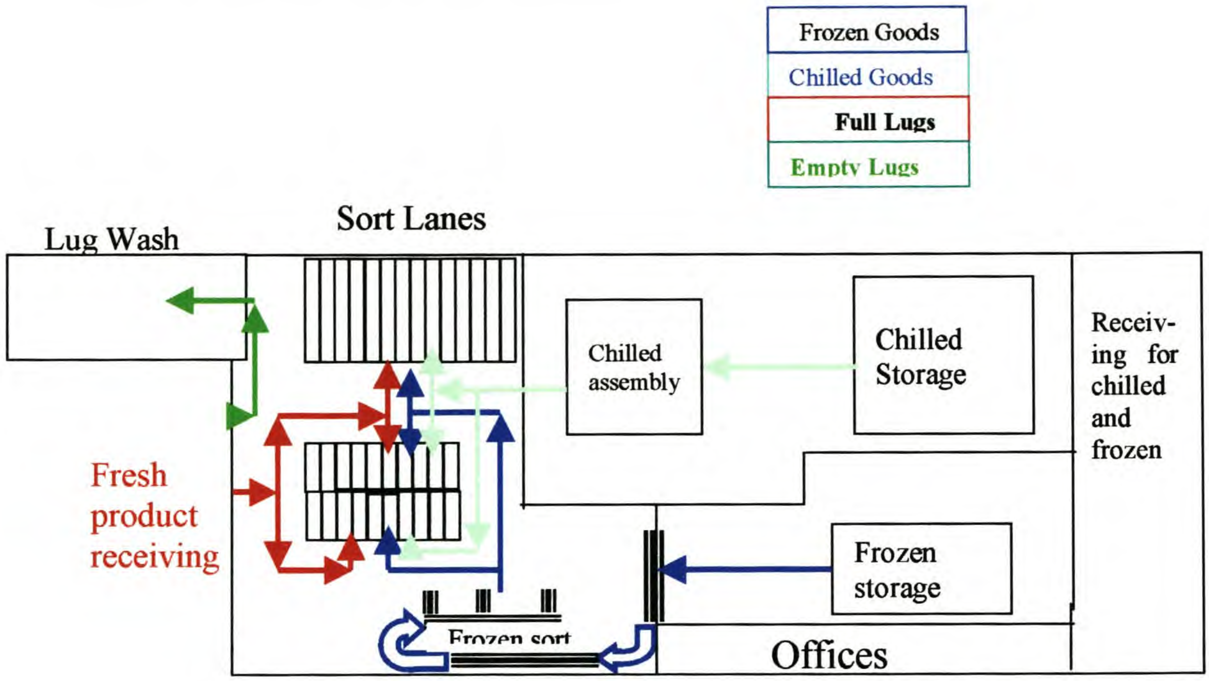
Chilled and frozen products with their long shelf life are delivered once per week to stores. Fresh products are delivered three times a week to accommodate the short shelf life. The number of stores that receive fresh product are limited. Fresh products are high volume products and have a low profit margin. Therefore, to deliver these products long distances impacts on the shelf life that remains for the store, and is not profitable beyond a certain distance due to the low profit margin and high volume.

The chilled and frozen products are normal boxes or cases of products. The fresh products are delivered in plastic crates which are 600mm x 400mm at the base and 340mm high.

4.3 Facility

The facility has two temperature zones of –25°C and 5°C. There are two shelf life categories of short and long. This results in three separate product categories that must be catered for in the operation. The fresh sortation is done on an open floor. The chilled and frozen products are stored in racks for stock holding, and picked as in a normal warehouse. The three products are assembled in the floor area allocated to the fresh for transport loading. This can be seen in the diagram 4.1 below. The chilled products are manually picked by store on one side of the fresh cross dock operation. The frozen products are taken in a bulk wave from the freezer via a belt conveying system to a twelve-way store sort. The diversion is done via pop-up diverters. This automated system is set on the other side of the fresh operation.

Figure 4.1 Layout of South Rand operation.



4.4 Identification of problems in the cross dock operation

The cross dock operation was analysed in detail as part of the generation of research knowledge. The operations were flow charted and analysed to determine the problems that had caused the facility to operate ineffectively. The operation had struggled for some years and the observations and the analyses are the direct work of the author towards building the knowledge of cross docks.

4.4.1 Variation in work loads

Part of the analysis in looking at this facility showed that the peak the facility worked with was excessive. On a week by week basis a 25% volume fluctuation is feasible in the fresh produce. There is a larger fluctuation on a day by day basis, caused by the allocation of the stores to the delivery cycles. The pick is done on two cycles for the fresh produce. The first cycle is a Monday, Wednesday, Friday and the second is a Tuesday, Thursday and Sunday cycle. Deliveries occur the day following the pick in all cases. The problem has been that historically stores in the retail grocery industry only remained open on a Saturday morning. The cycles were set in this time period and a Friday delivery or Thursday pick was desired by most of the large stores. In fact 80% of all the large stores that are serviced by South Rand demand a delivery on the Friday and therefore have been placed on the cycle with the Monday, Wednesday and Friday deliveries. These are large stores and the Thursday pick is consequently significantly higher than any other day. The pick variance from minimum to maximum is a ratio of 1.9 and from average to the Thursday peak is 1.5 times or a

50% variation. This was unknown until the analysis was done on the actual operation. It explains why the floor is highly ineffective and the operations staff cannot find a methodology that works for all days. The knowledge of the fluctuations in the day by day loads on the facility due to the major stores has helped in the understanding of the operating problems, but the facility has not changed the stores to alternative cycles nor have they created different cycles.

4.4.2 Flows in the facility

The flows from the fresh receiving and sort, the chilled pick and the frozen pick are all at right angles to one another or in counter-flows. This is shown in figure 4.1. This causes interference to movement of products and introduces a severe cause of ineffectiveness.

4.4.3 Sort system for frozen products

The frozen sort system was commissioned in 1999, and had not operated correctly until work was done to rectify it in 2002. SPAR allowed the suppliers to leave the site without proving that the store sort worked in all conditions and operating and logic flaws remained.

The design of the system is also flawed as the frozen products have too many products that do not work correctly with the automated system provided. These are products that range from small boxes such as I&J fish finger boxes through to large jute bags in which chicken portions are placed. These bags are a meter long and 300mm wide and irregularly shaped. The sort is placed in the 5°C area, and the frozen products tend to gather a film of moisture over them. This does affect the ability to read the barcode but the primary problem is that the roller beds that are utilised become wet and smaller, lighter products tend to catch on the rollers as the pitch is wide. The heavier, larger products tend to have increased friction as they go round the corners in the roller bed and, because of the liquid film on the rollers, slip quite easily.

The sortation system logic is faulty as it is based on a time delay from where the item crosses a measurement point some 8 m before the sort area to the expected time when the appropriate pop-up diverter for one of the twelve stores must activate. Any delay in the constant speed at which the parcel or item is assumed to be moving along the roller bed, will result in the popup sorter activating at the wrong time and not diverting the item or diverting the incorrect item. The logic is incorrect for accurate work. The correct logic should in fact count the parcels and not a time delay and activate a sensor immediately upstream of the popup sorter to recognise a parcel that is due to be diverted. This guarantees that the very short space between this sensor and the popup sorter is the only time delay and the distance is so small that any slippage that is present on the roller beds has no effect on the diversion. Because the automated diversion does not work correctly, six pickers work between the twelve chutes that are allocated to the twelve stores. Their role is to unpack these chutes and place boxes on twelve pallets placed in front of them essentially doing a pick from each of the chutes onto the correct pallet for the store. As the sortation system is working at a reasonably high rate, this requires six pickers and a fair amount of confusion does exist. Because of the confusion the SPAR operations added six security checkers because incorrect product was being sent to stores and shortages of products were being recorded.

To compound the problems associated with this operation the flow of this product was at 90° to the flow of both the fresh and chilled products. This made the assembly area somewhat chaotic and increased the ineffectiveness in the overall system.

4.4.4 Receiving of lugs

The fresh products are received in lugs. Approximately fifty percent of these lugs were delivered in trucks without being palletised. In this case the lugs were taken from the truck and a pallet was built containing forty lugs on the facility floor. The lugs were then labelled with a SPAR label which identifies the product and has the store number to which it is to be sent. The pallet is then pulled through to the sort area and the correct lugs are taken from this supplier pallet and are placed onto the correct store pallet. The store pallets were in a series of lanes adjacent to one another where each lane was for a designated store (see Figure 4.1). The lane lengths were the length of pallets that were required to satisfy the store at peak times. The process of sorting the fresh products was then to move down these lanes with the supplier pallet and to take the lugs to the far end of the lane where a store pallet was present. As some of the lanes were fourteen and fifteen pallet deep lanes this was a significant walk distance when the sorter was only carrying one or two lugs. The sorter would then return to the supplier pallet and find the lugs for the next lane and again move the lugs to the next store pallet on the far end of the lane. In this way the sorter moved through the assembly area, which was approximately 4000 square meters in total space, and placed lugs on the correct store pallet. The placing of the store pallets in the far side of the lane on which the load was being built for the fresh products, precluded the insertion of any chilled or frozen products into the same lanes. The chilled products were therefore assembled in a separate area. The frozen products were also held anywhere that the floor would allow, as no designated area for the frozen products was actually available.

4.4.5 Inbound transport scheduling

No transport is scheduled onto the cross dock doors. The process is a first come first served for the fresh produce transport. The receiving for the chilled and frozen is done on a separate dock on the far side of the facility and does not influence the operation of the cross dock.

As the transport is not scheduled, periods occur where the trucks are queued and there are periods where no trucks are available. Normal operating times are used for the sort and the receiving areas. This means that during the lunch and tea periods no unloading or receipting of trucks is performed. The product is delivered in chilled transport. Approximately 50% of the transport delivers individual lugs and not palletised loads or lugs. For these products the lugs are taken out and placed on pallets on the floor of the cross dock. Where the transport delivers a number of products, each product is placed on separate pallets. This allows the receiving staff to simply count the lugs for each product type and receipt against a total count for each product. Labels are then printed from the WMS and added to the lugs. The labelled pallets are moved towards the sort area. The lugs are placed on the pallet with the base of 5 lugs and 8 high creating a 40 lug pallet. The sequence of label placement on the lugs is for each column of lugs to be labelled from top to bottom. This has an implication in the sort area as will be discussed later.

4.4.6 Transport measurement

The receiving is driven by the SPAR belief that they need to turn around the supplier trucks as fast as possible. Delays are measured from the transport arrival at the gate to the dispatch of the transport from the same gate. During the peak periods and in particular in the late afternoon and early evening, the only way the operation can unload the transport quickly is to pull the pallets into the sort area on the cross dock floor. This means that the receiving floor area progressively encroaches into the sort and assembly area as the day progresses. The pallets are placed as the operations staff see fit as there is no particular instruction as to placement. This means that progressively more and more pallets are now blocking the normal operation of the sort, and the sort is taking place in an ever increasing area of congestion. Pallets now also have to be moved for labellers to access the four sides of the pallet as the lugs are labelled. This, coupled with the movements necessary to allow the sort to progress, introduces something approaching 50% more moves than was necessary in the operation. It significantly reduces the effectiveness of the receiving, sort and assembly areas. The only parties that benefited by this practice were the transporters, who had fast turn around of their trucks. This measurement had been in operation for a number of years without question.

4.4.7 Period of operation

Receipt of product occurred between 8 am and 10 pm. Peaks occurred in the early morning and in particular the late evening period around 4 – 7 pm. The operation managed to complete the sort and do a reconciliation (nominally) somewhere between 12 pm and 1 am of the following morning. This was two hours of overtime per night shift.

4.4.8 Measurement of receiving effectiveness

The overall operation essentially changed from a normal cross dock operation and began to focus on the transport in the mid-afternoon. To accommodate the transport peak, the available staff all helped with the unloading, leaving sortation to take place later. The peak in the afternoon was the greatest problem. By 5 or 6 pm the receiving floor had occupied virtually all of the sort area. This dramatically reduced the sort effectiveness.

4.4.9 Labelling of lugs on a pallet for the sort

The problem of the labelling of the 8 high pallets in columns from top to bottom was evident during the sort process. A sorter would pull the pallet using a pallet jack towards the appropriate lanes. As lugs are taken from the first column so the stop and start movement of the pallet made the other columns unstable. Due to this instability, as the lugs are taken off the second and subsequent columns, the pallet was dropped to the ground. As a large number of these stops and drops to the ground occurred so the overall time for the sort increased by anything up to 40%.

4.4.10 Sort of fresh products

Lanes were created for every store. The lane length was for the maximum number of pallets that would be delivered to the store. This committed floor area to the peak lane requirements. Lanes were numbered and these numbers matched the lane numbers on the lug labels. Pickers moved the supplier pallet of lugs past the lanes and where lugs were destined for the store in the lane these lugs were taken from the supplier pallet and walked to the furthest point in the lane where a store pallet was being built. This was a long walking distance and decreased the effectiveness of the sort. The floor area is used extremely ineffectively. Frozen and chilled products on pallets need to be stored in temporary positions until the fresh sort is completed. These pallets can then be moved into the lanes and the total load for a store reconciled.

4.4.11 Reconciliation of the product in the cross dock

Reconciliation cannot be done with any accuracy as the density of the pallets within the lanes, where a gap of 100 mm is available, means that all that can be determined is that a specific number of pallets exist for each store. The standard pallet size for the lugs is 40 per pallet and this is assumed in the final reconciliation. In some shifts the pallets in the fresh lanes are pulled out of the lane until a clear area is reached, a check is then done to determine all the lugs are for one store, and then wrapped so that the pallet becomes a single consolidation unit. This is not done on all shifts and the check that is inherent in this is valuable for the reconciliation. However it does occupy space and personnel and requires a movement of the pallet from the lane outwards, which again impacts on the area for the sort.

4.4.12 Dispatch

The dispatch of the product occurs only after the last lug of fresh product has been sorted and the final pallets from the sort are placed in the correct lanes. Reconciliation is not done until the truck is loaded as this is the only time that a count of all the product is available. A completely different team is used for the loading of the trucks. This is an outbound team and their primary concern is to load the truck with the correct pallets. It is assumed at this point that the fresh product pallets contain the lugs destined for the correct store and that the pallets with chilled and frozen products on them have been checked. While these latter two pallets probably have been checked to a reasonable extent, the lugs have not in most cases. The product is loaded and, once complete, transport remains at the facility until early morning deliveries commence.

4.5 Improvements

As a continuation of the research the analyses were presented and recommendations were made to the company. All the suggestions were proven valuable for the cross dock. As this was research and not an executive role, the implementation was in the hands of the operations and other considerations prevented the full value being realised in all cases. However all the principles and recommendations for improvement were as a direct result of this research.

The recommendations and the outcomes are presented for the problems for the cross dock.

4.5.1 Variation in work loads

The analyses from this research showed the magnitude of the problem. The stores that were the primary cause of the very large fluctuations were adamant they would not change and the DC was not prepared to move to a four day week for these stores as an incentive to change. The operation continued to suffer with these peaks, but at least they could understand the primary cause of the ongoing problems.

4.5.2 Flows in the facility

There is little that can be done to change the flows as these are inherent in the design of the facility. What the research analyses showed was that operating times could be altered to minimise the impact of these flows. The frozen products were done in the morning and into the early afternoon. The pallets were placed back into the freezer until the final loads were being assembled and checked and then moved out. Those products that could not be accommodated in the freezer, were placed in insulated boxes on the floor adjacent to the freezer belt sort. The entire freezer product therefore has the cold chain improved for the products that went back into the freezer, but the products did not interfere with the fresh sort or the movement of the chilled products into the assembly lanes.

4.5.3 Sort system for frozen products

Extensive work was done to analyse the sort logic and the underlying causes for the problems. These were then removed by re-writing logic in the controller system. This logic code and re-engineering was outside the scope of the research on cross docks, but highlights the problems of using automation in any facility and brings practical lessons to the research. Chapter 10 reflects these and other lessons as applied to the cross dock.

4.5.4 Receiving of lugs

Measurements from the research showed that the receipt of the lugs as individual lugs was slightly more effective for the volume in the transport. The time taken to unload and to then place these lugs on a pallet, plus the space required in the cross dock facility made this far more expensive. This was shown to management. All the transporters were made to bring products to the facility on pallets. The impact of this was to free up space in the cross dock, and to reduce the time taken for pallets to be unloaded. Where pallets contained multiple products (this was the reason for placing each product on a separate pallet) these were identified by a layer insert between the end of one product and the start of the next. Products were ordered in quantities of five so there was always a layer.

4.5.5 Inbound transport scheduling

The research showed the transport needed to be scheduled to create a more even work flow. This scheduling was particularly important during the day to moderate the peaks in the early morning and late afternoon. This late afternoon peak was a problem as it was a direct cause of overtime later in the evening. The research was accepted, but the implementation was only done partially as the buyers were not prepared to remove the flexibility of taking a transport when it arrived. This was necessary in the buyers' minds as there was a shortage of suppliers with the correct quality. Nevertheless the effect of the scheduling when it was applied correctly, showed significant improvements in time taken to complete the cross dock work with the same number of personnel.

4.5.6 Period of operation

The research showed the sort area had to be free of obstructions and simple flows, otherwise the effectiveness decreased rapidly. This was obvious here. The rule was that the pallets received had to be in a receiving space on the floor, and once these spaces were full, no additional pallets could be unloaded. This simple rule, derived from the research, dramatically improved the effectiveness of the operation.

4.5.7 Labelling of lugs on a pallet for the sort

The work done to move the products on the pallet drastically increased the time taken to sort the lugs from a pallet. Video showed the problem and the entire process was changed by the simple method of changing the lug labelling process. The labelling was done for the top half of the columns first and then the lower half. Tests in the research showed the splitting into two halves was sufficient to ensure the columns of lugs were stable enough not to require the pallet jack to be lowered at each sort location. The process also fitted with the multiple products on the one pallet as each product then makes a natural break in the vertical column of lugs.

4.5.8 Sort of fresh products

The layout of the entire cross dock was re-engineered. A central aisle was created for the sort directly in front of the receiving doors. Blocks of lanes of equal length were chosen from the throughput information for each store. These blocks were chosen in size and quantity and location on the floor to provide the shortest move distance down the aisle. As the lanes extended to the aisle in all cases, the sort pallet was placed on the end of the lane closest to the sort area.

4.5.9 Reconciliation of the product in the cross dock

The lugs could not be checked to ensure the lugs on the full pallet being moved into the assembly lane contained lugs only for the customer. The new layout of the sort brought additional benefit as there was space to see the two sides at least of every pallet moved into the lane. This significantly improved checking.

4.5.10 Dispatch

Largely as a result of the analysis of the major problems in the cross dock and the calculations which showed the area to handle the sort and the receiving was too small, an expansion (R15m) was undertaken. A new area was created from an adjacent existing facility area that was designated as the receiving area. The area is adjacent to the main floor and contains two receiving doors. The operation has accepted that only two doors are necessary and that the receiving pallets are placed in this new area. While the tendency has been observed that they will continue to place pallets within the sort area, and thereby reduce the effectiveness of the sort, there is a better balance between the servicing of the transport from suppliers and the interference with the sort. Considerable work is necessary in this area to make it really effective. Scheduling has been effected to a limited extent. Management is not willing to drive this scheduling other than when it becomes a total disaster to the operation.

4.6 Conclusions

The research led to the management understanding, for the first time, the extent of the ineffectiveness in the operation and the reasons for the ineffectiveness.

The research introduced the choice of new operating methods and layouts by measurement based on effectiveness criteria. Significant improvements were introduced in the method of the sort and the receiving methods. The need for scheduling to improve the supply chain introduced the interaction of the cross dock and the supply chain. This design with analysis is rarely done for warehouses, and no specific reference shows how it should be done for cross docks.

CHAPTER 5
RESEARCH INTO THE PICK'N PAY FRESH FOODS CROSS DOCK

5.1 Introduction

Pick 'n Pay operate an automated facility to distribute fresh, chilled and frozen products to the Free State and Gauteng region. This facility, with two smaller versions in Durban and Cape Town, are the only cross docks in South Africa that are fully automated. The Gauteng facility is therefore an important one to research as it gives an insight into one of the alternatives that face the introduction of a cross dock and that is the materials handling needed to make the facility effective. As Pick 'n Pay have utilised the automated approach in the small centres of Durban and Cape Town, the question of cost justification is raised.

5.2 Background

Pick 'n Pay distributes perishables, being fresh, chilled and frozen products only. The facility started in 1996 as a new facility. The location was decided with the assistance of consultants, as was the means of material handling.

This replaced 3 other facilities – Pretoria, Bloemfontein and Johannesburg (City Deep). Prior to the new facility they used a combination of drop shipments to stores as well as the direct shipments from these facilities. With the new facilities the drop shipments were replaced and all the product was handled through the new facility. The logic was one delivery point and stores appreciated the single delivery as it reduced the staff and problems with the receiving bay having to be manned the entire day.

All the old facilities were manual operations. This meant the facilities were subject to longer lead times in the supply chain, particularly when the volumes increased. The old facility suffered from late deliveries and long lead times due to manual processes, the problems with volume changes and the lower labour productivity as opposed to sortation equipment. The new systems introduced a much more productive system, as the manual sort process is removed and replaced by an automatic sortation capability. The estimated delivery times were of the order of 3 to 7 days. The new system was designed for and is operated at 48 hours cycle time, and they have reduced it to 36 hours, with increased volume. The size of the new facility is smaller than the sum of the previous three facilities, and the result is a reduced building cost with an increased sortation / automation cost. The automated facility improved quality due to the reduced lead times and the reduced handling necessary for the automatic process.

5.3 Suppliers

The suppliers deliver the required amounts of product in lugs. The lugs have a lug barcode which is attached by the supplier. The barcode label is a nameplate number which identifies the product only. Suppliers buy the labels from a label manufacturer and stick them on the lugs as required. The labels are all produced by one label producer; the only labels that are printed by the supplier itself is the variable mass labels for such items as cheese.

The move to lugs occurred before the move to the new facility. The advent of barcodes occurred with the move to the new facility. The conversion to the barcode was a major problem. It is simple and effective as the supplier buys labels only for the products it is contracted to supply. To convert to the barcode Pick 'n Pay did a number of seminars to alert the suppliers and to discuss the application of the bar code. As the sort is automated, if no bar code is present on the lug, then the products cannot be accepted. While Pick 'n Pay have label printing facilities in the DC, these are available at a cost to the supplier of the delay to its truck and a financial charge for the printing.

Pick 'n Pay schedule to bring as much as possible as early as possible. The larger orders are often left for the later periods of the day.

5.4 Stores

The facility serves 186 stores in the Transvaal, Free State, and surrounding areas including Upington. There is no scan into the stores, but the paper POD is still used. They are looking at the electronic route. The stores do receive an electronic download of the data for each invoice, but don't use it at present.

Deliveries are being reviewed. The current thrust is to create cold rooms for receiving at the stores. The product will be delivered into the room at night and then removed the next day. There are 11 such cold rooms at stores and more are planned. This is accelerated by the Gauteng ban (or proposed ban) of trucks in the early morning and afternoon peak traffic times during week days, that was scheduled to come into effect in 2003.

5.5. Process

The buyers fax / email the order today. Suppliers confirm back to the buyer today within a specific time limit. The confirmation of less than the desired amount may require the buyer to try to source elsewhere, if the quantity falls too low below his desired amount. All the major products with shortest life times are sourced from at least two suppliers. Delivery is effected by the supplier tomorrow and then Pick 'n Pay delivers partly tomorrow and completes the deliveries the next day.

The systems are being enhanced to allow the creation of an order on a computer at the store and for this to then be submitted directly into the WMS system. The WMS then places the orders via fax or other means acceptable to the supplier.

5.6 Systems

All systems are in-house and not packages. The only exception is specialist packages such as the sortation system. The belief is that the in-house route gives greater flexibility and the system can be tailored to the Pick 'n Pay process, not the process tailored to the systems methodology.

The initial conversion to the automatic sortation was fraught with some problems. The first day they struggled to do 3000 lugs. Problems with the flat file transfer to the sortation unit were the primary issue. Today the facility handles 50 000 to 60 000 lugs per day, and 5 000 to 6 000 lugs per hour.

5.7 Costs

Overall comparison costs for distribution can be seen in table 5.1. The Full Maintenance Leasing (FML) costs for trucks are included in the transport costs.

Table 5.1 Cost Comparisons

	Cost / sales	Distribution R / lugs
M&S	4.2%	
Tesco	3.8%	
Safeway	3.0%	
Woolworths	4.7%	
P ‘n P		2.07
Woolworths		4.57

5.8 Transport

Transport uses a diesel additive that has improved effectiveness by 12.5% with attendant emissions improvement. Mercedes Benz are resisting acknowledging this additive, but are being pressurized by Pick 'n Pay.

5.9 Sort

The sort is done based on the total ordered by the store. The quantity of product ordered is allocated pro-rata to the stores ordering the product, with a minimum quantity to each store.

The lugs are received against a specific order. Each lug has a unique barcoded number, which is then linked on receipt to the product ordered from the supplier and the order details. The sort system uses this barcode number to recognise the product and to then perform the sort process.

Currently doing 45 000 – 50 000 lugs per day through the facility.

5.10 Scheduling of suppliers

This is seen as a major issue. Pick n Pay now choose the larger volumes in the early 'part of the day to promote the movement of the goods into the sort. The aim is to maintain the sort throughput. The operating staff do not work staggered times to get a continuous input to the sorter, but shut it down for lunch and two tea times. This is primarily due to the need for labour to pack from the discharge lanes, although the sorter could easily work through the tea times as the sort lanes are of sufficient size to accommodate reduced offloading for a short period.

The corporate stores receive deliveries of the goods ordered seven times per week or once per day. The non-corporate stores receive deliveries three times per week.

5.11 Assembly

The delivery is done using rolltainers. No pallet jacks are used for transport other than the rare occasion where pallets are used. The vast majority of the product is moved via the rolltainer. The rolltainer means that there is no need for wrapping, and insertion of the pallet jack into the pallet. It is simpler for the store as well. It is a pre-requisite for the stores that are taking after hours deliveries as the rolltainer can be sealed and left in the store storage room.

The areas on the floor after the sort are used to store the goods in assembly lanes. The lanes are augmented with the trailers at the door to give additional space. The aim is to minimize the outbound cost of transport, DC floor area, and store receiving time and area. The orders are packed into rolltainers from the sort unit. There are specific rolltainers for specific types of product, so the packing may be into anything up to 12 different rolltainers, but this includes frozen products and imported products. There are usually only 3 or 4 rolltainers for the different categories of fresh products, plus one each for chilled and frozen products. Each rolltainer is invoiced separately. This means that the scan is to open the rolltainers, then to fill and then close. A packing list is then available, followed by an immediate ability to bill and deliver the rolltainers. The advantage is that the delivery is not contingent on the entire order for the store being available in the dispatch lane, but rather on an economical load. Approximately 30% is dispatched during the day the order is received.

5.12 Non-sortable products

Non-sortable products are handled differently in a separate area. These are fruit etc that needs to be picked into lugs or placed in a ripening area. The ripening of fruit at various temperatures was scheduled for a new facility in late 2003. Currently it is in one temperature zone only. The pick is done by hand using a pick list into a rolltainer. These are then delivered into the dispatch area.

5.13 Receiving

The information is recoded into the system by scanning the barcode on the lugs received from a supplier. The closure of the receipt is done by a lug with a special code to indicate a complete order. Once this is processed an Acknowledgement of Order Receipt is printed out. It can be sent to the supplier electronically, but currently is signed and handed to the driver.

5.14 Delivery

Delivery is done on the Packing list / Goods Received Voucher (GRV) note. A data file is sent to the store with the packing information for each rolltainer and the store can then manually check the rolltainer. In future the intention is to have the ability to scan the goods from the rolltainer for a full check.

There are 75 trucks in the Pick 'n Pay fleet and these service 168 stores. Of these, 11 stores receive night deliveries of rolltainers into small cool rooms and access for the delivery staff is via an external door to only this room. These rooms are being constructed and tested. The delivered rolltainers then stay in the room until the morning when the store staff access the room from the store.

Pick 'n Pay is trying to use their own transport on the return / empty legs to replace supplier transport in order to cut the cost of the product.

Routing of the trucks is done manually. Pick 'n Pay tried system packages and these produced no real benefit. They are not averse to packages, but the knowledge from the staff is extensive and is used to do the routing without problems. The biggest problem is the large variability of the product volumes per day and week, which makes the alteration of the parameters in the systems very difficult to achieve.

5.15 Success factors for the sort

The reasons for making the automated sort work were given as follows. Initially the system could only do 3 000 lugs per day; this was mostly caused by system integration problems. The facility struggled in the initial period to make the sort work. However, the staff were aware that there was no alternative. The goods were needed, and the sortation system needed less staff so they "had to make it work."

The DC has also moved all drop shipments to the DC. This means the delivery is into the DC and only the DC delivers to the store. This considerably reduces the time staff are required at the store for the receipt of goods.

5.16 Conclusions

The research shows the impact of the automated movement and sort in the facility. It lacks flexibility and cannot be altered to accommodate other induction areas for items such as fruit. The handling of fruit is a second channel in the facility and is ineffective and occupies space. The automated facility requires a secondary sort, which utilises additional space.

The research also shows the value of the requirement to make the facility work. There was no other alternative and the facility was made to overcome the initial problems. The conversion of suppliers to use lugs and the labelling of the lugs by the supplier was accomplished without major problems.

The scanning of the products from the automated sorter to the secondary sort rolltainers, allows the reconciliation of the received and dispatched products to be done simply and effectively. This scanning allows the creation of the rolltainers as a delivery consolidation unit that can be invoiced. This means that the separate rolltainers which comprise a store order, can be sent to the store in different trucks and at different times. This flexibility is far more effective than the system researched in SPAR, where a whole order must be assembled for delivery.

The research shows the advantages and problems of automated facilities. This research is invaluable for comparison with the more common manual processes.

CHAPTER 6
RESEARCH INTO THE WOOLWORTHS FRESH FOODS CROSS DOCKS

6.1. Initial stage

Woolworths has progressively grown its frozen, perishable and long life foods throughout the country. This has been augmented by the realization that stores that sell both textiles and foods enjoy greater purchases per customer than those stores that have only one of these two ranges.

The KZN facility was created in the 1990's as a distribution centre for foods. It receives some perishable product from suppliers, of which 20% is retained with the remainder 80% being trunked to Johannesburg. The majority of the products 80% are received from Johannesburg. It handles Frozen, Chilled and Fresh products (Perishable products) and mail for Woolworths. Perishables include the ambient longer life food products such as long life milk, bakery products, etc.

The DC services 14 stores in KZN main cities and towns.

6.2 Current Use

Essentially no storage is utilised in the facility and it functions as a pure cross dock.

Two distinct supply processes take place:

- The first is the movement of the frozen products. These are picked in Johannesburg into Thermotainers (Cold Boxes) for each store. Thus the Cold Box or Boxes destined for the store are loaded and sealed in Johannesburg. These are then sent to Durban in trunkers and received into the facility, cross docked and placed in the appropriate dispatch lane.

- The perishables are the second supply chain. The perishables are bulk picked in Johannesburg and moved to Durban. The dolleys are received into Durban DC. The receiving process is complicated by the WMS need to have all the same product on each dolley. The WMS requires that to receive a product a label must be printed and affixed to the dolley. The label is for one product on one dolley. As this one product rule is counter-productive to the filling of the truck, dolleys are loaded with multiple products. Each received dolley with more than one product needs to be unpacked onto one dolley for each product at the cross dock and only then receipted. The dolleys are then moved to the sortation area.

All the frozen products are picked in Johannesburg and placed into Cold Boxes which are in two sizes. The smaller is only 1.6m high and the larger is closer to 1.9m high. The base is the same as the dolley that Woolworths has developed. The boxes are fitted with CO_2 to keep the product below the –18 °C necessary for preservation of the cold chain. Problems exist as the boxes are often delivered to Durban stores with no CO_2 left, and the product is above the minimum temperatures for products such as ice cream when delivered to the stores in summer.

Woolworths are considering the use of a small trailer at –25 °C to transport the frozens in bulk to Durban. The sort in Durban would then be into the frozen boxes and then to the stores. It is hoped the time in the chilled atmosphere in Durban plus the effect of the frozen boxes, will preserve the cold chain.

6.3 Impact of WMS

The WMS system is the Triceps WMS produced by OMI.

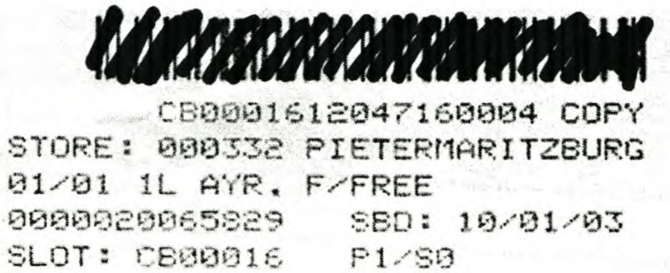
The WMS appears to handle the pre-picked cold boxes with the minimum amount of problems and touches. A delivery label is attached in Johannesburg and received into Durban. It is moved to the correct store assembly area and then a dispatch label from Durban is affixed for dispatch.

However the process is far from ideal in the receipt of the mixed pallets for the perishables. The need to have one product on the dolley to receive means that a substantial amount of work is needed to receive the product. In the cross dock environment, the dolley is received and immediate sortation begins. The life of the dolley as a receiving coded item is so short as to make this ineffective.

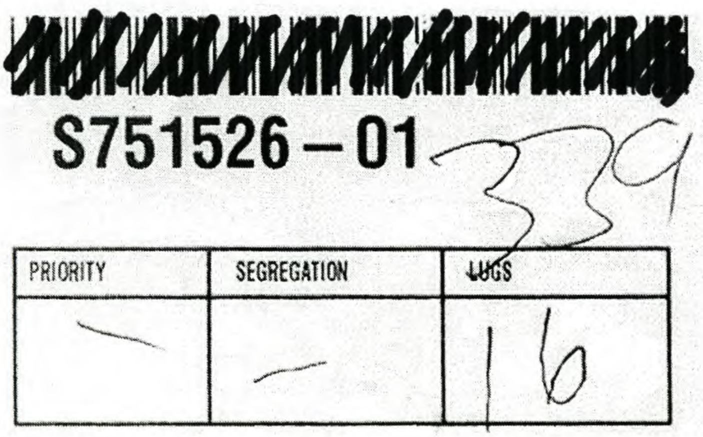
The receiving process applied is that of the normal receiving methodology. The ASN is received. The truck arrives and the dolley is unloaded. The quality and quantity is determined and the WMS prints the appropriate label for the dolley. This bar coded label reflects the product code and the other product details, the Purchase Order and then assigns a unique number to the dolley.

The lug labels are scanned into and out of the facility. The lug labels are scanned in the pick area for the perishables. The lugs are scanned on a particular dolley and then a dispatch label is printed and added to the dolley. This means that every dolley has a known quantity of lugs and the product in each lug is known. The entire facility can then be reconciled with minimal time, particularly with an empty floor. This "Pick Balancing" is the reconciliation of the total picked lugs to the total received lugs into the facility and the "Load Balancing" is the outbound to pick reconciliation. As the dolley is scanned into the truck the attachment of the dolley ID to the truck ID removes the dolley from the available dolleys to be loaded.

Lug Pick Label

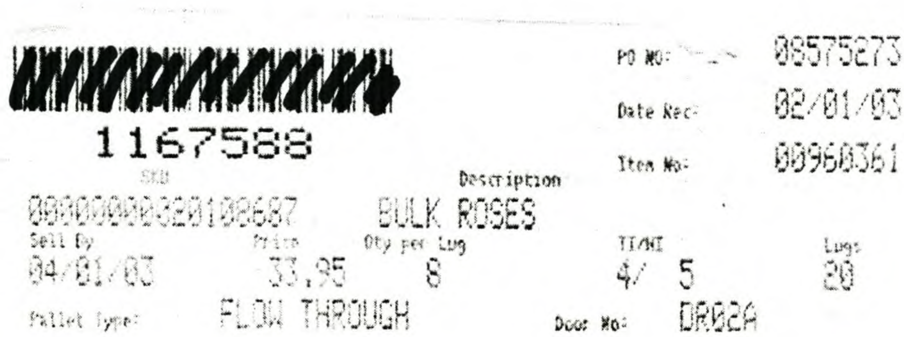

CB0001612047160004 COPY
STORE: 000332 PIETERMARITZBURG
01/01 1L AYR. F/FREE
0000020065829 SBD: 10/01/03
SLOT: CB00016 P1/S0

Ship Pallet Label


S751526 – 01 339

PRIORITY	SEGREGATION	LUGS
—	—	16

Dolley Receiving label


1167588
PO No: 08575273
Date Rec: 02/01/03
Item No: 00960361
SKU: 0000000320108687
Description: BULK ROSES
Sell By: 04/01/03
Price: 33.95
Qty per Lug: 8
TI/HI: 4/ 5
Lugs: 20
Pallet Type: FLOW THROUGH
Door No: DR02A

6.4 Handling of suppliers

The suppliers are scheduled to arrival times. The number of suppliers is low as the majority of product is received from the Johannesburg depot. The schedule of the high

[redacted]

[redacted]

[redacted]

volume, long distance transport from Johannesburg, which in effect is the main supplier to the cross dock, has a problem as the last trunker arrives at 02:30 and the first deliveries leave the facility at 03:00. This means that product that is received in the later long distance transports is never available for the first deliveries. This impacts on the ability to provide Priority 1 deliveries as requested by the store. Priority 1 deliveries are those that are required to replenish the shelves of a store before opening. Priority 2 is product required to replenish product during the course of the trading day.

6.5 Method of sort

The sort is done for the perishables only. The frozens are pre-allocated to the store in Johannesburg and a freezer box contains product for one store only. The sort is the pure cross dock of receiving and move to the appropriate lane for the store.

The receiving is done on the one side in line with the primary receiving door. The movement and sort is from this side to the side adjacent to this (i.e. opposite the doors) and then into the store receiving areas.

The sort is characterised by the allocation of the product into two Priorities – namely 1 and 2. Priority 1 takes approximately 60% of the volume. Priority 2 is the remaining 40%. Each of these priorities is broken into six segregations of product. The segregation is chosen for Fruit, Vegetables, Salads & Take Away, Dairy, Chilled Deserts, and Value Added Meats.

Sort and Picking is done manually and no Radio Frequency (RF) is used. Picking labels contain a label per lug, which contains the product ID, the ID of the store and an ID of the lug.

6.6 Method of assembling

The assembly lanes for the stores occupy a large proportion of the floor area. Each lane is large enough for more than one truck, appropriate for the store load size. The front of the lane is divided into six areas for the Priority 1 and segregation of the products, and then a metre into the lane a second area for six dolleys is made available for the Priority 2 products.

The dolleys can take 18 lugs.

6.7 Dispatch rules

Scheduling is done manually and in routes. This is fairly ad hoc at present as there are limited stores and a limited number of trucks.

The stores can be sent a Store Delivery Note (SDN), but the transfer is done on a paper POD and via a store signature. The PODs are filed. The store has 24 hours to register a claim against the DC on product receipt; the DC has the same time to register a claim against the Johannesburg DC for shortages.

6.8 Design principles used to lay out the facility

The layout is primarily done to suit the requirements of the assembly areas. The receipt area and the sort area are along two adjacent walls and the assembly areas are in the centre of the facility. These assembly areas are almost square in shape and six pallets wide. The sort occurs into the front of the area. These areas are sized for the full number of dolleys at peak times

6.9 Areas used for receipt, assembly, dispatch and sort

The floor area is roughly square. The door to one side of the transport doors is used to receive trunkers. The product is moved on dolleys from the trunker and staged along the adjacent side. The side is only long enough for 32 dolleys so the trunker is only partially discharged. Then dolleys with multiple products must be broken down and reassembled onto one dolley per product. These dolleys are then moved to the next adjacent wall, which is the wall facing the doors, and sorted in this area. The sorted products are then moved into the assembly areas for the stores.

6.10 Impact on inventory and space

Space problems are leading to the consideration that the facility should move all the suppliers to the Johannesburg facility. Additional space will be required if the frozen products are to be moved in bulk via a small trailer and then sorted in the facility.

6.11 Transport inbound and outbound

Movements between branches give problems as the stores have restrictions – height and length primarily - on which trucks can be used. Thus if a truck picks up a parcel for delivery to another store for which the truck is not suited, the parcel must be moved back to the DC and then rescheduled for the new store using the appropriate truck. This is time consuming and occupies space in the DC.

Outbound transport is dedicated transport for Woolworths. The inbound supplier transport is by the supplier. The trunking is dedicated Woolworths transport.

6.12 Equipment

The original method was to use wrapped pallets to move the product to Durban. The process was highly manual and the process was "sloppy" in that reconciliations were difficult and time consuming. The manual process made it difficult to look at any queries, and while reconciliations could be done in the DC, the inter-DC reconciliation could not be done without major effort.

The current equipment is a dolley and two sizes of lugs. The lugs can be nested or raised so there are in effect four sizes – two different areas and each lug has two different heights due to nesting or raised. The lugs have lips to effect the nesting and these are progressively being coming weaker / damaged. This is influencing the products as they are being squashed. All dolleys have wheels. The cold boxes are on wheels as well. The perishable products are picked into rolltainers, which are on wheels. The rolltainer can be nested by turning the front half of the cage back on itself. The frame of the rolltainer is a U shape which slots into the back of the next unit, just like airport trolleys. A trunker can handle 64 dolleys while a normal large truck can handle 18 dolleys.

6.13 Conclusions

This research reflects the problems with designing a cross dock in an existing building whose shape and size is not suitable for the operation. The distance the items must be moved to perform the sort leads to a significant reduction in the effectiveness. The WMS that is used is also not suitable for the cross dock operation due to the need to place each product on a separate pallet on receipt. It highlights the need for skilled, flexible management. In this case the receiving delayed the process and occupied a large amount of space. The management did not consider the use of smaller consolidation units to take less space or even to put multiple products on a pallet with segregation (stacking on two sides with a gap in the middle). The sort process of picking from the received pallets along the outer walls of the facility, guarantees that the distance travelled is the furthest possible in the layout.

CHAPTER 7
RESEARCH INTO THE HOME DEPOT AND SAM'S CLUB CROSS DOCKS IN FLORIDA, USA

7.1 Introduction

Access was arranged through an operating company in the USA to work at and investigate the operations of two of the foremost cross dock operations in the USA, being the Home Depot and the Sam's Club. The majority of time was spent on the Home Depot operation as this was the more complex and far more interesting in that it operated with individual items, consignments, and with consolidation for routes. The Sam's Club is all full pallets, and the systems are good, making the operation very simple.

To gain access, the operating company asked for a measure of consultancy in reviewing and advising on what could be improved in the Home Depot operation. To reflect this the actual report that was submitted is included. The recommendations are part of this report.

7.2 Home Depot

7.2.1 Overview and Detailed Observations

7.2.1.1 Relationship

The facility is a tri-party arrangement. It is owned by Home Depot. It is run by Saddle Creek. The transport is run by Consolidated Carriers. In supply chain terms Home Depot Head Office arranges the inbound, the node is managed by Saddle Creek, Consolidated Carriers manage the outbound transport and the audit and quality function of Home Depot is present at the facility. All three parties are housed in the same administration area. The facility has a Home Depot representative, a Saddle Creek representative and a Consolidated Carriers representative with related staff.

Home Depot staff offer an audit function on products received which is very useful to minimize time as well as space, both of which are at a premium in this type of facility.

7.2.1.2 Stock Control in Store

Store orders are generated by a scan of an item code, on the store shelves or the storage locations, and then manually entering the required amount for each code. The order is then created department by department into a composite order. No POS information is gathered. Maximum orders come on Monday, following the weekend. Store hours are 6 am to 9 pm approximately, for 7 days a week (Some stores have later Sunday opening times). Store receiving is only on weekdays. Receiving may be done later into the night as per arrangement / scheduled delivery time for the truck. Individual stores have different rules for delivery times.

7.2.1.3 Formal and Informal Systems

The formal system is from Home Depot (HD). It is still in its infancy and has been developed in-house. The system is not linked to the distribution facilities, but there is no pull from sales. The inventory to order from store is done as per the Stock Control in Store section. The cross dock system is based on labeling in the facility. The label is for a purchase order (PO). Where the PO is greater than one pallet, then the PO labels have the pallet number and the total quantity of pallets in the order, hand written on the label. This holds for orders that are at item or carton level as well. Where the PO is less than a pallet, the Pallet is given a Master label and then all the PO's that are on the pallet are added to the Master label by scan – one level of consolidation above the POs. There are in effect three levels of consolidation – cartons to PO, PO to Master, Master to Load.

The system is not provided with a work allocation or an interleaving module. The value of this in the terms of a cross dock is not that high, but any warehousing must be less effective without this.

The paperwork system is the management of labels for the order. A Probill (Home Depot's number for a transport manifest) number is allocated to each transport, and labels for the items on the transport are pre-printed and placed into folders by administration staff. The folders are 'queued' until workers are available. The Probill Number of the printed inbound manifest is scanned and activated. The activation assigns a door for unloading, a staging aisle, and a loading door. The loading door is usually the same as the lane, but is not constrained to be so. The staging lane is assigned to the same store. The movers use the staging lane number for a delivery address.

7.2.1.4 Work Balancing

There are 6 loaders (Zoners) whose sole task is to move product into the trucks in their allocated zone. There are designated unloaders and verifiers. Labelers work two trucks simultaneously. Designated movers (Runners) move product to the staging lane – normally – or on occasion, and on instruction of the loader, into the trailer. All movement is done with forklifts which are gas powered in this facility. There is no manual work done other than labeling / verification of loads received.

7.2.1.5 Layout

The facility is rectangular with a small protrusion approximately 80% along one end where a wider portion has been created (where doors 116 to 130 are shown in Appendix I). The arrangement of the facility indicates that there are plans to extend the length of the facility so that the wider dock will eventually be in the center of the building when the full size is reached.

The layout is with two banks of 9 receiving doors each, with the banks situated on opposing sides of the facility. These banks are located approximately 67% along the length of the building. There are 5 doors on the larger dock width approximately 80 % along the length of the building. These doors are used for the break bulk and sort items as it gives additional space to work. An additional 4 doors are available on the one end of the I shape that is used for large, bulky items only.

The outbound doors are allocated to the stores from largest to smallest starting from the doors adjacent to the receiving doors to the furthest ends of the building. In principle this places the highest volume stores closest to the receiving section of the building.

The control platform is in the middle of the opposing 9 receiving doors and in the center of the width of the facility.

7.2.1.6 Scheduling

The first open receiving door is allocated to the trailers on a First Come First Served (FCFS) basis.

7.2.1.7 Business Volumes

Approximately 25% of the stores receive multiple trailers per day. The next 50% receive approximately one trailer per day. The remaining 25% receive less than one trailer. These trailers are either held for more than a day until full or consolidated with another store to meet the required service standard of at least three deliveries per week.

This profile will be exacerbated with the introduction of the smaller (3^{rd}) store size.

There are no major differences between days. Although Monday is the day of higher orders the deliveries are also spread due to the variable lead times of suppliers. Periods of the year do have an effect, but only minor.

7.2.1.8 Culture

The culture can be described as low key. There is very little of the raised voice and shouting that can take place in a high pressure facility. This indicates that the training of new personnel is done carefully and this was witnessed. The lead is problem resolution without finger pointing. This is perhaps one of the reasons the operation has performed well in the joint venture concept with Home Depot. Communication is also well established between parties. Conference calls are common, and small informal meetings are held continuously. The working relationship between the three parties is also well developed.

7.2.1.9 Reasons for Success and Failure

Success Factors

Layout and design of the facility suitable for cross docking
Understanding of the cross docking principles to make the operation work effectively
Type of products correct for cross docking.
Volume improves the opportunity, but needs more space and time.
Planning of inbound to outbound
People handling multiple tasks concurrently

Failure Factors

System is not really suitable for cross dock processes
Delivered components that are wrong or for which the data is incorrect incur a tremendous amount of time to correct

Problem Products

- Product that takes time or space or special handling
- Very large
- Merge in transit (barbeque components for Home Depot)

Wrong perceptions or understanding of what the cross dock would bring to the company. Home Depot told stores it would improve delivery times. In many cases it increased the delivery time, but reduced the costs significantly and probably made replenishment effort significantly lower for the stores (no chasing or worrying when truck arriving in multi-drop scenario).

7.2.1.10 Systems

At Clermont the estimated cost of the Home Depot effort of working around the system is of the order of $150 000 per annum.

7.2.1.11 Processes

The detailed processes are shown in Appendix II

7.2.2 Statistics

The following is a summary of the pertinent statistics for the facility and its operation:

- Facility of 159 doors.
- All doors are fitted with seals and dock levelers
- Low roof
- Metal Halide lights
- Use garbage compacter
- LPG power forklifts. Small machines with 1 000kg capacity. Have forks – single length and clamps. Clamps are simple ones with rubber internally for traction.
- Floor is floated and unmarked other than for walk areas. Barriers for walk ways around doors.
- Trailers (53') per day = 90 / day
- Average PO's per trailer = 19
- Shifts per day = 2 shifts Monday to Thursday 10 hours, 2 shifts Fri to Sun 12 hours. All four shifts are unique people. No problems of recruiting staff, tends to have younger on late shifts.
- People per shift = 32 peak, 27 average
- Cartons per pallet = 16.5
- Cartons per 53' trailer = 1718
- Store sizes = 130 000 ft2
    - 95 000 ft2
    - 3rd smaller size contemplated
- Each store must receive 3 deliveries per week. Does mean there is pressure to consolidate loads depending on the rate of orders received.
- Effectiveness measures

- Size of facility L = 1 000 ft 333 m
  - W = 115 ft 38 m
  - Area = 115 000 ft^2 12 800 m^2
  - Excludes wider dock area and offices above.

7.2.3 Potential Areas for effective improvement

7.2.3.1 Ideal Facility

The ideal facility can be characterized in a number of ways. However, for this type of facility, in simple terms the ideal facility has:-

- Minimum interference on the dock between machines or people movements
- Minimum distance move of pallets
- Minimum number of movements and pick ups and put downs
- No manual keying of any data

7.2.3.2 Operational Improvements

The operation is well run and successful. It is unlikely there will be any major improvements from staff quality changes or different personalities.

A measure of the loads that are moved from the inbound trailer to the outbound trailer without being placed in the staging lanes needs to become one of the criteria for the operational effectiveness. The current split of work into receiving, runners and loaders makes this difficult at present and introduces no incentive to minimize the put downs and pick ups. A measure could be taken directly from the system and improvements may well follow.

If there are to be significant improvements then three areas need to be looked at. These are

- The positioning of the receiving doors
- The scheduling or allocation of trucks to the receiving doors
- The systems from Home Depot and Saddle Creek.

Layout and receiving doors

The facility is an I shape with a small protrusion approximately 80% along one end where a wider portion has been created. The arrangement of the facility, as shown in Appendix I, indicates that there are plans to extend the length of the facility so that the wider dock will eventually be in the center of the building when the full size is reached.

The layout is with two banks of 9 receiving doors each, with the banks situated on opposing sides of the facility. These banks are located approximately 67% along the length of the building. There are 5 doors on a wider dock approximately 79 % along the length of the building. These doors are used for the break bulk and sort items as it gives additional space to work. These 23 doors are situated on average at 70% along the length of the building. An additional 4 doors are available on the one end of the I shape that is used for large, bulky items only.

The outbound doors are allocated to the stores from largest to smallest, starting from the doors adjacent to the receiving doors to the furthest ends of the building. In principle this places the highest volume stores closest to the receiving section of the building. The assumption is this minimizes the distances traveled. It is accepted that the 5 doors in the extended width dock must remain as receiving doors as these serve a useful function for handling break bulk. There is no reason why the receiving doors in the two banks of doors cannot be moved or separated, and in truth the separation will assist the operational layout. As the majority of goods enter the facility via the receiving doors situated heavily towards one end of the facility, the average distance of move is 70% to the one side and 30% to the other side. The move distances can be minimized by relocating the receiving bays towards the center of the length of the facility.

The configuration of the doors into two opposing banks adds problems. The receiving doors are currently set on opposing sides with no interposing outbound doors. This means the full impact of unloading the trailers is confined to one restricted area. While the aisle for staging between the opposing doors helps to reduce this congestion, this is a labour and machine intensive area. This is exacerbated by the requirement at present of having to move nearly 70% of the product into and past this area to the outbound doors. Interference in this area is present and can be reduced.

The above leads to the need to introduce the best configuration of doors for this type of facility. The closest to optimum is to have alternative doors of receiving and outbound, and the outbound and receiving doors to be alternated across the dock as well. The best quality outbound doors are sequentially allocated to the largest stores. Where routes are permanently made up of two or more stores, these should be treated as one door volume in these calculations. The quality of the door is determined by the sum of the distances to all the other doors. An adaptation of this may be necessary to utilize personnel effectively in this facility. At present the verifiers work two trailers for receiving simultaneously, and it may be advantageous to make these as blocks of two receiving trailers and then two outbound trailers merely to reduce the personnel requirement. This configuration also reduces the congestion issue as the work is now dispersed over a wider area.

The scheduling or allocation of trucks to the receiving doors

At present the trailers are allocated to the first receiving door that is open on a FCFS basis. There is an advantage to place the trailer at the most appropriate door for its load. The trailer should be located at the dock that minimizes its freight movement to the outbound doors.

One could illustrate the point with the case of the largest store being situated next to the receiving door in the one bank of receiving doors. A trailer with a large amount of product for this large store is placed at the furthest receiving door on the far side of the dock and on the other side of the facility. The minimum orthogonal distance traveled would be the equivalent of approximately 18 to 20 doors. It is therefore of importance to place a trailer on the correct side, and as close to the side on which the store outbound door is located, as this would reduce the distance to the major store to 4 to 5 doors on average. The placement of the trailer is expanded on later.

As the inbound trailers have known amounts of freight for known destinations, the most appropriate door can be calculated for the trailer. It is accepted that the docks for receiving are not left open to suit trailers. However, it is of significant value to wait until a reasonably appropriate door is free. This may also be improved by not using FCFS exclusively. When a door is open, it is feasible to choose, from the first five (or any appropriate number) trailers, that trailer that offers the lowest move distance for the door.

This ensures the trailers are placed in the most appropriate location to maximize the facility effectiveness.

The systems from Home Depot

Home Depot provides the supply chain and WMS system used. The system is still in its infancy and will take some time to develop to maturity. It is therefore sensible that cross dock operators should promote the changes with Home Depot that are needed in the future, and in the interim the changes should be effected by the cross dock facility. This has a practical value for the operation as well as a value added perception for Home Depot if handled correctly.

The current system has some issues that affect the operation. The data for inbound trailer loads is received by email or fax at the facility. Facility personnel manually capture the data into the Home Depot system. The inbound manifest is then produced and the appropriate PO labels. An ASN is received from Home Depot, but this is not utilized to update the quantities entered from the fax or email information. The verifier alters quantities as received directly into the system while receiving goods on the dock.

There are two problem areas. The capture of the trailer load details is time consuming and subject to error. The data should be inserted into the system in an automated format, eliminating all data capture. This is not a major issue in database programming, particularly if the suppliers utilize a spreadsheet formatted document. This is not ideal but, as an interim method, is perfectly sensible to do data transmission and capture into the system. Checks can be built into the import of the spreadsheet data to ensure accuracy. This will improve accuracy of information, it will reduce data capture time and will reduce the time the verifier has to spend altering the quantities. A further refinement can be to show which suppliers have the greatest error rate in their quantities. These should be subject to audit on a regular basis and some form of penalty.

The information in the system can be used to create a trailer allocation calculation that shows the most appropriate door for unloading its particular load. The extraction of the data from the Home Depot system will allow the development of such a system. Care must be taken to ensure all eventualities are covered in the system logic so trailers are allocated to the correct sector of the receiving doors, and no trailer waits unnecessarily. The system can be modified with reasonable speed to suit the operation until the maximum value is extracted. In the future this may well be offered back to the client as value added information to be built into their system.

7.2.3.3 Overview of improvements

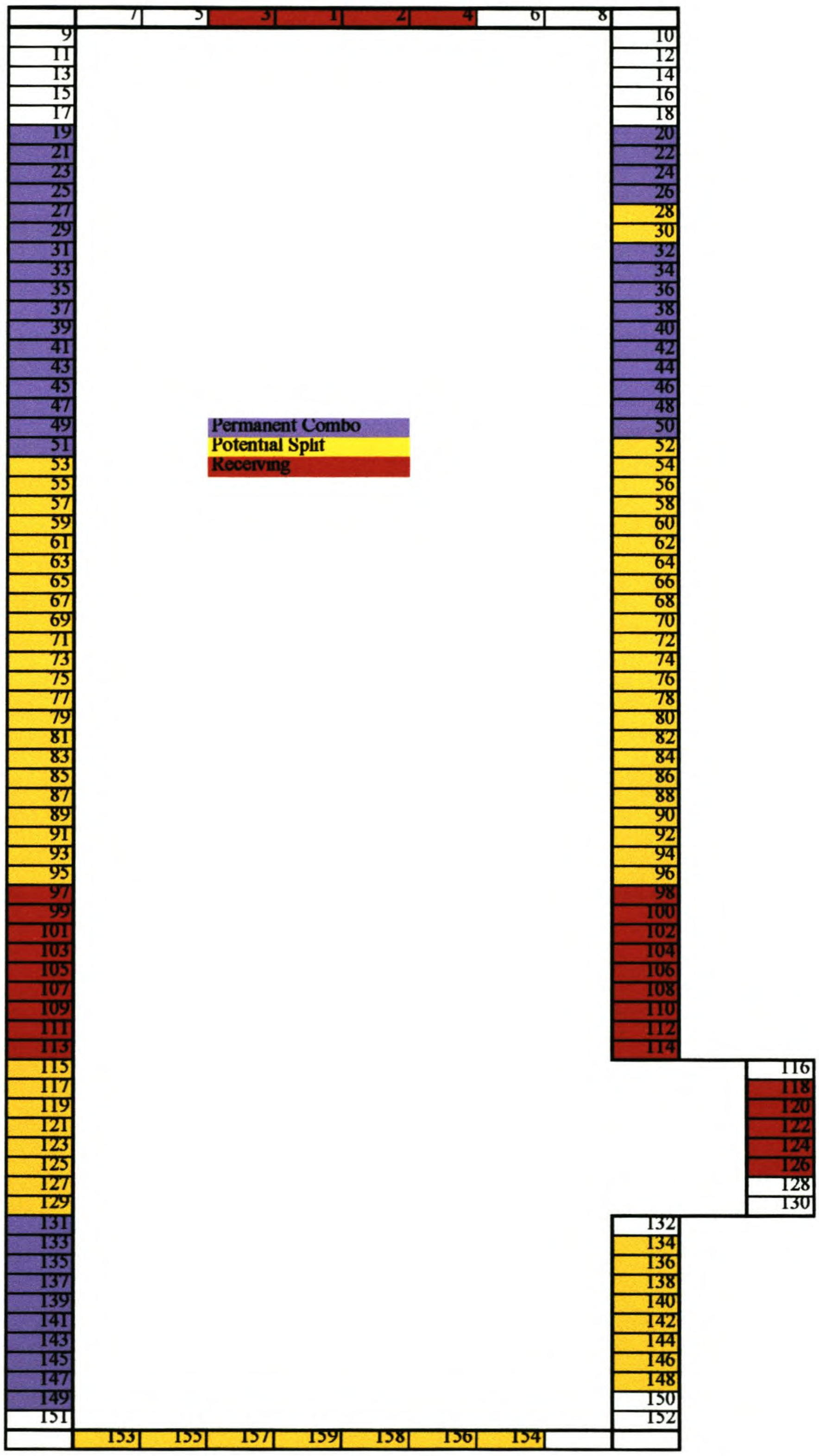
These improvements are practical and logical and will improve the overall operation. While there is a large amount of change management and some system development required, these can be effected relatively simply and with limited cost. To a large extent the system development needs to be driven by the cross dock operator, even if this means informal system development of a limited format is done by the cross dock operator. This could be, in the case of the data capture, a system that imports the data from the formatted spreadsheet and then does the verification and allows the update of the imported data. Once this is completed, the data can merely be exported to the Home Depot system.

One area of caution is necessary. The growth of the facility is obviously planned. The shape is also probably designated as an extension of the current rectangular shape. This may well not be the most effective design and may well reduce the current effectiveness levels the operator has achieved, negating the expected improvements from increased volumes.

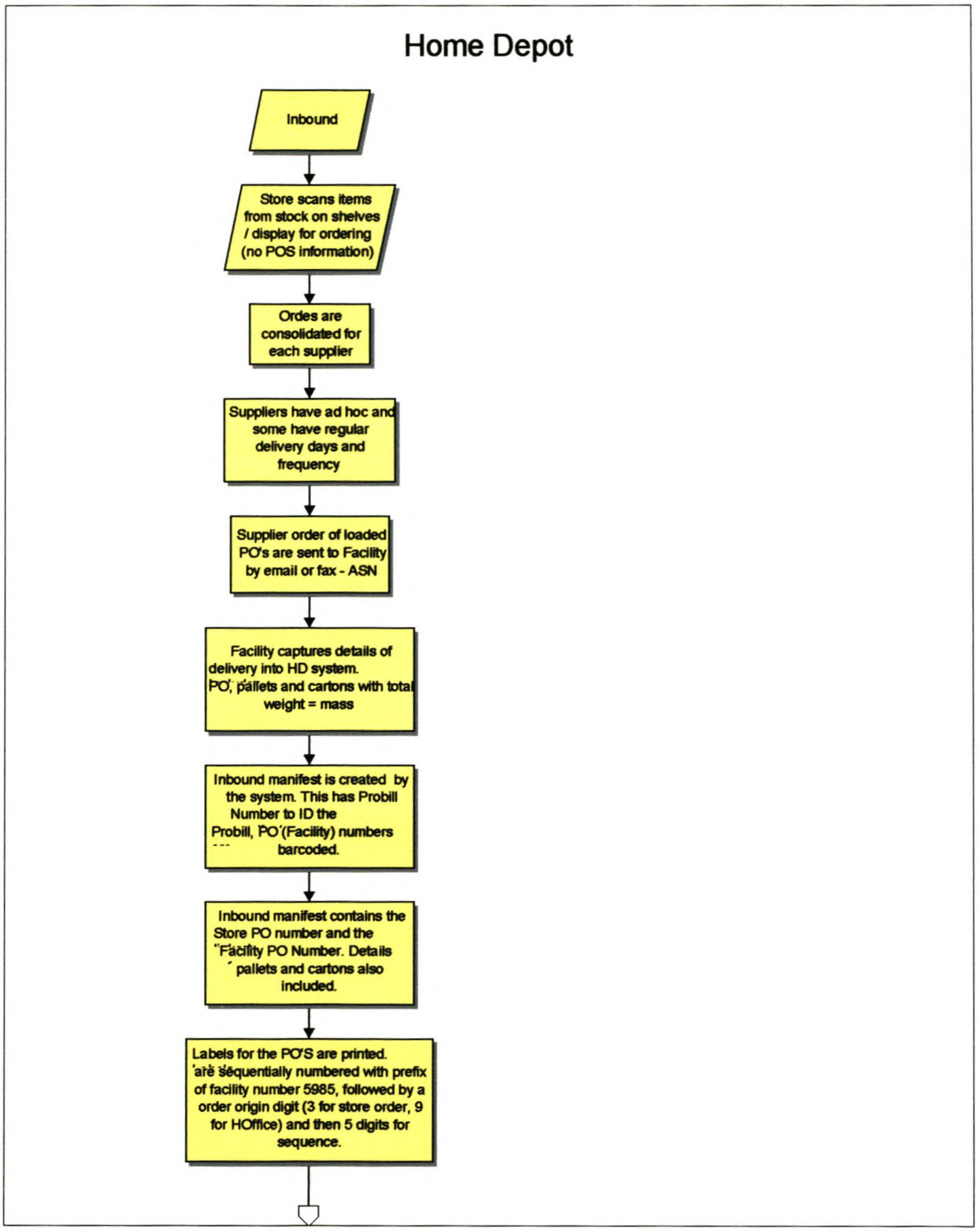
7.2.4 Appendices

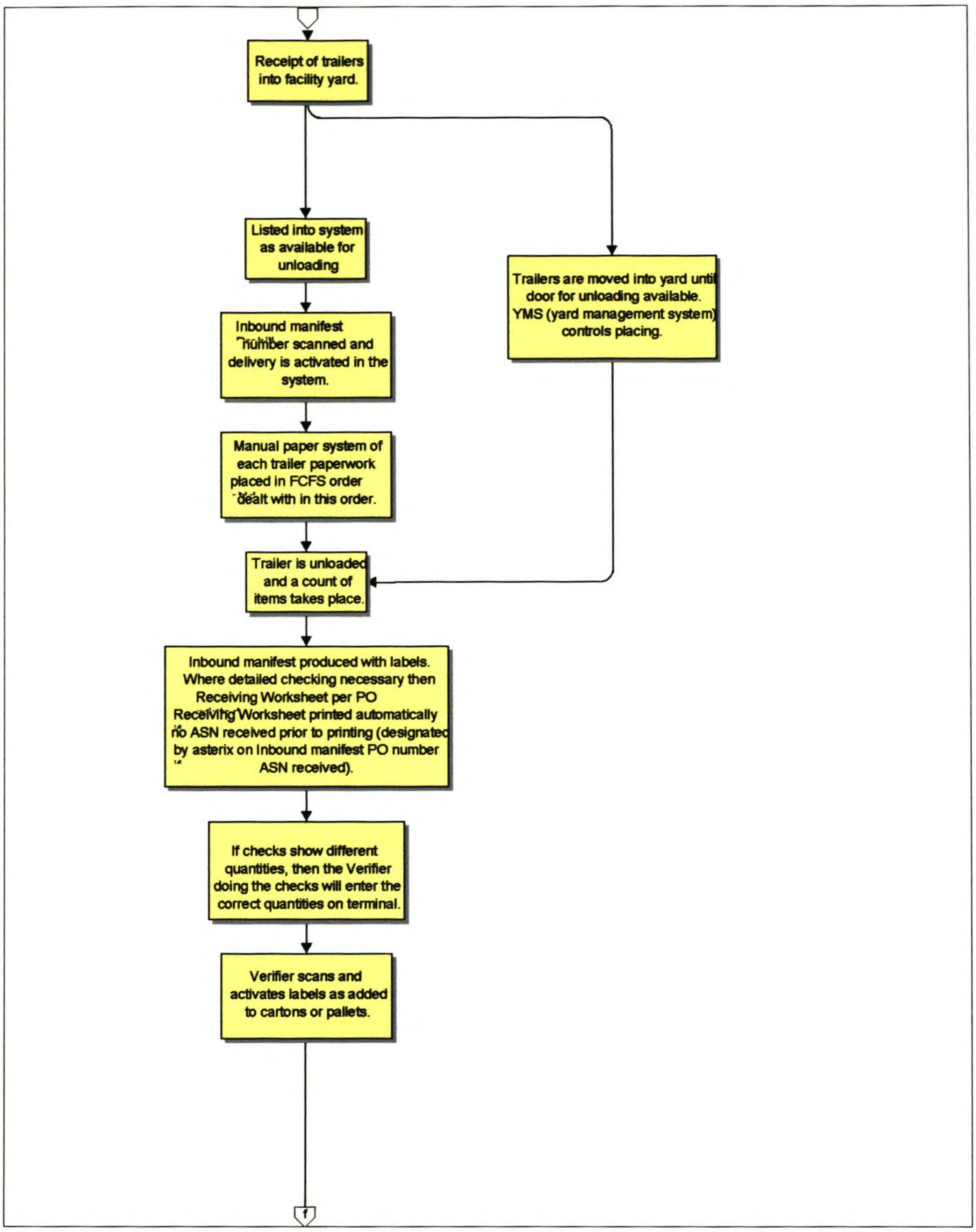
7.2.4.1 Appendix I: Layout

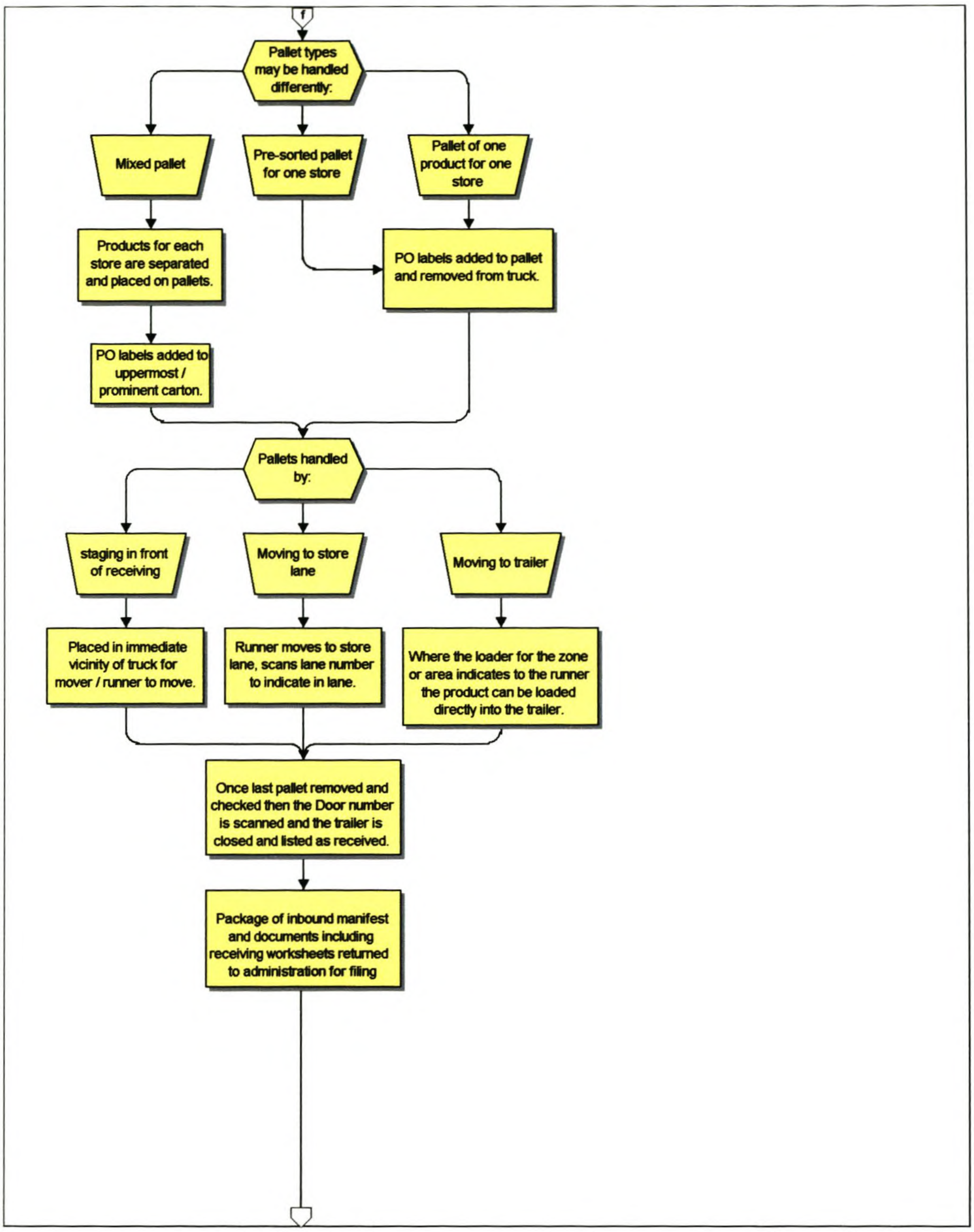
Home Depot Cross Dock Door Layout

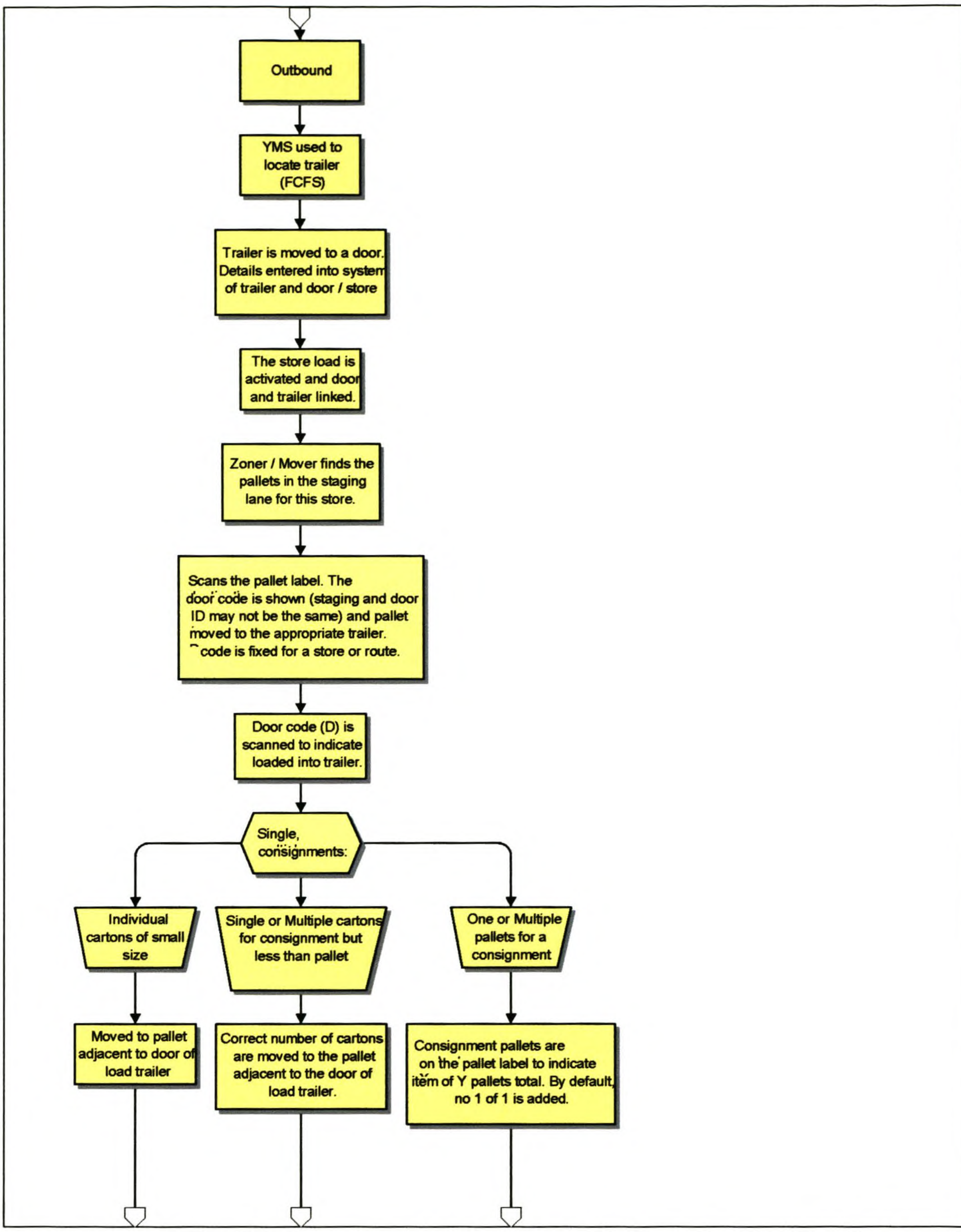


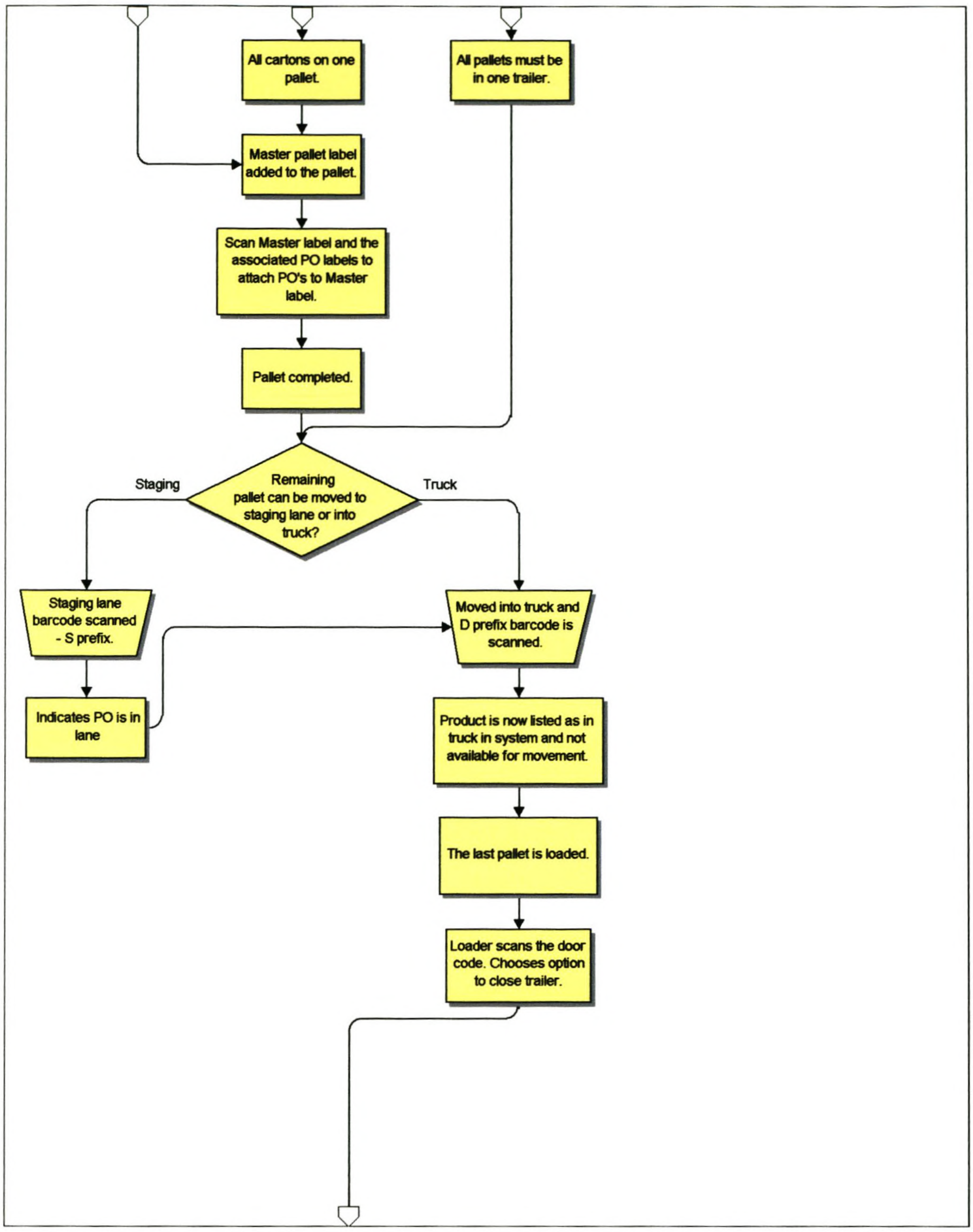
7.2.4.2 *Appendix II: Process Flow Charts*

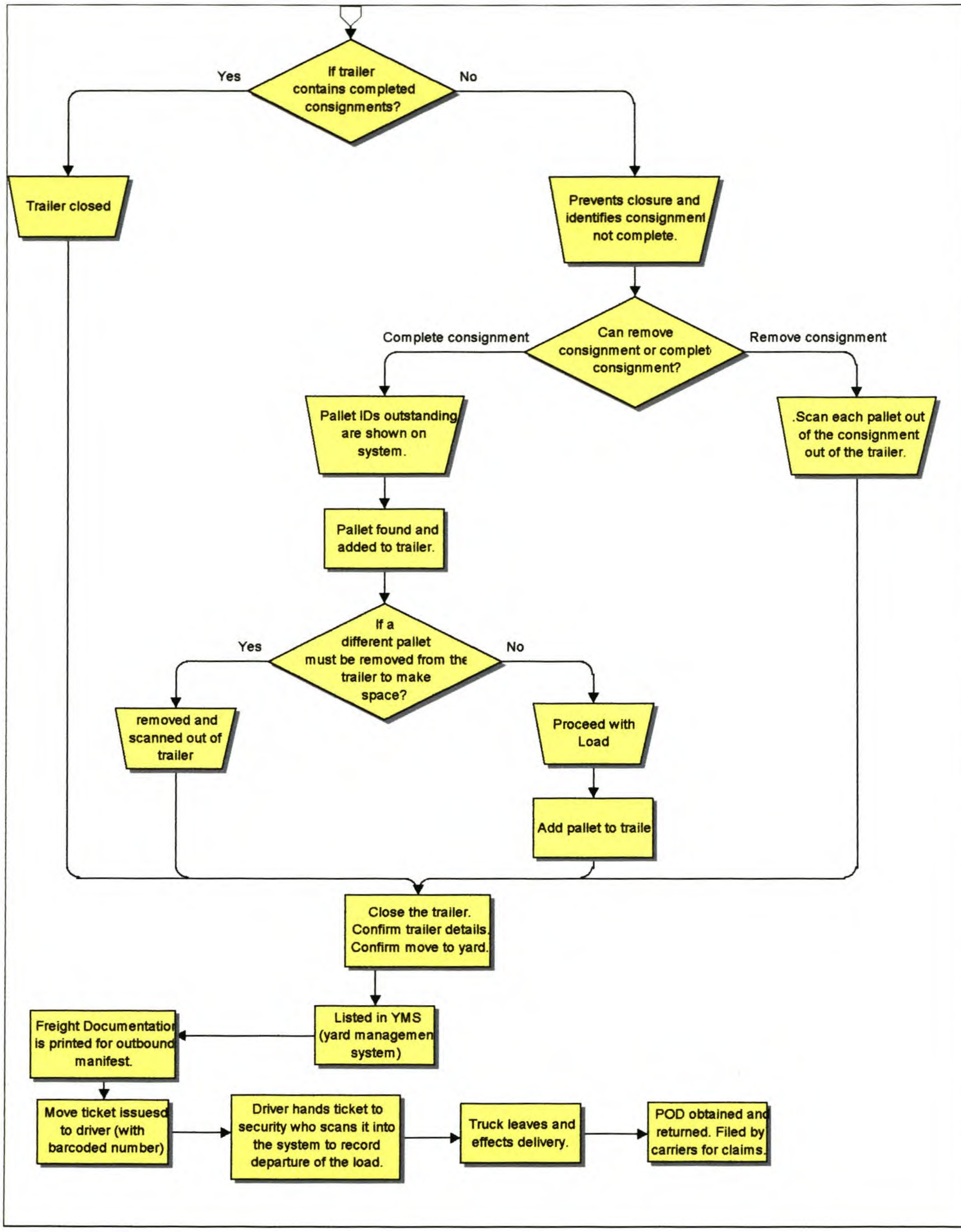



Receipt of trailers into facility yard.
Listed into system as available for unloading
Trailers are moved into yard until door for unloading available. YMS (yard management system) controls placing.
Inbound manifest number scanned and delivery is activated in the system.
Manual paper system of each trailer paperwork placed in FCFS order dealt with in this order.
Trailer is unloaded and a count of items takes place.
Inbound manifest produced with labels. Where detailed checking necessary then Receiving Worksheet per PO Receiving Worksheet printed automatically no ASN received prior to printing (designated by asterix on Inbound manifest PO number ASN received).
If checks show different quantities, then the Verifier doing the checks will enter the correct quantities on terminal.
Verifier scans and activates labels as added to cartons or pallets.
f


f
Pallet types may be handled differently:
Mixed pallet
Pre-sorted pallet for one store
Pallet of one product for one store
Products for each store are separated and placed on pallets.
PO labels added to pallet and removed from truck.
PO labels added to uppermost / prominent carton.
Pallets handled by:
staging in front of receiving
Moving to store lane
Moving to trailer
Placed in immediate vicinity of truck for mover / runner to move.
Runner moves to store lane, scans lane number to indicate in lane.
Where the loader for the zone or area indicates to the runner the product can be loaded directly into the trailer.
Once last pallet removed and checked then the Door number is scanned and the trailer is closed and listed as received.
Package of inbound manifest and documents including receiving worksheets returned to administration for filing


Outbound
YMS used to locate trailer (FCFS)
Trailer is moved to a door. Details entered into system of trailer and door / store
The store load is activated and door and trailer linked.
Zoner / Mover finds the pallets in the staging lane for this store.
Scans the pallet label. The door code is shown (staging and door ID may not be the same) and pallet moved to the appropriate trailer. code is fixed for a store or route.
Door code (D) is scanned to indicate loaded into trailer.
Single, consignments:
Individual cartons of small size
Single or Multiple cartons for consignment but less than pallet
One or Multiple pallets for a consignment
Moved to pallet adjacent to door of load trailer
Correct number of cartons are moved to the pallet adjacent to the door of load trailer.
Consignment pallets are on the pallet label to indicate item of Y pallets total. By default, no 1 of 1 is added.


All cartons on one pallet.
All pallets must be in one trailer.
Master pallet label added to the pallet.
Scan Master label and the associated PO labels to attach PO's to Master label.
Pallet completed.
Remaining pallet can be moved to staging lane or into truck?
Staging
Truck
Staging lane barcode scanned - S prefix.
Indicates PO is in lane
Moved into truck and D prefix barcode is scanned.
Product is now listed as in truck in system and not available for movement.
The last pallet is loaded.
Loader scans the door code. Chooses option to close trailer.



7.3 Sam's Club

7.3.1 Relationship

The facility is owned by Saddle Creek Corporation. The staff is provided by them and the system is provided by Wal-Mart.

This is a mature relationship and operation. The buyers from Sam's were required to work in the facilities and this has produced a vastly better understanding of the needs for packing, stacking and transportability. The staff at the facility are comfortable with phoning the buyer and advising the goods do not form a layer or are difficult to stack.

7.3.2 Systems

The system is sophisticated in that it has been developed over many years. The system takes a download of the ASN information to the facility. Entering the ASN number starts the receipt. The product code is scanned for one product. The product details are displayed and the quantity has to be entered. If the quantity entered matches the ASN number it is accepted, otherwise the system asks for a recount. The labels are printed and then added to the pallet or PO. The label is a double label so that it is put onto a corner for visibility on two sides.

7.3.3 Formal and informal systems

The system is complete enough to reduce the need for any informal systems.

7.3.4 Work balancing and scheduling

The system is balanced in that the planning is done to match the inflow to outflow volume. The volumes are nearly two inbound trailers for one outflow trailer. This is due to the ability to stack the goods and to have layers that can be stacked that are whole layers and not individual items.

7.3.5 Layout

Classic I shape with receiving in the centre. The facility is 100 ft by 400 ft long. There are 72 doors.

7.3.6 Business volumes

The facility does nearly twice the volume that Cleveland does. The goods are better packed, there is essentially no VAS, and goods are essentially all full pallets. The goods are moved from one side to the other without the use of a staging lane. The structure allows this to take place, as there are not separate runners and loaders.

7.4 Conclusions

The research was deliberately expanded to include a major, high volume throughput cross dock, which these two facilities are. The operational scale is significantly larger than anything in South Africa. The concept of receiving 90 plus large trailers every day is daunting against the scale of the larger South African operations which would struggle to reach 20 trailers in a day. The commitment of the staff to the operation is superb. Staying late wasn't a problem during the review time; the people did the work until it was complete. There was no hesitation and no uncertainty in the performance of the operation, indicating the level of training.

The research found that the operation had only reasonable systems. A number of flaws exist in these systems and they are not conducive to really good operation of a cross dock. There is no ASN information available, the labels are added without balancing labels and items, and the printing of labels was done in the dock administration office just as the trailer was to be opened. All in all there are significant areas where the systems and supply chain methods can be improved.

The concept of the total movement distance being minimised was understood, but the effect of the operation's allocation of doors to both receiving and dispatch did not support this. Once exposed, the operation's manager understood the principles, and implemented the changes necessary. The result was a fairly significant reduction in the time per move.

The effect of the changes recommended in this research resulted in a significant reduction in the movement distance in the facility. This was implemented in other similar facilities as well. The systems shortcomings were raised with Home Depot.

CHAPTER 8
CROSS DOCK TYPES

8.1 Introduction

There are a number of different processes that are classified as cross docking. Other authors refer to types of cross docking in different contexts. Napolitano[1] refers to pre- and post-cross docking as different types of cross dock. Gue[2] and Napolitano[3] refer to five types of cross docking namely: -

- manufacturing,
- distributor,
- transportation,
- retail, and
- opportunistic.

This chapter reviews the potential cross docking processes. Analysis in this chapter shows that there are only three fundamental types of cross docking that are feasible. These cross docking processes are derived from first principles as part of this research. The parameters that define the alternative types of cross docking are explored. Comparative views of the three primary cross docking processes and a basic warehousing process are done via flowcharts of the processes.

8.2 Processes

The work of Napolitano[1] differentiates between cross docking processes based on whether the labelling is done before receipt at a cross dock facility or after receipt. This is the pre-and post-cross docking types. The parameter utilised to classify these processes is whether the labelling takes place at the cross dock or not. This looks only at the cross dock and not the supply chain, and is only a positive or negative choice of occurring at the cross dock. This is not the only parameter that is pertinent to a cross docking capability. It is a valid starting point to differentiate between the various processes, but is one dimensional and focussed within the cross dock. The supply chain view must be taken.

The Gue[2] categorisation proposed is not done on the fundamental process parameters, but rather on the uses that the supply chain, which includes a cross dock capability, would provide. As such these will not be considered in detail in this chapter, as they have no contribution to make to the parameters that differentiate various cross docking processes.

In order to analyse the cross dock processes, and the parameters that are pertinent to define the various types of cross docking capability, it is necessary to look at the total supply chain. A significant amount of literature is about the cross dock in isolation. The cross dock is assumed to supply a customer and, in turn, derives its goods from a supplier. Whether the supplier is a manufacturer or a distribution centre is not of concern at this point, nor whether the customer is the intermediate or final customer for the supply chain. For the cross docking facility to operate it is necessary to have a number of process principles in place before the goods are finally sent to the customer. These are: -

- The goods need to be labelled so that the customer and product can be identified during the cross docking process;
- The load that will be delivered to the customer is comprised of items that are specifically ordered for the customer;
- These items are in a consolidation unit or pallet and the consolidation unit contains all the items to complete consignments to the customer;
- For the items to be on the pallet allocated to a specific customer, an item sort needs to have taken place and
- The pallet allocated to a specific customer must be moved within the cross dock to the dispatch assembly area allocated to the customer.

The principles underlying these stages are as follows: -

- The identification of specific items that are destined for a specific customer and
- To take the specific items in a consolidated form and move them to the dispatch lane allocated specifically to that customer.

There is therefore an item identification process and a consolidated pallet sort process in the total supply chain, unless the entire pallet is moved through the supply chain. Therefore two of the parameters that will define the various cross docking capabilities and processes will be where the item identification takes place and where the consolidation of the load takes place. While they may take place at the same time, there is the potential that they do not. One other parameter is pertinent: - whether the supplier is a multi-product or single product supplier to the cross docking facility. The occasion of the multi-product supply as a consignment to the customer causes additional work to ensure all the items in the consignment are delivered together (see Chapter 10). While the supplier is looked at in this logic, this is primarily the requirement to create consignments of two or more items. Whether one or more suppliers supply the items, does not change the logic.

It is evident therefore that three parameters can be used to define the types of cross dock processes and hence the types of cross docks themselves. The first is where the labelling of the items is done. The second is where the sortation of the items is performed. The third is whether the supplier is providing a single product or whether it is providing multiple products to the cross dock.

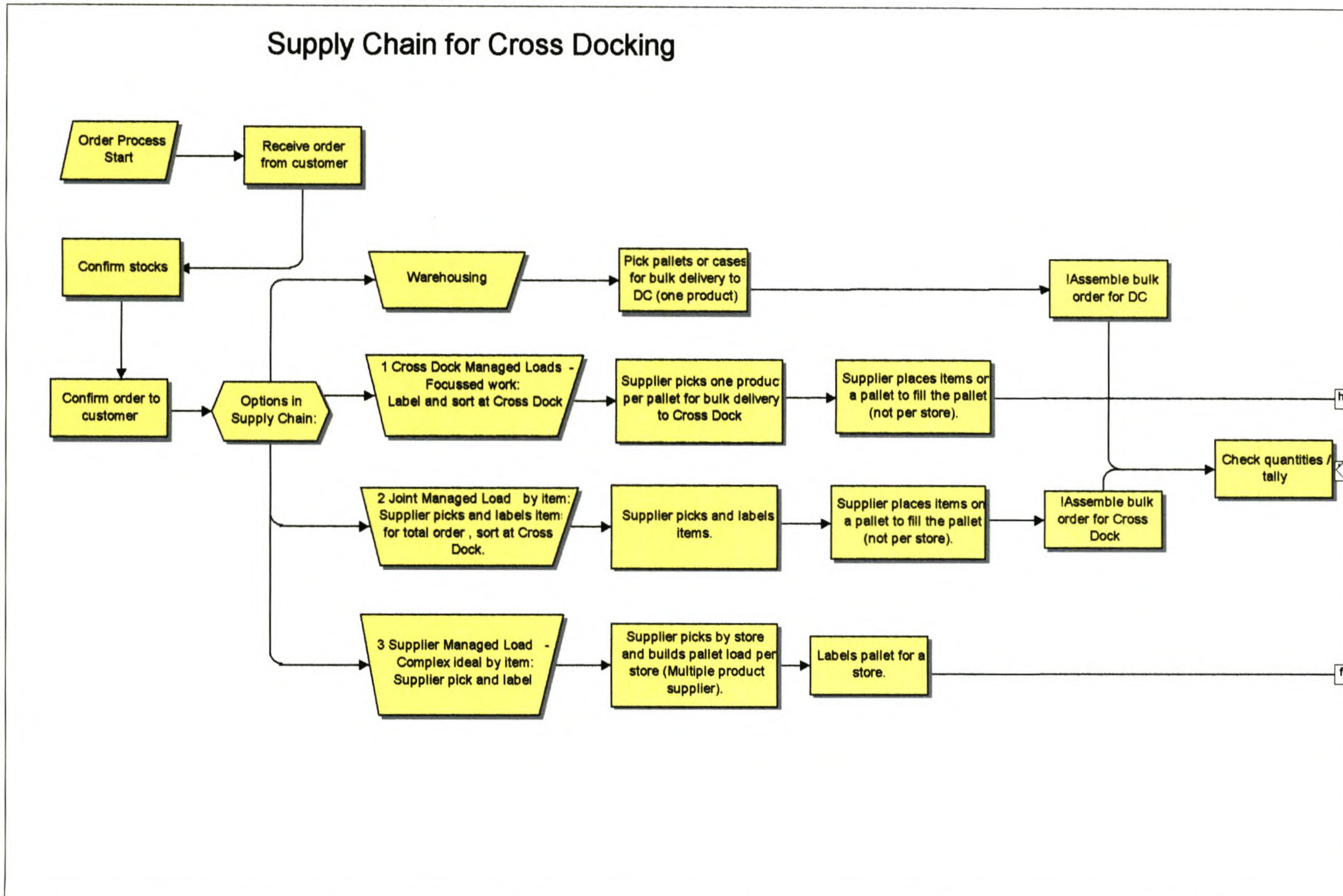
8.3 Classifications of supply chains with cross docks

Having established that these three parameters will define the types of cross docking processes, the types of cross docking processes now need to be defined from first principles. The work is shown in Table 8.1. The three parameters give eight potential alternatives. Not all of the alternatives are feasible alternatives. However, all the alternatives are shown for completeness. It is readily apparent that alternatives where the item sort takes place at the supplier and the load is built by the supplier, but the labelling is done at the cross docking facility are not realistic. To actually create the load in one location and then break it down in order to identify and label the items after the sort takes place at the second location is not sensible. This would quickly lead to wrong products being allocated to customers. Thus alternatives C and H are not feasible and are rejected. Two of the single product supplier alternatives (cases B and D) are covered by the multiple product supplier alternatives (E and F respectively). The individual or single item type alternatives are merely special cases of the multiple item type supplier alternatives. These are considered as sub-sets and not individual, fundamental processes in their own right. In the case (G) of the multiple item type supplier, the labelling at the cross dock would not be feasible. Identification of a multiple series of items, from a supplier by the cross dock personnel, that are not familiar to the personnel and who are not specialised in the products, while under time pressure in the cross dock, is not feasible. Product identification is the reason why the labels are utilised in the supply chain for cross docking. Personnel that can identify and distinguish the products apply the labels. The labels remove the need for individual personnel to be able to identify products, and provide the information that allows for effective sortation and track and trace for the supply chain. There are thus really only three types of cross docking that are primary processes. These are A, E and F in the table 4.1. The designations for these are given in the table as Cross dock Managed Loads (CML), Joint Managed Loads (JML) and Supplier Managed Loads (SML) respectively. These will in future be referred to by these acronyms.

Table 8.1 Types of Cross Dock Facility

Type Number	Supplier labels	Product to be matched in consign-ment	Labelling	Item Sort / Load Build	Comment	Name	Sortation
A	Pallet	1	Cross Dock	Cross Dock	Cross Dock takes pallet, labels items, and sorts item by item to Customers	1 Cross Dock Managed Load (CML).	Sutiable for item based automatic sort
B	Items	1	Supplier	Cross Dock	Very similar to E except restricted to one product.		
C		1	Cross Dock	Supplier	Not Sensible. Cant build load and then label.		
D		1	Supplier	Supplier	Subset of F where multiple products are picked.		
E	Items	Many	Supplier	Cross Dock	Supplier picks and labels items for total order (sends randomly packed in transport). Cross Dock sorts items from pallets which may contain products for one or many Customers	2 Joint Managed Load (JML) - ideal by item.	Sutiable for item based automatic sort
F	Items	Many	Supplier	Supplier	Supplier picks by store and builds pallet load per store (Multiple product supplier). Cross Dock moves pallet to appropriate despatch lane.	3 Supplier Managed Load (SML) - Complex ideal by item:	Not suitable for item based automatic sort
G		Many	Cross Dock	Cross Dock	Not Sensible. Would need excessive searching to identify and match items to labels		
H		Many	Cross Dock	Supplier	Not Sensible. Cant build load and then label.		

Figure 8.1 (a)



Supply Chain for Cross Docking
Order Process Start
Receive order from customer
Confirm stocks
Confirm order to customer
Options in Supply Chain:
Warehousing
Pick pallets or cases for bulk delivery to DC (one product)
!Assemble bulk order for DC
1 Cross Dock Managed Loads - Focussed work: Label and sort at Cross Dock
Supplier picks one produc per pallet for bulk delivery to Cross Dock
Supplier places items on a pallet to fill the pallet (not per store).
h
Check quantities / tally
j
2 Joint Managed Load by item: Supplier picks and labels item: for total order, sort at Cross Dock.
Supplier picks and labels items.
Supplier places items on a pallet to fill the pallet (not per store).
!Assemble bulk order for Cross Dock
3 Supplier Managed Load - Complex ideal by item: Supplier pick and label
Supplier picks by store and builds pallet load per store (Multiple product supplier).
Labels pallet for a store.
f

Figure 8.1 (b)

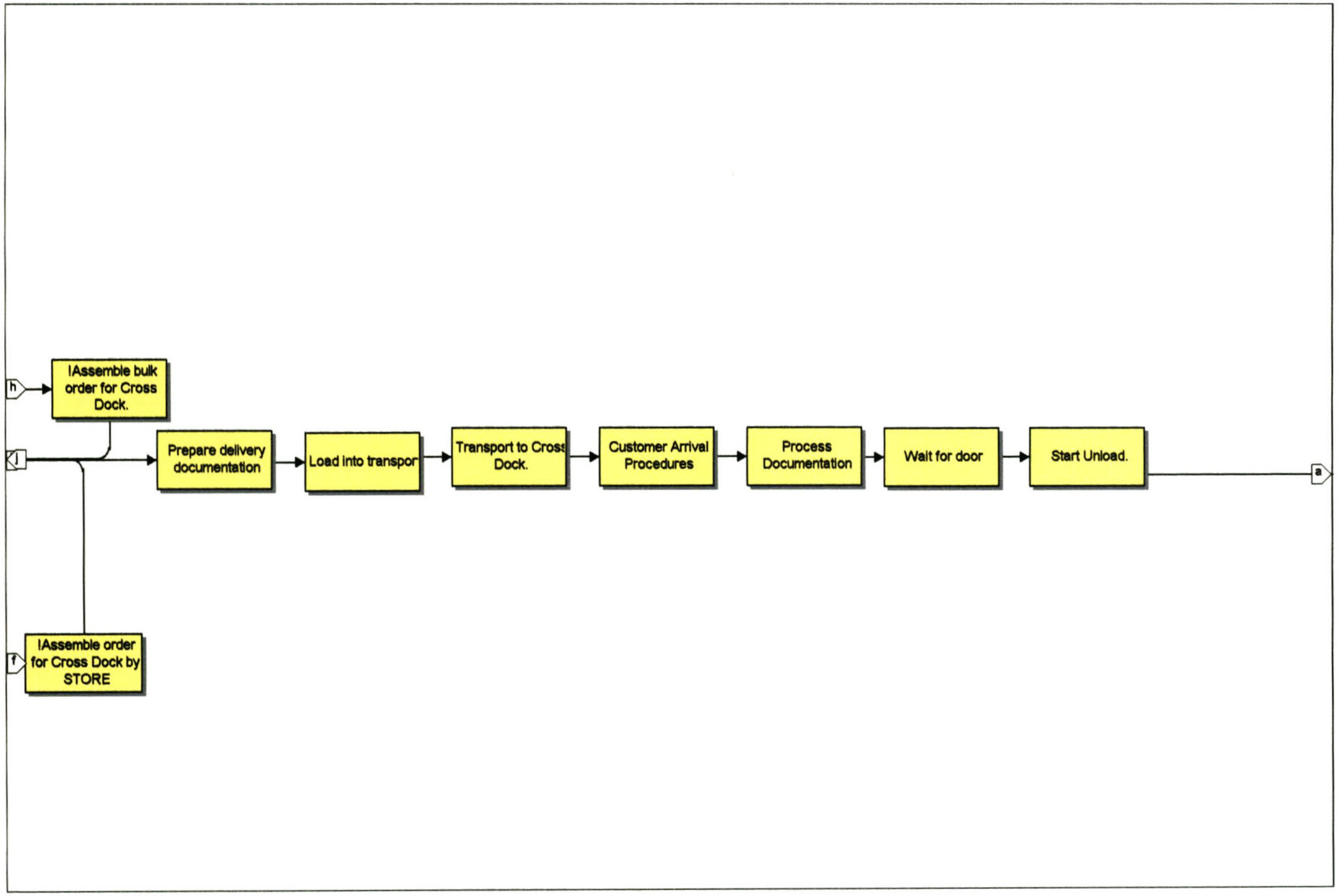

h
!Assemble bulk order for Cross Dock.
j
Prepare delivery documentation
Load into transpor
Transport to Cross Dock.
Customer Arrival Procedures
Process Documentation
Wait for door
Start Unload.
a
f
!Assemble order for Cross Dock by STORE

Figure 8.1 (c)

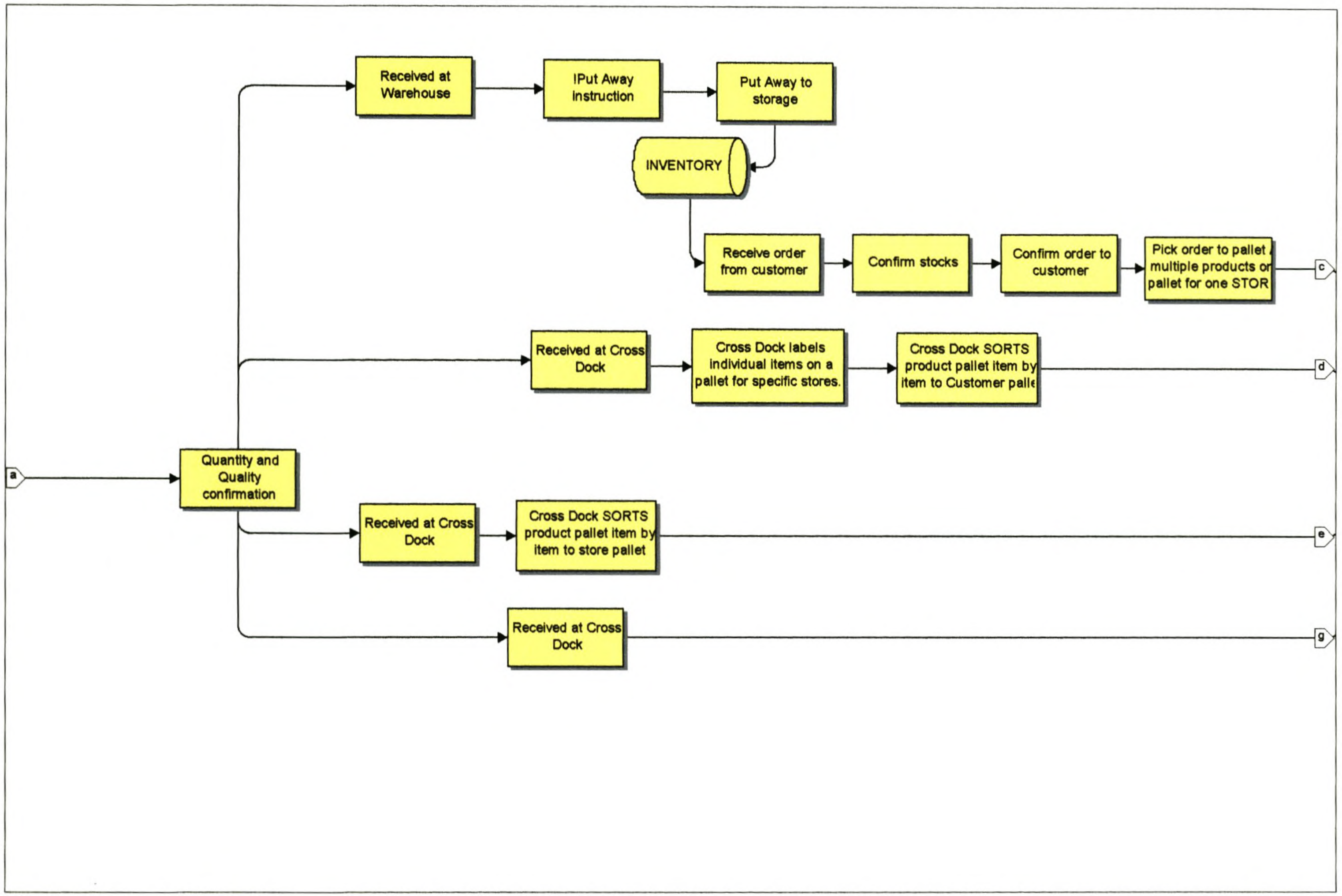
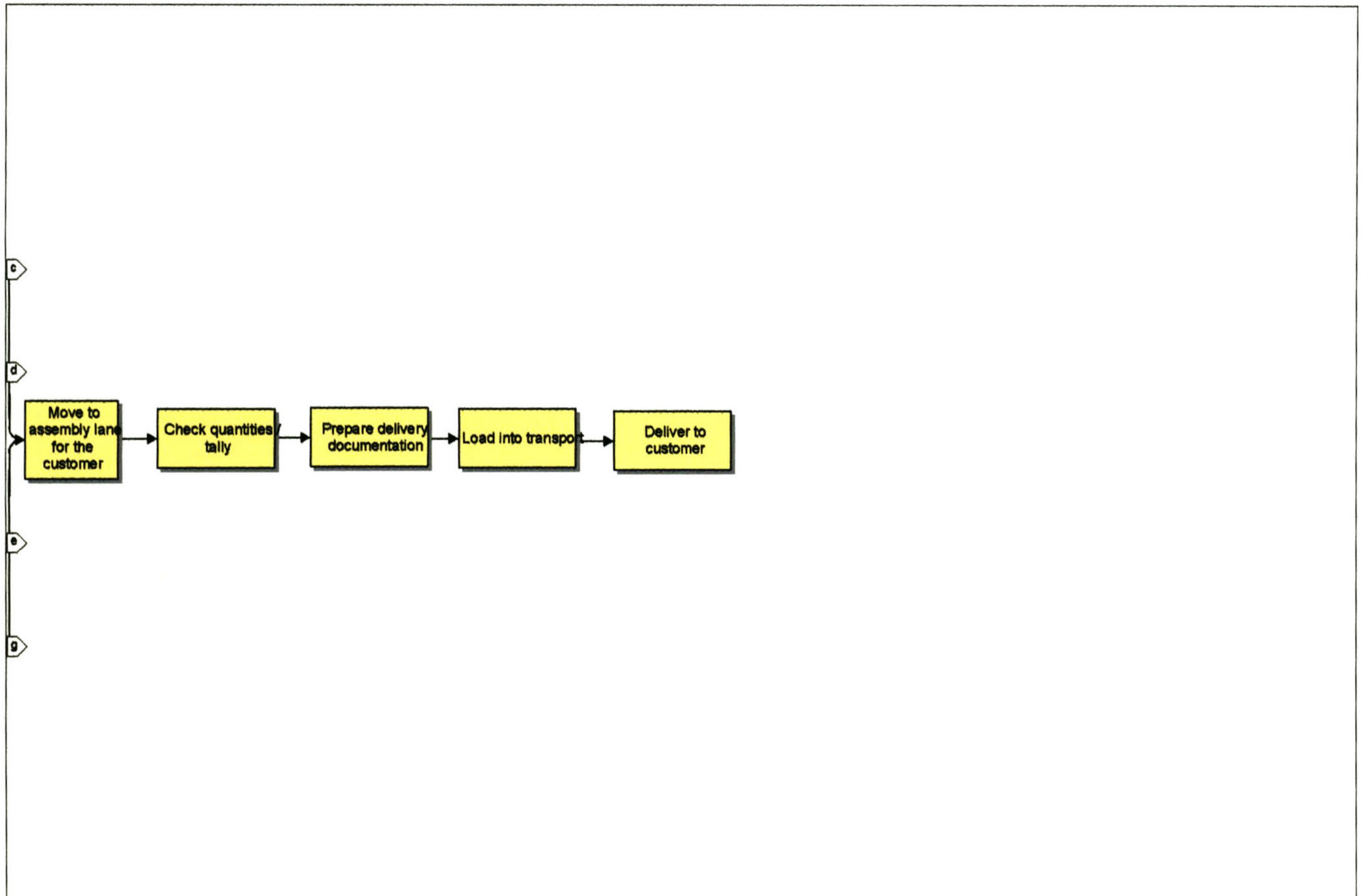

Received at Warehouse
IPut Away instruction
Put Away to storage
INVENTORY
Receive order from customer
Confirm stocks
Confirm order to customer
Pick order to pallet multiple products or pallet for one STOR
c
Received at Cross Dock
Cross Dock labels individual items on a pallet for specific stores.
Cross Dock SORTS product pallet item by item to Customer palle
d
a
Quantity and Quality confirmation
Received at Cross Dock
Cross Dock SORTS product pallet item by item to store pallet
e
Received at Cross Dock
g

Figure 8.1 (d)


c
d
e
g
Move to assembly lane for the customer
Check quantities/ tally
Prepare delivery documentation
Load into transport
Deliver to customer

8.4 Work performed in the various cross dock classifications

Table 8.1 summarises the pertinent parameters that define the feasible types of cross docking processes. These processes are placed into context against a warehousing process in the figure 8.1, which shows the process steps in a flow diagram. This diagram looks at the major process flows for the three cross docking processes and contrasts these to the typical warehouse process. It is very evident that the warehouse process contains far more steps than the cross docking capability. Each cross docking capability shows the movement of the labelling and load build as it moves progressively upstream in the process from the cross docking facility to the supplier. It is evident from these flow diagrams that each of the cross docking processes offer specific advantages. It is not the aim of this research to look at a comparison of these processes in absolute terms. This is a significant area of work, as the size of buildings and distances between them introduce variables that cannot be catered for simply. For this research, a simple comparison based on two measurements will show the value of each of these processes relative to the others, including that of a warehouse. This is a relative measurement and merely gives indications of the process capability and effectiveness. The first measurement is the number of pick ups and put downs that are undertaken to perform the entire supply chain process. This measurement is, in effect, the total work that is done on the item in order for it to move through the supply chain. It is not inclusive of any lateral movement such as transportation but is a measure of the work done. The second measurement is to look at where the items that are moving through the supply chain are at rest for any significant period of time. This would indicate a delay and an increase in stock in transit. Obviously the fewer the number of delay positions there are, the better will be the product flows through this supply chain. The simple analyses are shown in the table 8.2 for the pick-up and put down measurement and in Table 8.3 for the actual delays in movement measurement.

Table 8.2: - Work Done on an Item in the Supply Chain based on the number of Pick Ups and Put Downs performed.

	Ware-house	CDL	JML	SML
Supplier	3	3	4	3
Supplier to Cross Dock	2	2	2	2
Cross Dock/Warehouse	5	3	2	1
Dispatch to Customer	3	3	3	3
Total	13	11	11	9

What is evident from the above table is that in relative terms the warehouse has more process steps than the cross docking processes. This is not unexpected as the warehouse undertakes a put away function into inventory which is not present in the cross docking capability. What is of equal importance is that the SML process is somewhat better in terms of this measurement, than the other two cross dock processes. This is simply due to the pick that is done at the supplier being a process that combines the normal cross docking labelling and sortation into one stage, which does not require the labelling of individual items. As the pallet is created for a specific customer, there is no need to label individual items. The pick for a specific store is placed directly onto the pallet, which is then moved through the supply chain. In supply chain terms this is by far the most effective method of doing cross docking. On this evidence alone it is proven that the earlier in the supply chain the creation of the unit load that is to be moved through the supply chain occurs, the more effective the supply chain will be. There is no doubt that additional work is being done by the supplier and that less work is being done by the cross dock facility relative to the JML and CML processes. What is of importance is that the supply chain is more effective. The CML and the JML have the same quantum of work steps in Table 8.2. This is expected as the number of steps and the processes are identical, and it is merely where the work is performed that alters.

However, in the previous logic of a more effective supply chain being evidenced by how far upstream in the supply chain the work to create the unit load is done, the work measurement is obviously not the only measurement that needs to be considered, as these two processes are not the same. The labelling at the supplier must make the overall supply chain on this logic slightly more effective than when the labelling is done at the cross dock facility. It is necessary to look at Table 8.3 to see the total effect of this logic. While the CML and the JML have much the same work measurement as per Table 8.2, the delays are different and this indicates the slightly slower passage for products that have to be labelled on the cross dock facility floor. It is more conducive to a continuous flow of product, which is one of the cornerstones of a cross dock capability, to do the labelling as far upstream as is possible. This removes identification of the products from personnel not necessarily versed in the product details.

Table 8.3: - The number of places where the items are at rest in the supply chain

	CDL	JML	SML
Supplier	2	2	2
Supplier to Cross Dock			
Cross Dock	3	2	2
Dispatch to Customer			
Total	5	4	4

It is evident that overall the SML has fairly significant advantages over all of the other processes, while the JML and CML are significantly better than the warehouse performance in terms of process steps and in the work done. Where the cost of inventory is added then obviously the value of a cross dock is further enhanced. Transport costs may well offset this but this will be explored later.

Table 8.1 reflects in the column titled "Sortation" that the CML process and the JML process are both suitable for automatic item sortation. In both cases items are available to be sorted at the cross docking facility. The label is added in two different places but prior to this sort occurring. This allows the introduction of either manual or automatic sortation of the items. The SML process does not allow for an item sort. The supplier creates a unitised load or pallet and this moves through the whole process. Automated pallet sortation is feasible, but would only be justified in very limited circumstances. The circumstances would be where the goods came from a limited number of suppliers such that the induction did not occupy major space or cost of conveying, and where the trucks can be automatically loaded and unloaded without the use of equipment. The more common method to achieve this latter issue is to have roller beds in the transport, so the container can be pushed directly onto the induction conveyor for the sort and vice verso for the load of a truck. The container is not a pallet, but a special container made specifically for loading the transport to utilise the cube of the transport efficiently. Where items for the retail trade are moved through the cross dock, the transport can generally accept goods to a height of 2.6 to 2.8 metres. Two pallets being placed one on top of another creates this height. This would require the use of a forklift to double stack the pallets and place them into the transport. The unloading of the pallets would also require the use of a forklift. The utilisation of automatic sortation and then a forklift movement into and out of the truck is only justified with extremely high volumes and only for a very restricted number of suppliers. It is far more flexible and cost-effective in most cases to unload transport with palletised goods with forklifts and to move these across the cross dock and into the allocated outbound transport immediately.

8.5 Conclusions

The existing research classifies cross docks based on the single parameter of whether the label is added to the item before or after arrival on the cross dock. This is the pre-or-post type of cross dock from the literature.

This unique research shows that there are only three feasible types of cross dock process. These processes are differentiated by three parameters. These are the point in the supply chain where the identification of the product is done, the point in the supply chain where the load is built and whether the supplier provides single or multiple products. These give the three processes and help to categorise the effectiveness of the supply chain in which the cross dock operates. The effectiveness is improved as the identification and the load build are done further and further upstream. As the cross dock is a fast moving process without storage, there is no real danger of obsolete stock in the process, thus negating the manufacturing problem of early order entry positions in the manufacturing or supply process.

Only two of the processes are suitable for automated item sortation. The third builds the pallet early in the process and moves the pallet as a unit load throughout the subsequent cross dock operation.

The research has produced a new and comprehensive method of classifying types of cross docks.

NOTES

1. Napolitano, M and Gross & Associates Staff. 2000. pp 68 - 70
2. Gue, Kevin R. May, 2001
3. Napolitano, M and Gross & Associates Staff. 2000. pp 9 - 14

CHAPTER 9
CROSS DOCK OPERATION

9.1 Introduction

In the review of companies described in chapters 3 to 6 the underlying theme from management has always been that the speed of movement through the cross dock operation calls for a different breed of manager. Managers have found cross docks neither easy nor simple operations in which to achieve consistent performance. The literature records significant periods are required to make these cross dock operations successful. A highly qualified senior manager in the Woolworths textiles operation was removed from the regional manager position because the job required fast decision-making and inherent discipline, which did not suit his co-operative style of management. The discussions with the reviewed companies showed that decision making was important coupled with the commitment of the management to enforce the correct way to perform the work. Without this "correct procedure" the sheer volume of work quickly overwhelmed the entire operation and each person started to do whatever came to hand. This led to local effectiveness and overall disaster. The Woolworths Textile operation nearly did not succeed due to this, and only strong management and continual drive for improvements made this successful.

The literature supports these views. A number of authors[1] have described cross dock operations as complex, demanding and high-speed when compared to warehouse operations. It is evident in the literature review that the operation of a cross dock is inherently very different from that of a warehouse. In the Woolworths Textile operations it became evident that staff with strong warehouse background were not of necessity the best personnel for the cross dock operation. Approximately one in three of these people found the work too onerous. The requirements to do the work in an extremely disciplined, step-by-step manner, were unacceptable to them and they returned to warehouse operations. The operation of a warehouse where the processes are buffered by storage in each element of the supply chain - the inward bound movement into storage, and the pick into an assembly staging which acts as a shorter-term buffer - removes a large amount of the onerous requirements that are present in the cross dock operation.

The literature and the companies performing cross dock operations talk about doing the work in a disciplined manner. In a large measure this discipline can be translated into performing only the right action, at the right time and in the right manner. The one operation reviewed actually had a manager working on the floor coaching the staff in improvements and at the same time directing actions to remove the bottlenecks. The majority of personnel were given specific work tasks. These bottlenecks were removed by having two or three personnel as roving problem solvers. The work for the problem solvers ranged from the mundane of bringing new supplies of pallets to assisting with the sort where a large volume appeared for a group of stores and threatened to overwhelm the operator designated to do the sort for these particular stores. This process of overcoming the local problems, before they become bottlenecks or restrictions for the entire system, improved the overall throughput tremendously. It also engendered into the operation a continual problem solving attitude. The supervisors rapidly learnt how to perform this management of the small imbalances in the operation and direct resources on a temporary basis to solve these small problems quickly and effectively.

The cross dock has no storage or staging facilities to leave product for problem resolution at a later stage. There is no management time to solve significant numbers of queries. Management focus is on maintaining the throughput of the operation. This will be dealt with later in this chapter as it as a significant impact on the people requirements and the operational requirements of a cross dock.

9.2 Characteristics of the operation

The review of the cross dock operations in chapters 3 to 6 leads to four pre-requisites for a successful operation. The literature supports these observations in general principle, although they are not stated in these terms. These are that the operation must be:

- Disciplined, with an high level of training and coaching to do the right operation at the right time and in the right manner;
- Done in real time to minimise the impact of restrictions and / or bottlenecks;
- Eliminate errors quickly and effectively; and
- Improvements to prevent restrictions and / or bottlenecks from occurring must be pursued aggressively.

The cross dock is a sequence of steps that must be done in a defined order. The throughput time is dependent on the cumulative cycle time of each step. This is very similar to a manufacturing or assembly line process. The absence or minimisation of stock in the process leads to the assumption that JIT, which is associated with minimum stock holding in the process, is an applicable characterisation of the cross dock operation[2].

However, this characterisation looks at the cross dock in terms of its own performance and not that of the supply chain. In order to characterise the process of the cross dock and its contribution to the supply chain, it is necessary to review the cross dock as part of the total supply chain and not in isolation. The question of whether it is a JIT operation or other types of classification needs to be logically reviewed.

The definition (European Logistics Association[3]) of JIT can be given as follows: -
"In the broad sense it is an approach to achieving excellence in a manufacturing company based on the continuing elimination of waste where waste is considered as those things which do not add value to the product.

In the narrower sense JIT refers to the movement of material to the necessary place at the necessary time. The implication is that each operation is closely synchronised with the subsequent ones to make that possible."

The APICS definition[4] is somewhat different in wording, but conveys much the same philosophy. It is as follows:

"A philosophy of manufacturing based on the planned elimination of all waste and on continuous improvement of productivity. It encompasses the successful execution of all manufacturing activities required to produce a final product, from design engineering to delivery, and includes all stages of conversion from raw material onward. The primary elements for JIT are to have only the required inventory when needed, to improve quality to zero defects, to reduce lead times by reducing setup times, queue lengths and lot sizes; to incrementally revise the operations themselves; and to accomplish these activities at minimum cost. In the broad sense it applies to all forms of manufacturing – job shop, process and repetitive – and to many service industries as well."

The two definitions convey very similar meanings, albeit the APICS version is much wider. The application of JIT philosophy results in such techniques as Kanban and Keizan. The APICS' [4] definition for these techniques is:

Kanban "A method of Just-in-Time production that uses standard containers or lot sizes with a single card attached to each. It is a pull system in which work centres signal with a card that they wish to withdraw parts from feeding operations or suppliers (The Japanese word kanban, loosely translated, means card, billboard, or sign)".

Keizan is the Japanese word for continuous improvement, which can be defined as "A never ending effort to expose and eliminate root causes of problems; small step improvement as opposed to big step improvement".

Both of these techniques are only applicable to the operation if it is in balance between each stage and if the operation is continuous and at a steady level or uniform plant loading. Both allow for continuous, small or incremental improvements, not quantum changes. This is emphasised in texts[5] on the techniques where the stable environment is necessary for the methodology to function correctly. In many manufacturing cases, the scheduling process is utilised to achieve this stable environment. The month's production is decided and cannot be altered, irrespective of market changes. This introduces a stable manufacturing environment. Because of this fixing of the production for a defined period, the system is referred to as a pull system for the manufacturing process – it obviously can't be a pull system for the entire supply chain as it relies on a forecast for the scheduled period. This stable environment allows the use of incremental improvement via the Keizan technique and the reduction of inventory by the use of the Kanban technique. Neither of these techniques can work successfully if the volume, throughput or type of work is altered significantly. Inherent in this methodology is the need to have some form of inventory before each operation. While the need is to reduce this, the inventory is never zero as the total process is balanced and inventory is needed to cater for small fluctuations and timing issues.

It can be seen that the JIT characterisation has application in certain circumstances. The large cross dock operation that receives only one type of item, with respect to the physical size and characteristics, at a constant level throughout the day would be immediately characterised as a JIT operation. This is a rare, if not impossible, condition for the normal cross dock operation. While the inherent premise of the JIT philosophy is applicable, the techniques that are used to achieve the effective JIT production are not generally applicable because a stable environment or uniform loading is not available. The cross dock cannot alter or control the supply chain throughput, nor the timing of the volume to be handled nor the work that is needed for each product to be handled. These are in the hands of either the downstream customer or the upstream manufacturer.

The JIT philosophy is still applicable to the cross dock as a strategic aim. Its techniques are not truly applicable to the operation of the facility as a stable operating environment is not available and constant loading is not feasible other than in exceptional circumstances.

One other philosophy of improvement from the manufacturing or assembly area is a possible reference tool for the operation of the cross dock. This is the Theory of Constraints or TOC. It is a process of continuous improvement that, at a philosophy level, is very similar to that of JIT. The primary focus of TOC states that the company is in business to make profit from sales. Concurrent with this focus on profits is the minimisation of the inventory and the operating costs. In these areas the two techniques are essentially the same.

The philosophy focuses on the flow or throughput through the facility and attempts to maximise this flow to achieve profits from sales (not inventory). It recognises that all processes cannot have exactly matched flows and determines the processes which restrict the flows – the bottlenecks. It then concentrates on these bottlenecks to use them to their full potential initially, and then to find additional capacity to either remove them from the status of being a bottleneck, or to reduce the bottleneck to a lesser restriction. The inventory at all the processes other than the bottleneck should pass whatever is produced immediately to the next step. Thus inventory for all non-bottleneck processes should be one item or as close to one as possible. The bottleneck must always have inventory to be able to maximise its utilisation at all times.

The emphasis is to build up inventory in front of these bottlenecks such that they are in continuous use, even if the upstream processes fluctuate. The upstream resources have, by definition, more capacity than the bottleneck (otherwise these upstream resources would become the bottlenecks). These upstream resources are then able to continue to supply sufficient items for the bottleneck never to have to slow down or stop.

The philosophy espouses the following technique to improve operations[6] where the text in brackets is added by the author for clarity: -

1. Identify the system constraint (this is the weakest link in the chain or the bottleneck)

2. Decide how to exploit the system constraints (make the constrained resources as effective as possible)
3. Subordinate everything else to that decision (concentrate on this issue only)
4. Elevate the system constraints (wherever possible increase the resource capacity by acquiring more of the resource)
5. If, in the previous steps, the constraints have been broken, go back to step 1, but do not let inertia become the system constraint. (The additional resources created for a bottleneck in the previous step may provide so much increased capacity that this is no longer a bottleneck. In which case different (new) bottlenecks will be found.)

The technique that comes from this philosophy is almost identical to the observed operation described earlier in the chapter, where the manager directed resources to remove or alleviate the problems and bottlenecks. This was an instinctive application of the technique in a crude form, as the manager had not been trained in TOC. The process ascribed to TOC is the more applicable operating method for the cross dock, until the cross dock becomes so large and operates over such a wide range of industries that it approximates a constant operating load. These will not be the norm in the cross dock industry, where the majority are used for one industry at most and more normally for one retail corporation or one manufacturing corporation.

The cross dock facility receives product from numerous suppliers and performs the cross dock operation so that the correct product is sent to the desired following location in the supply chain. It is simple to see that in the supply chain context the cross dock could be classified as a bottleneck in that multiple flows go into the operation and radiate out from the operation. Within the cross dock the labour, equipment, administration or systems must all operate to the same effectiveness. If the cross dock facility is not operating to the expected effectiveness, then it will be a bottleneck and product will have to be held back or diverted around this bottleneck. This is evident in the SPAR Perishable operation, where the product is occasionally not sorted in time for the deliveries to be made in the early morning as is required, and a later delivery is required. This implies that some stores will open without fresh product (perishables such as fruit and vegetables) on its shelves. This was evidenced on Thursdays when the weekly peak occurred and the facility struggled to finish the sort.

The correct level of labour, equipment, administration and systems is difficult to achieve in a cross dock. Any one of these out of balance with the others will limit the capacity of this facility and turn the cross dock into a bottleneck within the supply chain. While there are physical limitations in respect of the size of the facility and the shape, the operational issues will need to be maximised to extract the greatest throughput possible. If the cross dock is a bottleneck in the supply chain, then the TOC would require the presence of a buffer of product upstream. This inherently happens as the inbound transport acts as this buffer, if correctly scheduled. Without this buffer the bottleneck could not be utilised to its maximum potential and throughput would be reduced to this lesser level. TOC requires that this buffer be as small as is possible, to minimise the inventory, but large enough to cater for fluctuations in the supply of items for processing by the upstream resources. This is the essential aim of transport planning or scheduling. The correct scheduling of transport is a major requirement for the correct operation of a cross dock facility.

The aim of the supply chain and TOC are both focussed on satisfying customers. Both look to throughput as the source of profit. Both have profit decreased with increased operating cost or increased inventory. TOC is particularly useful where the operating environment and the work load varies, where JIT cannot be applied. This is exactly what occurs in the cross dock, as different throughputs occur and different work loads occur day by day, week by week, and month by month.

While the strategic intent of the cross dock operation is to strive for the JIT philosophy, the operation of the cross dock can more accurately be described by the TOC process improvement and management philosophy.

9.3 Consignment complexity

The sort operation of a cross dock can be as simple as the sortation of each parcel to an individual store. The most complex sort is where a number of parcels from more than one supplier need to be grouped together and then delivered at the same time or as a consignment to a store. This is deemed to be a "merge-in-transit" process. The intermediate position of complexity is where a single supplier sends multiple parcels to a store that need to be delivered together. The complexity of the operation is then in progression of difficulty to manage:

- Single item delivered to store;
- Multiple items from one supplier and delivered to a store as a consignment and
- Multiple items from multiple suppliers delivered to a store as a consignment.

There is a significant rise in the complexity as the operation moves to deal with consignments as opposed to the far simpler single item. The operational complexity increases significantly as parcels need to be tracked and moved concurrently. During the sort process individual items, if they can be identified as such, are placed on a separate consolidation unit only for individual parcels. This consolidation unit can then be dispatched immediately once it is full. At the same time, the items for consignments are placed on a separate consolidation unit. A secondary sort is required to sort all the items for complete consignments and to leave those items for incomplete consignments at the sort. A system is required that will advise when all the items for the consignment on the consolidation unit are present, so that the secondary sort is done with the knowledge of which consignments have all items present and which consignments are incomplete. This aids the secondary sort speed considerably. This requires a system and a barcode that identifies items within the consignment as well as the consignment itself within an order number.

The segregation into individual items and consignments by the operating staff effectively makes two parallel processes for this portion of the work. The system itself needs to be able to determine whether all the items in a consignment have been received into the facility and, if not, to provide the details to expedite these items. Receipt of less than the full consignment number of items automatically means that a consolidation unit will have to be created for this consignment and held within the cross dock facility until the outstanding items are received. This utilises space within the cross dock, and introduces the secondary sort of the consolidation unit to separate the completed consignments and the still to be completed consignments. It also affects the size and shape of a facility as space has to be dedicated to retain the incomplete consignments until the outstanding items are received and sorted. This also reduces the throughput for the facility.

The barcode and system to deal effectively with the consignments is of vital importance. It must contain sufficient information to track and identify individual items in the consignment, and identify the consignments to which the items belong. Where the sort of the consignment is done manually, the label must contain this information in text format as well as within the barcode.

9.4 Operating errors

The personnel, equipment, administration and systems can cause errors. These errors can be because one of these four aspects are out of balance for the work with the other three. The error can also be where the facility is, in either shape or size, inadequate and cannot handle the throughput. These are the common errors and can be seen quickly and simply. The lack of a forklift truck to move pallets means there will be a fast build up of the pallets for movement. In the Woolworths Textile operation in Johannesburg the majority of the items arrived as major transport loads from the other two cross docks. The transport could be unloaded far quicker than the induction process could scan, mass and measure the item. This delayed the transport. The induction speed problem was overcome by extending the conveyor to the induction station, thereby allowing the transport to be unloaded onto the conveyor. This is also an application of TOC, as the extension of the conveyor was simply a creation of a buffer in front of the bottleneck, the induction station. The bottleneck in the SPAR perishable operation is the space required to sort, as SPAR does not have the refrigerated trailers available until late in the evening. It is evident the bottleneck in the cross dock environment is associated with the sort, unless other restrictions occur from an incorrectly designed facility.

One potential error in the operation is of major consequence to the operation. This is the level of operating skill required. The cross dock is already a potential bottleneck for the supply chain, even if it has sufficient capacity to handle the average load. The introduction of an inherent problem or restriction in the operation could have a severe reduction in the throughput. Operations staff are under pressure to perform tasks in specific sequence and a short time to be effective. The operation of a cross dock does not allow space or time for error rectification of unknown parcels or problems with labour, equipment, administration or systems. The creation of errors by the operating staff is of even greater potential consequence than any of these imbalance problems between the personnel, equipment, administration and systems. Inherent in the operation of a cross dock is the absence of any real capability to accept return items. Very few of the systems allow for this other than as an exception and the administrative system is not geared for returned items. Incorrectly sorted parcels will cause significant problems. If not picked up and resolved immediately within the facility, the amount of work is very significantly increased, and premium space is utilised. Errors will be more likely to occur in operations with the higher levels of complexity. For this reason alone the labelling of items must be done as early as possible in the supply chain, as this minimises the complexity for the operator. The more complex the sort, the more complex is the overall process, as induction and dispatch processes are essentially the same. In operations such as the Home Depot, the number of sorts of individual items was very low. In the Sam's Club operation the sort was only at full pallet level. The SPAR, Woolworths and Pick n' Pay perishable products have the entire sort in the operation, but each of these are individual item sorts. That is, there were no consignments comprising multiple parcels that were moved and needed to be delivered together. The Woolworths Textile operation used consignments and this significantly increases the potential for and the problem of an incorrect sort. To alleviate this the staff created two pallets to sort to – one was for the consignment orders and one was for single item orders.

The balancing of each stage in the process with the correct personnel, equipment and systems is an ongoing process for the overall operation, and will vary depending on the mix of goods to be handled. This is the classic identification of the bottleneck, using TOC, and the raising of the constraints that are present in any and all the stages.

The cross dock operates very similarly to a manufacturing or assembly line process. Errors in the manufacturing process have much the same effect as errors in the cross dock process. They immediately reduce the throughput and increase inventory. The limited period in order to rectify the error is also common to both, as there is no opportunity in either case to remove the problem, quarantine it and deal with it at a later stage.

9.5 Conclusions

This research shows the complexity of the operation is significantly influenced by the complexity of the items handled. The complexity is based on whether the items are delivered by one supplier, or multiple suppliers, and whether the items are individual items or consignments. The most complex is items from multiple suppliers in a consignment.

The research has proved that it is essential that the operation be done by well trained personnel, who are capable of operating in the high volume and time pressure of a cross dock. They must carry out the process using only the right action, at the right time and in the right manner.

Errors are a major source of problems and the personnel and processes must be managed to minimise these. This is achieved by the disciplined approach to the overall process. Included is the scheduling of movement in the supply chain to minimise fluctuations, and to ensure the correct number of well trained staff are available to undertake the work.

The research changes the current thinking away from Just In Time and proves that the more appropriate method of managing the process is using Theory of Constraints. Where bottlenecks occur, then the process can be identified and then improved by utilising the principles of the TOC. This is far more applicable to the operation of the cross dock than the literature proposed JIT process.

The literature refers to training and errors as problems. The requirement for disciplined operation is also recorded. Training and a disciplined approach have not been researched as in this work, but are anecdotal information from operations, often where failures have occurred. Errors are not covered in the literature, but were clearly observed from the work done for this research in the operations. This research places this information into reasoned, logical research. The research knowledge is significantly extended by the introduction of the Theory of Constraints as the most appropriate process for the analysis and improvement of the cross dock.

NOTES

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CHAPTER 10
MATERIAL HANDLING IN A CROSS DOCK

10.1 Introduction

The five companies that were reviewed in detail in previous chapters have a mixture of manual and automatic movement and sortation equipment. The correct choice depends upon the application, but in at least one case (Pick 'n Pay in Durban and Johannesburg) there seems to be little justification for the use of automation from a financial point of view.

The choice of automation is not merely for the sort area but also for the movement into and out of the sort area. The fully automated movement of parcels from the inside of a truck at receiving to the inside of a truck at the dispatch is not common in the cross docking facilities reviewed. The facilities that use total automation have very uniform items for the cross dock sort, and a perceived stable business environment. Only one facility that was reviewed had extendable conveyor belts that would go into the trucks. The value of this was evident, but the financial justification needs to be looked at. Notwithstanding the above, it is important to understand the principles that govern whether a facility should be manual, partly automated or fully automated. From these principles it is feasible that more sensible decisions can be made by people utilising cross docking capabilities.

10.2 Design principles

The choice of manual, partially automated or fully automated movement systems can be made for the: -

- induction area, and / or
- assembly areas and / or
- sortation area.

The choice of a manual or automatic process is dependent upon a number of factors. This section will review the most pertinent factors in deciding on the choice between manual and automatic systems.

Automated equipment is capital intensive. For any given facility area, for very low volumes it is difficult to justify the high capital cost for automated equipment. As the volume rises, obviously automation becomes economically feasible. It is therefore simple logic that leads us to understand that volume will be one of the primary issues in choosing between manual, partial automation, or full automation.

The overall effectiveness of any manual operation is critically dependent upon the distance that the goods must be moved by manual means. The further the distance to be travelled in the facility, the greater the ineffectiveness that becomes inherent in the system. This determines the shape and size of a facility, and gives reason to the findings which recommend that the shape of a cross dock should alter from the initial rectangular shape, to progressively a T shape and then an H (or I) shape of building. These minimise the total distance travelled and thereby improve effectiveness. This is discussed in Chapter 14. Extending this logic, the manual movement of goods across the floor and in the sortation area cannot be done in increasingly larger areas and with longer distances as the throughput volume increases, without an impact on effectiveness. The effectiveness from the longer distance is in proportion to the distance travelled. If the width does not increase, which it should not in a cross dock, then this is in direct proportion to the increase in length.

As the volume increases, so the number of operating personnel will increase. As the length of the building, and hence the length of travel of the items, increases with volume, the number of personnel will increase even further than the pure length increase would require, as this length influences the productivity of these personnel and the effectiveness of the operation. Personnel would need to traverse this larger distance to carry out this manual process. As more personnel are introduced to overcome the distance problem and the ineffectiveness that results from it, so more interference would occur in the process flows as the personnel move goods between the receiving and the dispatch doors. Progressively, this interference will add to the reduction in the effectiveness of the operation. The effectiveness is then dependent on two major factors – that of distance and the interference that results from increased personnel operating in a defined space. These two factors working in combination would ensure a continuous decrease in the effectiveness as the volume handled increases. Ultimately one could postulate that the effectiveness would decrease at such a rate as to make the introduction of additional personnel of no added value. This is the point of marginal value for the manual operation. This will be at the point where the interference factor is so high that the error rate becomes significant. The system is at the point where it cannot handle any increase in the volume and the volume has to be curtailed if it is to continue to offer a service of value. This is a natural limit for any manual operation. Space in the manual cross dock cannot be infinitely increased as it requires personnel to operate and these additional personnel, with the volume increase, result in progressively increased ineffectiveness as the size, and hence distance items have to be moved, increases.

For the automated option the logic is somewhat different. An automated system is designed with a specific speed of movement, for which the motors and mechanical mechanisms are specified. Once chosen, this speed cannot be altered without significant cost, if at all. Thus the automated movement and sortation system is designed for the maximum throughput required at any given period of operation. This equipment can only run at this design speed, unless more expensive motor control systems are introduced, which add cost and limited value to the operation in terms of cost reductions. Automation is therefore installed for the future maximum sustained throughput that needs to be achieved in a period. The period may be a peak of a few hours or a particular day, depending on the overall supply chain. Thus, the lower throughput is an ineffective utilisation of the automated movement and / or sortation equipment. As throughput increases so the effectiveness would increase to a maximum when the equipment is operating at the maximum throughput for which it is designed.

The above principles were observed in all the operations reviewed in chapters 3 to 6. It is interesting to record the differences between the smaller South African operations and the larger American operations. The American cross docks managed to work at a continuous level of operation throughout the observation days. This was primarily due to the large size of the operation and the principle that these operations were receiving goods in large volumes, with a manual sort of items for direct movement to outbound transport. This whole process results in an essentially continuous flow of items across the cross dock floor, as the number of receiving doors is sufficiently large that a single door preparing to receive a trailer makes no difference to the amount of goods that are available to move into the sort area. The workload does vary, but this fluctuation is not as large as in smaller cross docks. The defining criteria in these operations is the number of personnel that can move the goods from receiving to dispatch and the space that is available for the movement lanes. This operating restriction will be the bottleneck of the operation in TOC terms. It was observed that where items had to be moved from one receiving bay past a receiving bay where goods were being moved out of the transport, one of the movements were stopped to allow the through traffic. The South African operations are significantly smaller than the American operations. These operations see peaks and valleys of operational volume so the scheduling of incoming trucks becomes more and more critical with the limited number of trucks that are received in any period. There are regular periods at all the South African facilities when trucks were not available for receiving.

10.3 Movement and sortation

Movement and sortation can be done by manual methods, where personnel manually move and sort the items without the use of automated equipment. Where items are being handled in a partly or fully automated process, the goods can be placed on a conveyor, moved to the sort area and sorted on the conveyor either manually (partly automated), or by automated (fully automated) sortation equipment. This material handling design and specification is not within the purview of this dissertation. Suffice it to say that movement systems and sortation systems are available which can handle progressively higher throughputs. These systems all have high capital cost. As the speed of movement and sort increases, so the cost increases even further. Technology also has to change to accommodate the higher speeds. As the speed increases so the change in impact on the item to change its momentum from the current path to the new diverted path increases. Automated sort equipment ranges from a soft move to a more serious impact, where fragile items are easily damaged in this diversion process. There are a number of different sort technologies. The more gentle diversion of the item is done by some form of arm that pushes the item into a new direction. Harsher sortation methods have wheels that pop-up and accelerate the items in the new direction. To utilise these automated movement and sortation systems, the range and size of products need to be restricted to within limits that suit these sortation methods and the conveyers that feed them. Automated sortation was considered in the Woolworths Textiles case. The textiles in boxes were suitable for automated sortation. Unfortunately significant quantities of items in the range were either very small, poorly packed, the contents not suitable for high speed diversion or were too large and bulky. For example, the Woolworths Textile operation has small boxes of lipstick measuring approximately 75 mm by 50 mm by 15 mm. These were too small to handle on the roller bed specified for the standard boxes for clothes where the boxes are nominally 400 mm by 500 mm by 200 mm. The automated system cannot handle these very large or small items, nor can it handle very heavy or very light items consistently and reliably. Items such as duvets at nearly two metres long and 200 mm cylindrical diameter, to glass vases are very difficult to sort with automated equipment when the bulk of items are standard boxes. For this reason the Woolworths textile operation has an automated movement from the receiving doors to a manual sortation area. In contrast the Pick 'n Pay foods operation is handled in a standard size of a plastic tote box and is ideal for the application for automatic sortation from the point of view of the physical constraints – there is only one size and it is a robust construction.

It is evident that the use of automation in the sortation area is dependent upon the physical characteristics of the goods as well as the speed of the sortation. The faster the speed, the higher the impact that the diversion facility will have on the product, and the more restrictions the design will place on the physical characteristics of the product. When automated sortation is introduced, the premise to make it cost effective is that all products must be handled, otherwise two processes exist in parallel, additional space is required, as well as additional staff, all of which adds complexity and costs. These defeat the potential benefits of automation. Fragile products and extreme size or mass items cannot be handled on an automated system for standard items. It is therefore evident that a restricted range of physical characteristics within clear limits only can be handled by the sortation equipment, and that fragile products in particular cannot be handled in an automated sortation system.

However automation to move product to the sort area from a receiving area can be utilised for a much larger range of physical characteristics than the sort will allow. The items to be unloaded from vehicles can be placed immediately on to a movement system that delivers these products to the sort area. This precludes the need to take the product out of a truck, place it on a consolidation unit, move the consolidation unit to the sort area and place it in a wait zone and then finally pull it into the sortation area. A significant number of steps can be eliminated with the adoption of the automated system. The automated system can replace all the steps, but at a capital cost as well as a rigidity in the design and operation of facility. Once automated equipment is installed, this cannot be moved or altered in any significant manner without considerable time, money and effort. The movement conveyor also makes it difficult to allow any movement from one side to the other, as this is a physical barrier when in use. For this reason, a large number of automation systems are placed on an elevated platform or structure above the operational floor and only after the sort occurs does the chute from the sort or diversion return to the floor area.

10.4 Characteristics of manual and automated processes

There is a continuum of operating capabilities between the manual, partially automated and fully automated systems. This research will deal with the manual and automated capabilities.

Manual sortation can operate up to medium volumes. Thereafter the number of people and the rate of sort action required by the operator is too high to make the process feasible. To sort a single parcel the operator must identify the parcel as being necessary for the sort, push or pick up the parcel and move it to the diversion and push it onto the diversion conveyor. Above a certain speed the parcels will just travel too fast for the person to perform this sensibly and automation is required. Once automation is introduced the products must be identified and barcodes have to be present on the items so that they can be read automatically. Automatic barcode scanners not only have to read a barcode, they must read the barcode on the face of the item while in motion. This makes the use of an in-line barcode scanner, which is considerably more expensive than the hand held unit. The installation of this equipment is a permanent fixture. It is a large capital investment and cannot be altered to incorporate a slight change in the process or one additional customer without time and effort and cost.

The automated operation requires a process that is defined prior to the installation of the equipment as the equipment design is based on a specific operating process. The process cannot be changed as the automated equipment demands a specific set of steps are completed before and after the automated system is utilised. For example, the design must decide where in the supply chain the barcode label will be fixed to the item. If the decision is to place the barcode label at the cross dock, then sufficient area will be set aside to allow this operation. If the labelling operation is then moved upstream, the area in the cross dock is under utilised, as the automated equipment cannot be moved to incorporate this area. The automation also requires that the process is done in a specific sequence and at a specific minimum rate. This sequential requirement can be illustrated with the requirement that the barcode must be added prior to the item entering the automated sort equipment. The face of the item showing the barcode must be orientated in a specific direction to be read correctly by the in-line barcode reader. The rate of induction must be sufficient that the system is able to handle the full throughput volume in the day. The system has a maximum speed limited by its design. It must run at this speed if one or a thousand parcels per hour are being sorted. This holds up to the point where the maximum design level is being sorted. The impact of this is the same as if this was a manufacturing capability. The sortation acts as a bottleneck and any time lost on the automation, is lost capacity. Thus if the trucks are not scheduled correctly and there are no items to sort for an hour, the system will have lost an hour. If five hours remain of the day to complete the sortation and dispatch the system must now operate at 20% above the previous average (6/5) to complete the sort in time. If the system is designed to work to less than this 20%, then the sort completion will be delayed and problems will occur. Thus the automated process has far less flexibility than the manual process and is far more rigid in its demands for space and the steps in the operating sequence.

Manual sortation is flexible. The use of people can add flexibility to the operation. As average volumes change, as long as these can be roughly forecast, so the number of people that are added or removed can be altered to match these changes. The short term fluctuations can also be accommodated as more or fewer operators can be scheduled to work on a particular day or time of day. This flexibility is essential when one looks at operations such as the SPAR operation for foods, with a 90 per cent change between minimum and maximum days in the week. Thus nearly a 50% variation of staff is required on each day of the week. The use of the manual operation's flexibility allows the staffing to be set at the level required for the lower throughput, and then to use additional staff as required for the peaks. Skilled people can be scheduled in the shifts as well as in the times they work in order to cope with these peaks and valleys. The Home Depot operation in America has the same principles. Shifts are arranged as the operation works seven days a week with two shifts per day. Four shifts are used with two teams performing the work from Monday to Friday and another two teams the work on Saturday and Sunday. Less volume is received on the Saturday and Sunday so these shifts have less manpower and work different periods to match the throughput.

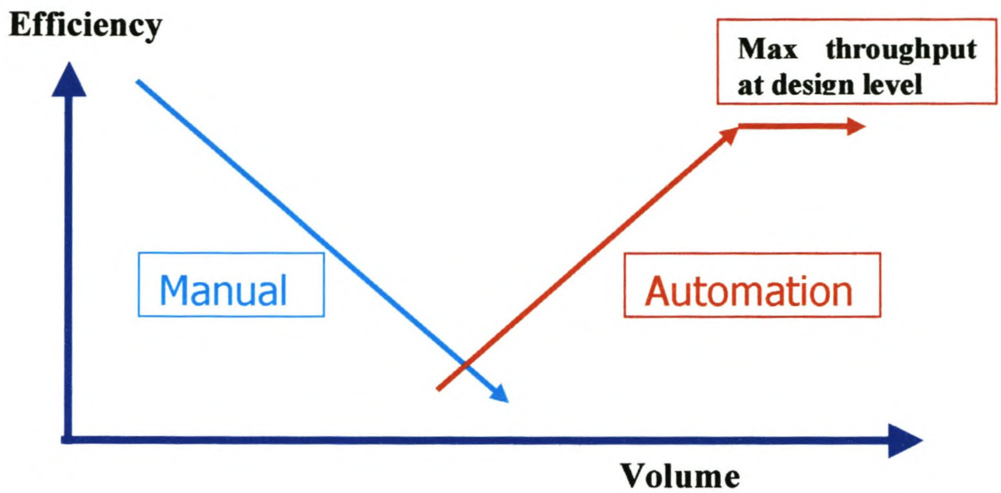
Obviously the manual operation, even with utilising forklift trucks for the movement of the goods, has a lower capital investment than the automated. As the volumes grow, additional equipment and personnel can be added without significant impact on either capital cost or the actual operating needs. This adaptation and agility allows manual operations to undertake a business that has a variable throughput or requires special operations such as VAS. Automation cannot be altered with ease. Automated equipment, and changes to existing equipment, cannot be introduced as quickly and simply as can be done in the manual system.

The introduction of automation reduces the flexibility inherent in the manual operation, and in exchange offers a continual flow of items without the requirement for people and machines moving along the cross dock. The speed that items can be moved and sorted is higher than in a manual process. The problem of interference between personnel as they move goods from one place to another place in the cross dock also disappears as automation replaces these people and machines. The multiple steps of taking items from the truck, placing them on a consolidation unit, moving the consolidation unit to the required sortation area, placing it in a holding area, and doing the sort and moving the items to the assembly area are replaced by the automated operation. The automated sortation is designed for a specific throughput, with a specific number of induction points (receiving) and sort chutes to dispatch assembly points. This does make it extremely difficult to change any of the induction points, the sort points or the speed in the future. The automated sort must also be sized for the maximum throughput required in any one period, and must run at this high rate. The manual equivalent would achieve this change of throughput with additional personnel and pallet jacks or fork lifts which can be acquired in a day.

Where value-added services are to be performed, the automated system is less advantageous than a manual system. The automated system delivers items and a separate VAS area would then have to be created adjacent to the automated dispatch points from the sort chutes. Each item would then have to be handled and moved into the new area and thereafter consolidated for dispatch. These additional steps and touches of the goods negate the advantages of automation to a large extent. The one exception to this is VAS done to segregate products as they are taken from the sort chutes. For example, the perishable products that are handled in the Pick 'n Pay operation are taken from the sort chutes and placed in 6 different rolltainers, depending on the product type, by the operator. This is done by a simple visual check and label information so that the chilled items and the frozen items are segregated and placed in consolidation units or, in this case, rolltainers. The perishable items are placed in up to four separate rolltainers. The perishable products are segregated, as some products require different temperatures, some products are not compatible with others and some influence the shelf life of the other perishable products. For example, bananas and cauliflower must not be near one another as the cauliflower creates ethylene which speeds up the –undesirable- ripening of bananas. The operator does this sortation because the automated equipment would have become far too complex to sort the product to six chutes for each store. The sortation equipment would have been six times more complex and the capital cost would have increased commensurately.

This can be summarised in the following Figure 10.1 to record the differences and values of the manual and automated systems.

Figure 10.1: - Comparison of manual and automated systems



<table>
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Manual

- •To match throughput fluctuations:
  - Hours worked can fluctuate
  - Staff levels can fluctuate
- •High flexibility
- •Low capital cost,
- • - high operating cost
- •Supports VAS

</td>
<td>

Automation

- •To match throughput fluctuations, the rate of induction is altered to match the throughput
- •Maximum speed set by automation
- •Fluctuations increase the capital cost of equipment
- •Limited flexibility
- •High capital cost ,
- • - low operating cost
- •Difficult to introduce VAS

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10.5 Comparison of actual operations

In chapters 3 to 7 the perishable product cross dock operations of SPAR, Pick 'n Pay and Woolworths were investigated. The three operations are of comparable size. Pick 'n Pay has chosen fully automated equipment in all three centres of Johannesburg, Durban and Cape Town. SPAR and Woolworths utilise manual methods only with personnel and pallet jacks. The automated capability in Johannesburg for Pick 'n Pay gives them an advantage. It allows the product to be delivered to an operator at the sort chute who has the ability to sort into six different categories (rolltainers), thereby preserving the quality of the product. This is not feasible in the manual sortation, as the area required would be significantly higher. A capital cost is involved but, with the volumes, it is probably justified. SPAR attempted to introduce automated systems in the perishable and frozen areas in their Witwatersrand facility. This was not a success as the design was flawed. The system was initially introduced for the frozen goods on a batch pick basis. The sortation equipment did not work correctly, as there were logic flaws in the control system. Equally, SPAR did not commission the equipment correctly. Even if the equipment works correctly, the flows of the frozen items from this automated system feed into the assembly area for the chilled and fresh items. The flows of fresh and chilled oppose each other, and the frozen items are at right angles to both these flows. The interference level between these flows is high. This makes it extremely difficult to utilise the automated equipment correctly, even if it functions correctly.

Pick 'n Pay have utilised automated equipment and sortation in both Durban and Cape Town. With the volume of approximately 20 to 30 per cent of the Johannesburg centre these facilities cannot justify automated equipment on a simple financial investment calculation. The Durban centre is not restricted for land, so this was not a factor for automation. It may be that Pick 'n Pay wished to reduce staff complement, but from discussions with the operating management (financial information was not available), it would appear to be that the quality of the product is the overriding factor and Pick 'n Pay is prepared to pay the premium. The fourth South African grocery retailer – Checkers - does not use automated sortation in any of its centres.

10.6 Conclusions

The research sets out the value of manual and automated sortation systems for comparison. It is evident that as the throughput increases and as the work done within the facility increases so it becomes more and more difficult for a manual operation to maintain the efficiency required for a cost-effective operation. The first move to automation may well be the automated movement of the product to a sortation area, with the automated sort and its high capital cost delayed for the future.

The sort is the highest capital cost in the process and the automation speed sets the upper limit of the throughput. These can only be altered with physical changes to the automation system and software changes, which will be both expensive and time-consuming. Automation has its place to cater for higher volumes, but it needs to be chosen carefully and for the appropriate operation.

The choice of automation requires that all, or if not all, only a very small quantum of the products are suitable for automation. Once this is established, then and only then, should automation be considered. Operations with high fluctuation in throughput and with incompatible products are not suited to automation. Automation also demands more rigorous operational practices, where specific steps must be completed before induction into the automated system and, unless specifically designed, downstream processes are significantly curtailed in the cross dock due to lack of space and the throughput rate.

The research has set the principles for the choice of automation or manual processes in a cross dock. As companies have used automation and removed it (SPAR), had it work poorly (SPAR) and probably committed excessive capital for poor financial returns (Pick 'n Pay) the criteria to choose the automation or manual processes adds to the research knowledge and the practical design processes of a cross dock.

CHAPTER 11
MANAGEMENT SYSTEMS AND BARCODES

11.1 Introduction

The volume of goods to be handled within a cross dock of any significant size, coupled with the timescales over which these goods are handled, makes a system that can record the details and location of items being received, moved and dispatched in the cross dock operation, a pre-requisite. For the system to work effectively it must promote the flow or movement of the goods and not introduce any delays. The systems must therefore have a minimal amount of paperwork attached to the process of operating the cross dock. The movement of paperwork, with high volume throughput, means that the paperwork and goods need to be reconciled at specific stages to ensure the correct flow of goods to the correct customer. This guarantees some form of delay as the reconciliation process takes place. The options are therefore to have delays in the system due to the matching of paperwork and the flow of goods, or to move to a paperless system which requires some form of scanning and barcodes.

The concept of Radio Frequency Identification (RFID) is a step for the future. It does not alter the requirements for data at the cross dock, nor does it alter the requirements for the supply chain.

11.2 Requirements for a system in the cross dock operation

As alluded to above, the system really needs to be able to perform a number of simple functions. The more complex functions from a warehouse management system (WMS), such as replenishment of the pick face to let downs for picks of greater than a full pallet quantity, are not necessary in a cross dock operation. However to run the cross dock operation correctly, it is essential that a system, which is simple and effective for the Track and Trace of the goods, needs to be in place. This Track and Trace requires more than just the information pertaining to the goods within the cross dock. It is also essential to know which items are in which truck awaiting delivery at the cross dock. The Advanced Shipping Notice or ASN generally provides this information. This enables the load pulled into the sort to be maintained at a constant level, thereby achieving high-effectiveness. It equally allows the cross dock to allocate the transport to the most appropriate receiving door to minimise the volume distance movements for additional effectiveness. This will be discussed in detail in chapter 13.

The system requirements are therefore, at the minimum, to have the capability to track every item received into the facility, placed in an assembly lane and moved into a transport. For the supply chain and the cross dock itself to be the most effective possible, the capability to monitor the goods with the supplier, item and customer information available to the operations is required. Therefore, in order to achieve an effective cross dock operation the following principles need to be part of the system: -

- Paperless;
- Advanced Shipping Notice with item information for each transport;
- Unique identification for each item;
- Unique identification for each consolidation unit recognising each item in the consignment;
- Dispatch of a transport; and
- The location of the transport in the yard.

These functions are derived from a number of different commercial packages. While each system manufacturer is different, in general the functions can be attributed to specific sections of the system. The management of the transport at the facility would be a Yard Management System (YMS), which locates transport staged at the facility. This is often a subsystem of a good WMS. A Track and Trace (T&T) system is required to monitor the items as they move from one monitoring point to another point in the supply chain. This monitoring is not just within the cross dock, but is across the supply chain. The information of the items contained in the specific order is extracted from an Order Management System (OMS). The allocation to a transport and the specific items in the delivery note for the order is a combination of the Order Management System, including its Advanced Shipping Notice (ASN), and the WMS. The only portion of the Order Management System required is the provision of information on the order, the line item details within the order and the advice of when and how the order was dispatched. No purchasing details as regards to commercial terms are required. With these three system building blocks, namely YMS, T&T and OMS, a cross dock can be effectively operated. The complexity of the distribution transport may or may not require routing optimisation. This is local effectiveness and is not included in this research.

The volume of the goods that are handled by the cross dock will determine how effective the systems have to be. As the demand for greater effectiveness increases, so the need increases for the system to be more and more removed from paperwork and replaced with a scanning and computerised methodology. This requires the introduction of a barcode to identify the items. This barcode can be applied at the cross dock and satisfies the needs of the cross dock only – the CML option. The next step for improved effectiveness is that the labelling point needs to move further and further upstream in the supply chain. This reasoning to achieve greater effectiveness has been discussed in Chapter 8. The advantage is to be able to track throughout the supply chain rather than just within the cross dock. The ability to track goods within the supply chain adds significant knowledge of the movement of goods through the supply chain, or pipeline, towards a customer. This information precludes duplicate buying or ordering. The knowledge of the estimated delivery time is valuable when dealing with the customer and is an essential part of an effective cross dock operation.

An Advanced Shipping Notice is necessary for an effective cross dock facility. It is essential that the goods inbound are known, allowing for effective planning of the operation. The greatest effectiveness has to be to extend the flow or movement knowledge as far upstream and downstream in the supply chain as possible. However, as a minimum it is essential to track the items on entering the cross dock, when placed in the assembly lane and when loaded into a transport.

The identification of the correct transport, and the allocation of the correct door that makes the cross dock as effective as possible, are necessary for an effective cross dock operation. The Yard Management System records the transport and its location in the yard, so easy and timely retrieval can be effected. In order to be able to achieve this item identification, every item and every consolidation unit must be uniquely identified in the most effective manner possible. While paperwork systems can do this they, are to a large extent, ineffective in high throughput operations. This criticism is true of the paperwork associated with the application of barcodes to the items at receiving. It has been demonstrated by logic and by the research done on each of the operations that the further upstream this label is inserted the more effective is the operation. However, if it is necessary to be done on receipt at the cross dock, then this occupies space, time and effort.

Paperwork of some form must be used as a check on the items received, when the barcodes are added at the receipt into the cross dock. The supplier has advised, via the ASN, the items that are present in the transport. There are two ways to check the receipt of items in this case. One is to print labels and to check the items against a printed version of the delivery note or invoice for the items in the orders. The alternative is to take the delivery note information and to print the exact number of item labels that are required, again based on the supplier's information. Any shortage or surplus of labels will automatically indicate whether the correct number of items is present as specified on the delivery note. The use of the delivery note to verify goods is in itself acceptable. However the printing of barcode labels to identify these goods needs to be strictly controlled, whether they are used as the check or not. In a number of the operations, including Home Depot, this was not controlled and this could lead to errors. It is more than feasible that the identification could be done incorrectly as there is no check done on the number of labels printed or used. The loss of a label and an incorrect reprint, or a substitution of one item label with an alternative product's label would only be determined at the receipt of the item by the customer. If found, the customer can reject the items, causing a costly return flow. Even more costly to the cross dock is when the customer accepts the incorrect item or items, particularly if these are of greater value than the correct item. In this case the supply chain has a loss of an item, a surplus of a stock item for which an order does not exist and a shortage of an item that was ordered and not delivered. This is an expensive error in stock replacement and the movement costs are significant for no gain, just one or more unhappy customers.

11.3 Barcodes

There are a number of barcode standards, which are not part of this research. While there is no standard barcode that is applicable to all supply chains, or even to all supply chains within an industry, the principles that are necessary in a barcode for this research are discussed in this section. While the research does not require a standard to be in place, this is one of the outstanding issues that each industry or, in preference, the logistics fraternity, should address to make supply chains more effective. A comprehensive barcode standard, unique to a channel, or one industry would be of great assistance to standardising scanning processes. The correct information for all the parties in the supply chain can then be available in one format if this is implemented.

The issue of effectiveness for a supply chain with a cross dock is not the barcode standard that is applied to the cross dock or the supply chain. The important issue is the data that can and should be applied at each of the possible application points of the barcode. Different information is available at the various points of the supply chain where the barcode can be applied. This will be reviewed in more detail later, but whether the barcode is an identification number or contains data pertaining to the item is important.

The question of whether the required information should be on the barcode or whether the barcode should be an identification number which references the information retained in the computer system is complex. If the information is retained in the barcode, less communication happens with the computer system. More work can be done without reference to the computer system, but the barcode is more complex, requires a larger label size and printing capability and greater intelligence in the scanner. Alternatively, the simple identification number can reference all the information stored in the computer system. There is a compromise or a trade off between communication time to and from a scanner to a computer system with a simple barcode label and a simple scanner, versus a more expensive scanner with greater intelligence, less communication traffic and a more expensive barcode label. The choice of this can only be made once the point where the label is added has been determined, and the sophistication of the system in each entity in the supply chain. The determining factor is the sophistication of the systems in the supply chain. This is researched later in this chapter.

The simplest operation is where a cross dock label is added on receipt of the items at the cross dock – the CML type of cross dock. In order for the cross dock to operate correctly the minimum information is a barcode label which references the system information, recognising the item and the customer. This requires the check of the item against the paper delivery note. To link the item with the information in the system, the barcode identification number must be recorded into the computer system as being associated with the item, and also with the customer via the order. Thereafter, to access this information requires a scan of the barcode to access the system information. This scan will have to take place everywhere the item has to be staged or consolidated. Where high-speed sort of the items is required, this needs to be automatic scanning and sort, as the manual stopping of the item to scan and read the customer information by each person performing the sort is not feasible. The label can have text information added to reflect the customer number, which will overcome this sort restriction (need to scan the barcode) and allow a manual sort. Where a manual sort is performed, the consignment details - number of items in the consignment and the item identification - is also required on the label. This allows the consignment to be manually sorted as far as is possible, and only when necessary is a scan performed to record movement. More information is not required, as a scan must be made for movements and the relevant information is in the system. More commonly the items are consolidated and the consolidation unit is given an identification number on a barcode. This is a different matter as the consolidation unit is only moved, not sorted, and can be scanned to indicate pick up and the scanner can reflect the correct delivery location from the system at this time. The process does not require high speed response of fractions of a second for this process, as it might for a high speed sort, and normal system response times are acceptable for the registration of the pick up and the indication on the scanner of the delivery location.

It is of value to the supply chain, as well as the cross dock, to be able to link up the line item of the order to the customer information. This allows the cross dock operation to know that a specific item, as identified by the manual check of the order line item, was received, is at specific locations in the cross dock or is moving to the customer. This additional information is of value for the customer to determine when and what will be delivered in the immediate future from the cross dock operation. This allows the cross dock operation to utilise data in the Track and Trace capability as to what was moved through its operation and when. If the insertion of a label is still done on the cross dock, the inherent problem of incorrect identification and the checking against a paper based delivery note remains a potential source of errors.

If the barcode is to contain the information, then the label will have the information of the item identification, the consignment information and the customer information inserted into the barcode. The inherent problem of identification on the receipt into the cross dock remains, and the complexities of the work to link the identified item to the correct order in the system using a manual paper based delivery note also remain.

If the labelling is moved further upstream towards the supplier, then the supply chain systems capability has been significantly extended and the use of the label and associated information in the system now becomes of greater value to an entire supply chain. The information that is potentially linked via the barcode to the system or contained in the barcode is:-

- Order number;
- Customer number;
- Supplier number;
- Consignment number of items;
- Item number in the consignment;
- Physical properties, such as mass and / or dimensions;
- Priority code; and
- Billing information.

While it is feasible on the cross dock to print labels that contain the correct consignment numbers and to identify each parcel as belonging to the consignment, this is extremely time consuming and space consuming. It does require that the entire consignment be assembled and then labelled as the physical check of all items needs to be done. This is extremely difficult where large numbers of items constitute consignments. It is far simpler to have a label that is produced at the source of the item that recognises the majority, if not all of the above information and allows the consignment to be tracked as individual items but with knowledge of the consignment through the entire supply chain. Such information, whether obtained from the system or from the barcode label, provides a major advantage to the cross dock. All items now have a barcode label which shows the upstream supply chain information, order information, as well as the downstream supply chain information. Receipt can be done by a direct scan into the facility without the requirement for space or time to add the labels. The receipt scan can perform the item identification and immediate movement to the sort. The receipt will now be done with the minimum of handling of the goods and movement can either be done manually or with material handling equipment. As the items move through the process towards the assembly lanes and into the trucks the system knows precisely where these items are. If consignments are not completely received within one transport, these can be looked for within other transports that are within the yard or en route to the facility. The required transport can be brought to the cross dock for unloading so that all the items in the consignments are available in the cross dock for sorting. This is an additional requirement that may well be a value to the truck scheduling as discussed in Chapter 13. The pre-requisite is that every item can be tracked through the supply chain, including into, through and out of the cross dock facility.

The choice of the barcode label having the full information or having an identification barcode label which is associated with the information in a system is dependent on a number of factors. The system traffic is reduced by the greater information on the barcode, but the scanning equipment needs to have greater intelligence. This is an economic compromise, but it is not the pre-eminent reason for the choice of barcode label information. The issue is the sophistication of the supply chain. In supply chains where the various entities are all sophisticated and the systems are integrated, interfaces are established and the data is compatible, then data and information can flow from one entity to the next in the supply chain without restriction. In this case the simple identification number on the barcode is more than sufficient for tracking, as all the data is moved as necessary to the supply chain entities. The label will still require information of the customer and consignments for the supply chain to be effective, if the sort is done manually. Alternatively, the supply chain where the various entities are not integrated, or the data is not completely compatible or the interfaces from one system to all the others is not established, the flow of data will be restricted or not able to take place. It must be borne in mind that the level of systems sophistication for the supply chain from the cross dock point of view is the lowest level of systems integration capability and practice in the upstream supply chain. The cross dock cannot afford to handle goods with different systems, that is multiple processes, caused by some members being integrated for data transfer, and other members not being integrated. This would significantly reduce the ability of the cross dock to handle high volume goods effectively. Therefore the choice of the data on the label is done by the following criteria, in order of importance:

- The sophistication of the upstream supply chain systems – if it is feasible to move all the data as required, then the data in the system is valuable; if not, then the information on the barcode is the preferred choice;

- The type of sort. Where the sort is manual, additional information is required in the barcode and in text on the label; where it is automated, no additional information is required;
- The point where the label is added. The further upstream the more the label adds value to the chain and
- The technical and economical issues of the scanner cost, the barcode cost and the communication traffic cost to the entities in the supply chain.

It is common practice to place multiple items onto a consolidation unit after the sort and to label this consolidation unit with a unique identity. This barcode label need only be an identification number, which the system records as the common reference number for all the items on that consolidation unit. As this consolidation unit number moves through the supply chain, so each of these items are located in the system at the same point as this identification number.

The value of the data required at the labelling points in the supply chain has been discussed in this chapter. The issue of whether the barcode label must be a reference number or a comprehensive encoding of the details that are available in the supply chain has also been considered. It is of relevance to note there is the choice to have comprehensive information on the barcode and to also move information to the entities in the supply chain. This caters for various levels of system sophistication. While this is slightly more expensive as the scanning equipment is more intelligent, and the barcode is more expensive, it allows the entities to start by using the label with all the data and to then progress towards true data integration without significant changes in the processes in the supply chain. This is of major advantage as a supply chain can continuously improve without having to be re-engineered. It is also of great value as new entities can be brought into the supply chain as necessary, where they have a lower level of systems sophistication, without disrupting the supply chain.

In some cross docks (Woolworths Textiles) the receipt into the cross dock triggers the payment to the supplier. The cross dock is paid on delivery to the customer as the POD is scanned. This is only feasible with the label applied at the supplier and with the information available throughput the supply chain. The reduction in manual processes, and the increased effectiveness reinforce the value to the supply chain that is brought by the earlier application of the barcode.

11.4 Barcode labels in cross docks

The labels can be simple identity numbers as described above or the label can be a more sophisticated conveyor of information. The research shows that various companies have chosen to use barcode labels differently, but all accord with the logic espoused in this chapter. SPAR is the only company that does not use barcode labels in its cross dock operation but a barcode label and scanning is to be introduced in the latter half of 2003.

SPAR has had significant problems with reconciliation of the receipts with the dispatches, because of this deficiency.

A simple numerical identification is shown below:

Figure 11.1 Identification barcode

While additional information is printed on the label, this is the information to effect the sort and receipt manual check and is extracted from the system.

The more sophisticated information label is taken from Woolworths Textiles, where all the information required for the supply chain is contained in the label. This was placed on the barcode as the sophistication in the textiles industry varies from ERP systems to manufacturers who have one PC on the desk of the secretary to the Managing Director, which is used exclusively for correspondence.

[redacted]

Figure 11.2 Comprehensive Information barcode

This barcode label contains in sequence the following:

- Woolworths store number
- DI (Order) Number
- Total number of parcels per consignment
- Parcel Number
- Supplier Number
- Type of Parcel or Distribution Unit (Packaging)
- Service type
- Type of goods
- Destination Cross Dock

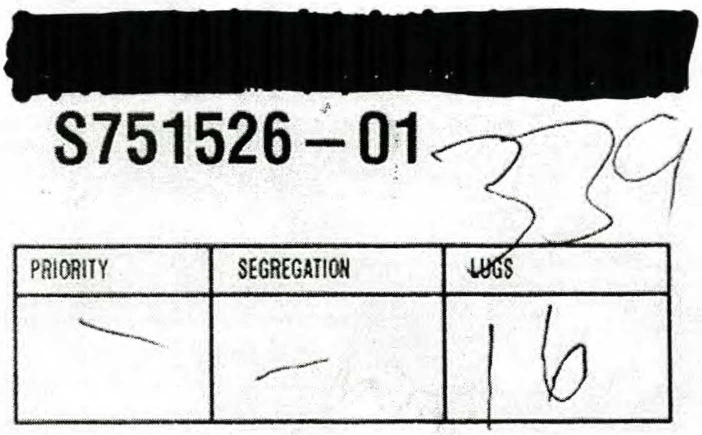
A large measure of this information is printed on the label, as the process was a manual sort. All Track and Trace work was done by a scan. The information of all the parcels in a transport sent from one cross dock to another was transmitted via an interface to the receiving cross dock facility to act as an ASN. The scan into the receiving facility immediately showed if any parcel was not received or another parcel was found.

A consolidation label taken from the Woolworths Foods is as follows:

[redacted]

[redacted]

Figure 11.3 Consolidation unit barcode



11.5 Conclusions

The research clearly identifies the need to have an identification label on the items moving through a supply chain with a cross dock. It specifies the information that must be known at each point of tracking that is required to make the supply chain effective. The movement of the information may be done from system to system or by embedding the information in the barcode. The research shows that the primary reason to choose one method or the other is the sophistication of the systems in the supply chain, with the lowest systems capability in the supply chain being the determining factor. The value of both methods and the reasons to choose the most appropriate alternative are discussed.

The system functionality to make the supply chain effective are specified. These are:

- Track and Trace capability;
- Order Management System information including order details and the Advanced Shipping Notice; and
- Yard Management System to effectively manage the staging of the transport at the facility.

The earlier the barcode is applied in the supply chain, the greater the value to the entire supply chain. The more information associated in the system or contained in the barcode label, the greater the value to the entities in the supply chain, and the less data capture and paperwork that is required in the supply chain. Less space is required in the cross dock as the type of cross dock moves from the CML to the SML versions.

[redacted]

CHAPTER 12
PERSONNEL ISSUES IN A CROSS DOCK

12.1 Introduction

Supply chains spanning from source to end consumers generally have one or more components outsourced. These operating entities within the supply chain need to work together. All the parties will acknowledge that the end customer is the prime objective. However, very few of these entities are focused on optimising the supply chain at the expense of their own profitability. In this macro view the focus on the customer remains a major draw card, and the correct measurement metrics within the supply chain are essential. The measurements need to be very different from the traditional throughput or maximised profitability, in order to tie the entire supply chain to satisfying the customer. The personnel that work within the cross dock are of prime importance to the success of the operation. These personnel are somewhat different from the traditional warehouse personnel. In the cross dock there is continual pressure to perform the sortation, which is the bottleneck as has been shown in previous chapters. There are other capacity constrained resources such as the equipment and the doors as well as the scheduling of the transport. The personnel need to work as an integrated team to make the various stages work in conjunction with each other to ensure the flow of items through the supply chain. This is particularly true in the case of the cross dock. The cross dock is made more problematic, as the interfaces are more complex where the inbound transport, the outbound transport and the cross dock operation can be in separate hands.

12.2 Operator skills and capability

Even in the case of a fully automated facility a fair measure of the operational capability is dependent upon the skill and knowledge of the personnel that unload the trucks, load the trucks and do the final sort from the automated facility. It has a management component that is particularly important, as receipts and dispatches must be balanced in a continual flow in order to make the sortation as effective as possible. The problem with the cross dock is that the very principle of the cross dock, to sort product with a high volume throughput, is the reason why it is actually so difficult to operate. There are constant references in the literature to the problems where cross docks have been introduced. These problems are not only ascribable to the systems utilised, but also to the personnel not understanding the complexities of the operation and the time pressure. From a management point of view there are the complexities and the discipline needed to operate effectively. From the operators' point of view, a different mindset is required. This mindset is to continually balance all the work in and around the cross dock so that items are never at rest within the facility other than in the assembly areas. This is very different from the warehouse where items are received in one discrete operation, then identified for put away into storage and so on. This operator mindset has to focus on the ability to effect continual balancing of the total work as different product mixes move

through the facility. This requires the continual improvement and balancing of the operation, and an understanding of the principles of TOC.

With the sortation system as the bottleneck, a buffer of stock needs to be created upstream. This is the receiving stock in the inbound transport. This needs to be managed to the minimum required to ensure the continual feed to the sort. This requires inbound, or the upstream, transport scheduling. Restrictions downstream must be removed so that items flow through the sort and are assembled and dispatched without the build up of any buffers. To a large extent all of these operations are dependent on personnel, and the integration of these personnel to ensure a continuous flow of items. To achieve this continual flow requires management and operators of a different calibre from the normal warehouse personnel. These operations personnel must work as a team. One of the primary requirements is the continual balancing process to make all the aspects of the chain work to ensure the flow of items without build up of stock. The balance will continually shift, as the product mix will change with every delivery. The individuals within the team must have the ability to perform whatever tasks are required to balance the flow for short periods of time to cater for different product mixes. This requires the trust that other team members are multi-skilled and capable to see temporary restrictions and remove them by performing the necessary tasks to achieve the balanced flow.

While trust within the cross dock facility is essential, trust within the supply chain is of major importance. If the supply chain is unable to have trust between the various interfaces of the entities forming the supply chain, then each entity will lose sight of the need to satisfy the end customer and begin to seek local optimisation. This will be at the expense of the overall effectiveness of the supply chain. The trust is also in the understanding of the supply chain and the role of the cross dock within the supply chain. In the case of Home Depot, the stores were told that they would get an improved service. The introduction of the cross dock did not improve their delivery service as the time scale was actually extended when compared to the drop shipment process that existed.

However, the cross dock process offset the additional days delay by improved transport effectiveness and more effective store receiving. All transport into and out of the cross dock were essentially full loads. The delivery to the stores was done at scheduled times, with one set of documentation and with labelled or identified items. The receiving work was significantly reduced due to the use of the cross dock.

12.3 Physical design and personnel

The physical design influences effectiveness and to some lesser extent the flexibility of the actual operation. Insufficient doors, aisles that are too small and similar problems make the task of the personnel operating the facility extremely difficult. Where cross flows are evident in the movement, this reduces the effectiveness even further. The Spar Foods design is a prime example of multiple flows that oppose each other and, in this case, where flows are at 90° to the main flows. This facility is highly ineffective. The primary problem for any of these facilities has been shown to be the sort. The Spar operation where the sort was done by walking down the assembly lanes and delivering the lug to the store pallet placed at the furthest point in an assembly lane reflected the most ineffective method of doing this sortation. The personnel managed to make this operation effective by long hours and with major management commitment. As the management has been convinced to introduce shorter walk distances, so the amount of management work and the operator work has reduced. This is evidenced by the ability of the facility to finish the work quicker and with less errors to be reconciled.

The people that operate within a cross dock environment need to understand how to balance the flow through the entire operation. There is no storage to buffer or segregate the receiving and dispatch functions. Any imbalance will result in a build up of items in front of the section of operation which is performing below the required throughput rate. The personnel who can work with this from a management perspective are those that can actually see and understand the operation must proceed as if it was an assembly line or manufacturing process. One of the skills is the ability to apply manufacturing process knowledge such as TOC. The time pressure is significant as there are high volume throughputs occurring at all times and the operation must work on a continual basis to move goods in, through, sort and out of the facility. There is no space to store goods to rectify problems. All of the space is valuable and any space taken to rectify problems is a potential restriction of the sort or movement of the product. It is therefore evident that the personnel must be able to work at a high pace continually and to be able to solve problems immediately. The production skills of line balancing and TOC mean that these are somewhat unusual personnel for the traditional warehouse operation.

12.4 Management

The management need to be able to make fast and correct decisions. This means that they must understand the principles of TOC and line balancing and be able to convince personnel to continuously change roles in order to balance the entire throughput. This is even more important where the overall process varies day by day as to the throughput, as well as perhaps the range of products handled. The knowledge that there is no ability or time to solve problems means that the skills level to use systems and to be able to understand the consequences of any decision are severe. The primary skill, beyond the line balancing and TOC capability, must be with management's ability to foresee problems and to prevent them. Fixing problems is not a methodology that is going to work, other than on rare occasions, within a cross dock that is handling high volumes. The principle is very evident that there is only one way to do any operation within the cross dock. Having determined this correct method, all parties and personnel within the cross dock must adhere to it. This is not discipline in the military sense, but is effectively disciplined operation in compliance with best practice. Anyone may suggest improvements, but these must be tested and then recorded so that all personnel adopt the new methods. The ability to work with multiple information systems has been shown to be a great necessity. A cross dock must have track and trace, order management and yard management systems to be able to manage an effective operation.

Other than for the automated facility, the operators themselves are essentially working on a manual manufacturing line. These personnel need to be able to work and perform at a specific, continuous level throughout their shift. Personnel cannot work at different rates throughout the shift as this would immediately cause imbalances in the throughput within local areas and cause so many problems in line balancing that it would fully occupy management. The error rate of these personnel also needs to be extremely low. There are very few double checks that are feasible with the throughput rate that occurs in a cross dock. This is far more demanding than in a warehouse where a large number of inherent double checks take place.

From the above it is essential that all personnel adhere to and are versed in the correct operation of a cross dock. There is only one way to perform each process and this needs to be taught to each person until that person does it instinctively. Only then will we find the refinements of line balancing occurring and the full potential of the cross dock becoming evident. It is essential that this training is done formally and it needs to be done prior to the person accepting a role on the floor. It is almost inconceivable that professional management would allow an unskilled person to start to move goods, but it does happen in South African operations. The interference with other personnel performing their duties, the use of space and the need to occupy more senior personnel to correct errors means that personnel that work in the cross dock who are not fully trained and have a reasonable level of experience in the work, are directly affecting the entire operational effectiveness. They must be formally trained before performing on the cross dock floor. This is the classic case of applying training in order to make a person skilled prior to entering the actual operation. Training is given until the person has moved down the learning curve to a point where the work is performed without errors and effectively.

Figure 12.1 reflects the balance between the facility and the people that is derived from this empirical research. It can be seen that the design limits the physical capabilities of the facility. It also limits the ability of the personnel to use the facility and the maximum effectiveness that can be achieved. That being said, the personnel can negate the value of a very good facility that has been designed to the most appropriate standards for the focus and the function that it will perform in the supply chain. Equally the personnel can change the same facility into the most effective operation possible. It is therefore absolutely essential that the correct personnel to work effectively in the cross dock are chosen and trained for the operation. The numerous references in the literature often ascribe cross dock problems to either systems or a design flaw. Inherently the cross dock itself requires a different management philosophy and different type of operating personnel, and this is one of the areas of the least attention and potentially the greatest problem for the cross dock. The research in Chapters 3 to 6 record and reflect these issues, and is supported by the literature reviewed in Chapter 2.

Figure 12.1: - Physical Design and Personnel influences on the Cross Dock

Physical Design Effectivemness	Hi	High Potential, Poor results	Highly Effective and Efficient Facility
	Lo	Failure	Good people, poor results
		Lo	Hi
		Personnel Capability	

12.5 Personnel

It is evident that the personnel that are effective in the operation of a cross dock, need to be able to perform functions in a far more disciplined manner than in a warehouse, and under greater time pressure

The personnel that operate the cross dock need to have the three characteristics of: -
- Disciplined approach;
- Ability to perform procedures consistently and correctly; and
- Work consistently under time pressure all the time.

For those companies that have a number of cross dock facilities in operation, it is feasible to recruit and introduce individuals into the operation and progressively train them before they begin to operate on the cross dock. These trained staff can then be used for new facilities and expansions. If the training is formal and detailed, this is the most advantageous manner to increase the staff level in an operation. This is true for such operations as the Home Depot and Sam's Club.

In the Pick 'n Pay perishables operation and the Woolworths Textiles operation major changes were introduced with the introduction of the cross dock facility. In the Woolworths Textiles case three cross docks were interlinked in order to move product from one part of Southern Africa to the final store destinations. In both cases the management has stated quite clearly that only the determination of management to make the cross dock system work enabled the operation to survive the initial months. In particular the Woolworths Textile operation was sorted manually, and had a group of operators and management who were inexperienced in cross dock operations. The structure that was initially conceived was common for warehouses and was comprised of a Regional Manager with an Operations Manager, a Transport Manager and an Administration Manager reporting to this position. The Operations Manager was from a warehousing background. Prior to commissioning, careful work was done to determine the number of operators and the shifts that needed to be worked. What was found was that the practice was very different from the theoretical concept. The splitting of the operation into the two entities of operations and transport was not effective. The staff that were recruited from cross dock backgrounds were not immediately comfortable with the discipline and process rigour that is necessary in a cross dock. As the staff learnt to do the exact process in a specific manner that was determined to be the most effective by the management and operators, so the amount of work that was expended by the operations reduced. It was found that a manager was required for decision making and de-bottlenecking on each of the two shifts worked, and that two managers were not effective together. The transport manager began to function as a second shift manager, when more emphasis was placed on the transport loading. It became very evident that the operations team started to look at the entire flow of the goods in their operation. In order to achieve throughput, the managers began to balance each stage of the process with sufficient people in order to ensure continuous throughput. This focus on throughput and balancing or de-bottlenecking of the actual process paid handsome dividends. A year after commissioning the Johannesburg facility had reduced its staff by 30 percent and had increased its throughput to nearly double what it was able to do in a 24 hour period a year previously. One of the primary concerns for the operations staff was to ensure this continual throughput without errors. Errors in the initial portion of the operation were found to be a major source of problems, and staff were coached and managed to ensure that they did the right process for every step every time.

It is evident that personnel quality and the ability to perform the tasks in a strict sequence and correctly every time was a major requisite to work within a cross dock facility. The following section tries to set out, based on this empirical evidence, the issues that affect the operator in the cross dock .

12.6 Errors and the operation of a facility

The cross dock staff are faced with a number of factors that affect their performance. In this context performance is the ability to do the required processes at the expected speed and without errors or omissions. Poor performance results in the two problems of reduced productivity and increased errors. These are two symptoms of the same problem – poor staff performance.

The consequence of poor performance is significant in both the time and effort required to rectify the situation as well as the use of the restricted space available in the cross dock. Poor performance as defined here results in errors and omissions. The consequence of errors or omissions results in significantly increased work: - the error occurs, the error must be found if not recognised immediately, the error must be reversed and then the correct process must be carried out. All this occupies time and effort, and results in unnecessary costs and reduced effectiveness. It is accepted that no operation can provide an error free service. However, the level of error needs to be very low, otherwise the consequences of the errors begin to be very significant. As operations suffer increasing levels of errors, so the customers start to check in detail all the deliveries, thereby delaying the transport and unnecessarily adding significantly to the administrative burden. The delayed transport also causes other customers to begin querying the delivery times, so that the cross dock is involved in tracking the delivery times to supply the customers with the correct information. To reduce the errors, additional checks are performed in the cross dock and the transport functions, delaying the flow of the goods. All this requires ever increasing numbers of staff and effort. This begins to snowball, and results in the "errors" dominating the operation.

The consequences of the increased level of errors or poor operation are dire – reduced effectiveness for the logistics chain. The cause of these can be attributed to two prime factors: -

- overload of the personnel for a limited period
- personnel capability

The overload is where the workload is so much more than the personnel can handle, that errors occur far more frequently because of the pressure of the work. The capability aspect is the ability of the staff to handle and correct errors or problems that occur in the processes. These may be caused by such issues as a product that is damaged or in the wrong place, or missing. Staff often refer problems to supervisors, and proceed with the focus of their tasks in sequence. This means that they are inexperienced in correcting these problems themselves. The inexperience results in slow problem solution when the supervisor is not available to correct the problems. Problems then become errors or omissions, or occupy an inordinate amount of time. The correct staff, not properly trained to do the primary processes as well as the error rectification, will have a lower capability than the staff that are able to do all the functions with skill and expertise. This is a capability problem.

In both cases the cause of these is the stress of performing the required processes at the desired rate of work to maintain effectiveness. An error introduces stress to a staff member when the capability limit is reached and uncertainty begins to slow down the performance. The increased workload means that time for thought doesn't occur and the errors slip past the staff, even when they are capable of correcting them simply and quickly.

From this argument it follows that if the training and experience is low, lower effectiveness will result. If the workload fluctuates, then the error rate may well rise significantly. The level of staffing can fluctuate, but the capability must remain at the desired level of effectiveness, as the introduction of less skilled staff is a direct cause of errors or omissions. The cause of the workload fluctuation is often part of the business.

There are fluctuations in the workload, which occurs from day to day and week to week. If these remain relatively constant, then the impact on the cross dock staff is small, if not negligible. The problems arise when the workload varies significantly. This occurs due to seasonal changes such as Christmas, Easter, the launch of new lines, short weeks where the stores are closed for holidays and so on. Many cross docks also suffer day by day changes that have a major impact. The sales on Saturday and to a lesser extent Sunday are higher than in the week days. This means that a cross dock must pick orders on the Thursday for delivery on Friday to meet these peak days. If deliveries don't happen on both Saturday and Sunday, then the peak increases even further, as the two largest sales days must be catered for in one delivery. The impact of this may rise to a doubling of the workload level from the lowest to the highest days, or an increase of 50% over the average workload (SPAR Perishables). The impact on the performance of the operational staff due to these fluctuations is significant.

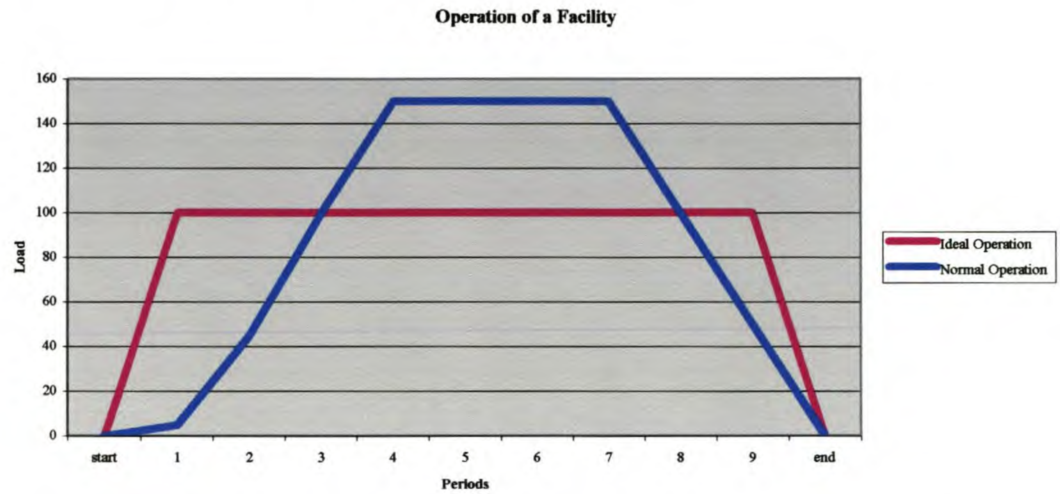
The effect of errors is to introduce additional processes, which impose further time and effort and reduce effectiveness, when the staff are already under time pressure. The consequence of increased pressure is further errors and omissions that affect the performance standards of the cross dock.

In a cross dock the inbound operation can also be affected by the poor management of the inbound deliveries. The ideal is where the suppliers deliver equal amounts of goods every hour of the workday, so that the workload remains constant throughout the workday. This is different from the receipt of a constant amount of transport, where some trucks may have large loads and some small loads, which result in varying workloads. The practice is often that the trucks are scheduled as trucks and not as workloads, and often that trucks are not scheduled at all (SPAR Perishables). Where scheduling doesn't occur, the cross dock is pressurised to take a truck that arrives so that it doesn't wait. This significantly varies the load on the staff of the cross dock, helps make the transport effective, and requires increased receiving areas in the cross dock – the only beneficiary to this is the transport as the cross dock staff are less effective and the space utilisation is less.

The empirical evidence is that the cross dock is often clogged with goods, staff are frantically trying to move, label and sort goods and all the while paper is moving and equipment is trying to move items at high speed. All this is occasioned by the pressure that the cross dock allows the external environment to create. The root cause of the pressure is that the cross dock does not balance the work load it receives to match its capabilities. The consequence is that the staff are placed under pressure on occasion and this leads to errors and lower effectiveness and ultimately higher costs in the logistics chain with reduced service. This is depicted in Figure 12.2.

The cross dock must act as part of the logistics chain. This is often stated, rarely understood in detail and, even rarer, made to happen. The complexity of receiving goods from many suppliers overwhelms the planning capability.

Figure 12.2: - Operation of a Facility.



Five questions are pertinent when the normal operation is compared to the peak operation:

- The impact of the normal operational load on staffing taking the expected effectiveness and the staff capabilities into consideration;
- The level of errors during normal operation;
- The level of the peak and its frequency of occurrence;
- The effectiveness of the operation during the peak;
- The level of errors that occur during the peak.

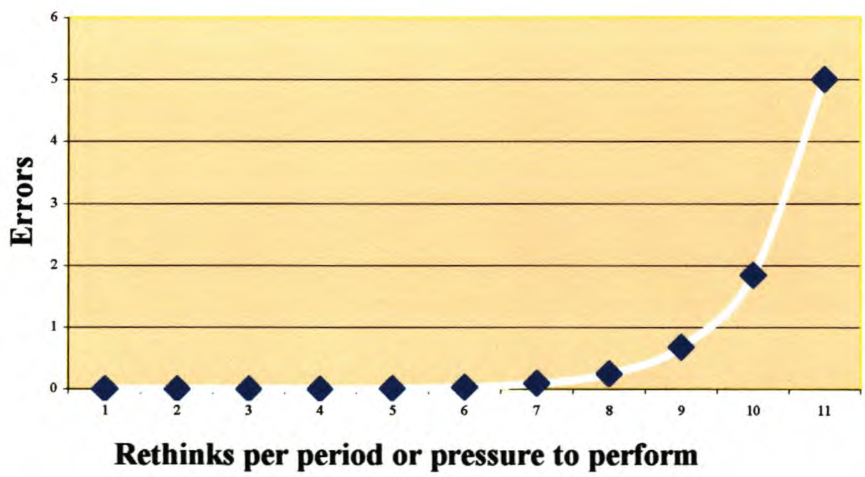
The previous arguments lead to the conclusion that for a given cross dock the staff make the effectiveness of the operation a reality. There are two primary factors that influence staff performance – workload and staff capability. Both of these can be addressed. The capability reflects the standard of person allocated to the cross dock , and the training quality and standards. This is a medium term issue. The workload is a more immediate issue. The cross dock can, to an extent, manage the environment of the logistics chain for the benefit of the logistics chain during the working day. This can remove severe fluctuations in the workloads during the day, alleviating the pressure on the personnel. If this is not done the effectiveness of the logistics chain is adversely affected.

Normal people make mistakes. The less pressure on a person, the less likely the person is to make mistakes. The converse is also true. As pressure is applied, so the person is more and more likely to make mistakes. Eventually the person begins to make so many mistakes that the process the person is performing grinds to a halt.

There are two broad categories of pressure that affect people in industrial situations. The first is where the work load is raised above the capabilities of the person. The person just cannot cope with the workload and starts to make mistakes. The second is where the person is unsure of what has to be done in the process and starts to query the actions in his/her mind. The uncertainty makes the person concentrate on the steps taken and not the steps to be taken. Errors begin to occur as the uncertainty of the process translates into historical focus and not future step awareness. In both cases the person realises there may be a mistake, or knows there is a mistake, and begins to focus on the mistake and not on performing the future correct steps. The vicious cycle continues as this uncertainty and focus on errors means the person starts to come under time pressure, begins to make more mistakes and this adds further to the pressure on the person.

The effect of this can be seen in the following graph

Figure 12.3: - Errors under Pressure: - nominal curve



The graph shows the person can perform actions quite competently until a point where the number of "rethinks" start to cause the person to move from the normal care of the job to a point of uncertainty. The time pressure precludes the person from going back to check the steps and processes as being complete and correct. The pressure rises and at a nominal number of 7 or 8 re-thinks or checks in a period, suddenly the person starts to make errors. The time constraints as this threshold is passed means the person cannot go back and do the checks necessary to remove the potential or actual error. Obviously this number of rethinks will be unique to each operator, much as learning curves are applicable to all personnel.

Errors occur and the rate of error increase is significant as the person is now placing himself under more pressure as the uncertainty makes him doubt his ability and clouds his judgement. Ultimately the person ceases to do anything useful.

The consequence of such a problem is that errors probably take 4 times longer to find and fix than to do correctly. The person making errors introduces a problem that is far larger than the error itself, and the delay in fixing means the error must be detected first and then fixed. This is a problem that means that service is compromised, as either the customer gets an order with an error in it, or checks have delayed the product. In either case the distribution costs are increased due to these errors.

12.7 Conclusions

The research proves that the success and effectiveness of a cross dock facility in a supply chain is dependent on the facility design and the operating personnel. The research has expanded the knowledge of the type of personnel required for the effective operation of a cross dock. The characteristics of these personnel are set out, as is the need for detailed, formal training. The need to manage the supply chain to prevent the personnel becoming overloaded was researched. The effect of overloading personnel is to introduce errors, which quickly reduce the effectiveness of the supply chain if allowed to continue.

The management is also a more demanding process. The manager of the facility must undertake fast decisions and be able to understand the consequences that come from these decisions. These decisions must not be incorrect or introduce further problems in the operation or the systems that the operation uses. This places an onus on the management to understand the operational detail, the systems and the capabilities of the personnel and to be comfortable with making fast and correct decisions in this environment.

The causes of errors were explored using empirical evidence of the operations in the cross dock. This work supports the requirements recorded from the research.

CHAPTER13
DEVELOPMENT OF THE CRITERIA FOR A DESIGN OF A CROSS DOCK IN THE GROCERY AND RETAIL SUPPLY CHAIN

13.1 Introduction

Previous chapters have discussed the principle that there are three basic types of cross dock, with two of these having subsidiary categories dependent upon whether the cross dock handles product from suppliers that deliver a single product or multiple products. The three types of cross dock were the Cross Dock Managed processes (CML) where the work of preparation and labelling of the items was done at the cross dock, Joint Managed Loads (JML) where the work of labelling and preparation of the product was shared between the supplier and the cross dock and Supplier Managed Loads (SML) where the suppliers do all the preparation for the product prior to the shipment leaving for the cross dock.

This chapter will look at the development of the criteria that underpin the design of a cross dock. Each of the primary design criteria that may or may not affect the design will be critically appraised. The majority of these criteria have been discussed in previous chapters or highlighted within the research of the companies that operate cross docks. A clear definition of what is relevant in designing a cross dock needs to be determined, as it does not exist in the literature review.

13.2 Size of the load received

The method and timing of the product arrival will have an influence on the receiving of the goods. In all cases the inbound process will be applied to all transport, whether the transport is large or small or whether it contains a small or large volume of items. The process can be broken into the following major steps: -

- Verification that the transport is destined for the cross dock;
- Verification of the delivery details against the original order;
- Amendment of the order if there is a discrepancy;
- Transport is placed at the cross dock door;
- Unload the transport on the receipt of the items;
- Record of the quantity and quality of the items received against the amended order;
- Transport is removed from the cross dock door;
- Verification of the received items against the amended order or delivery note; and
- Release of the transport.

It is evident that the time spent on administrative processes is essentially the same whether the transport is a large or small volume mover. The time at the dock, and hence the transport effectiveness, is dependent on the items in the load and the amount of work the cross dock is undertaking in the supply chain before the sort – whether it is a CML, JML or SML. The larger the transport, the greater will be the door utilisation of the cross dock. As the transport effectiveness increases so, for a given throughput, fewer doors will be required.

13.3 Criteria for the number of doors in the cross dock

The size of transport is primarily determined by the function the inbound operation is designed to perform. When the cross dock is utilised to assemble collections from local suppliers, and then to trunk the product to a another cross dock (Chapter 3: Woolworths Textiles) or to another Distribution Centre, this will require a large number of inbound doors with a limited number of outbound doors. Small trucks will presumably do the collection. In this case, the amount of time expended on preparing the trucks for offloading and performing the administrative processes will be higher in proportion to the offloading time than if the trucks performing this collection function had a larger volume. The reverse is true. For the cross dock receiving the large volume, densely packed transport from large suppliers or the collection cross dock, the number of receiving doors will be reduced as they will be utilised more effectively. This can be seen in the Woolworths Textile operation where the receiving facility in Johannesburg had only two receiving doors, while the facility in Cape Town which was primarily a collection cross dock, had eight doors for receiving.

Where the cross dock has a large number of inbound transport, the design may well be altered to accommodate a separate area where the administrative processes are completed prior to the truck being allocated and backing against an unloading dock. This would maximise utilisation of the dock but would be a different design from the more traditional cross dock. As the truck size increases so the need for the special administrative capability decreases, so it is really when there are a large number of inbound transports that the issue of making the door have as high a utilisation as possible leads to a separate administrative processing area.

The products that the suppliers deliver to the cross dock will also make a major difference to the receiving process. The supplier of multiple, individual SKU's, when compared to the supplier that delivers palletised items, will require far more handling to remove the product from the transport.

It is therefore evident that three major criteria influence the number of receiving doors. The first is the characteristics of the goods that are being received. The more that these are individual items that have to be handled, the greater the amount of work that is required. This requires increased space, personnel and equipment to perform this function. The second is the size of the transport, which shifts the ratio of non-productive and administrative functions relative to the productive unloading of the transport in the cross dock. The larger the transport the greater will be the utilisation of the cross dock. This reduces the number of cross dock receiving doors. The reverse is true that as the transport reduces in size, so the number of receiving doors will be increased for the same throughput. The transport size needs to be determined by the volumetric measurement of the load, not by the volumetric measurement of the transport. Obviously it is important that the load be measured, as this is what is handled by the cross dock and LTL movement is possible in the supply chain. The product cubic metres is the correct measurement, rather than the 25 cubic metres of trailer volume. The third is the amount of work to be done for the supply chain at the door or in the transport. This is the labelling and quality and quantity processes that are necessary to effect the handover from transporter to cross dock and the preparation work necessary for the effective sort in the cross dock operation.

The *inbound movement* is therefore characterised by two issues. These are the transport size and the work required by the item handling to accept the product into the cross dock. This has been developed into the figure below, which shows the four categories that one can ascribe to these criteria. While these are shown as discrete categories it is important to note that the balance between the size of the transport and the number of items within the load will act as a continuum rather than as a discreet stepwise function.

Figure 13.1 Characteristics of the Inbound Movement

Load volume	*Large* ↕	**Simple handling; Efficient doors; Moderately complex flow balancing.**	**Difficult handling; Efficient doors; Very complex flow balancing.**
	Small	**Simple handling; Inefficient doors; Easy flow balancing**	**Difficult handling; Inefficient doors; Difficult flow balancing.**
		Easy, few ←→	***Difficult, many***
	Work to handle the item		

13.4 Customers

The profile of the customers being served by the cross dock facility will influence the shape and size of facility. Where all the customers are offered the same service of a unique transport delivery every day, as in an ideal facility, each customer would be allocated a single door and the cross dock sortation can be done directly into the transport. As the customers begin to change in size and frequency of delivery so the problem becomes more complex. Large customers will be allocated a single door and where possible the load will be placed directly into the transport. The use of a dedicated transport to the customer is only economically feasible where the size of the customer's orders is at least a trailer per day. If trailers are not used, then the load must be assembled in the lanes in front of each dispatch door. As the customer size decreases, so the load needs to be placed in assembly lanes on the cross dock floor. These loads in the assembly area can then be combined to form a route with multiple drops. The transport utilisation can be maximised by what is assembled on the floor and what constitutes an effective route. This may well change from day to day as the buying volume of the smaller customers is generally not consistent on a day-by-day comparison.

The complexity is increased as the number of customer cycles per week is increased. Customer cycles are where customers are serviced on certain, specific days of a week. The period is chosen to make the customer load large enough to economically justify a drop. A two cycle, six day week would be, for example, an A cycle where deliveries are done every Monday, Wednesday, and Friday. The B cycle would have deliveries on Tuesday, Thursday and Saturday. The ideal is where all customers receive a load once per day. In practice it is more likely that some customers will receive one or more full transport loads per day, some will receive full transport loads every second day and some may only receive full transport loads once or twice a week. This essentially means that the outbound loads need to be added together in a different manner each day to create cost-effective routes. This ability to build loads is dependent upon the correct layout of the lane area. This is very evident when one compares the Woolworths Textiles where a large number of store orders had to be assembled into routes to service the further stores in the Limpopo, Mpumalanga and Free State regions. These routes have 5 to 6 drop points, and the drop points alter within the route on a regular basis. In America, even the Home Depot with its enormous throughput has approximately 30 to 40 per cent of its stores on any given day allocated to combined loads. Obviously the complexity is significantly less, as a combined load to the Home Depot is in fact only two drops, as opposed to the African 5 to 6 drops.

13.5 Fluctuations in the work load

The cross dock is designed for a maximum throughput and has the area and doors necessary to operate at this throughput. The limitation is the size and shape of the facility, which cannot be altered in the short or even generally in the medium term. It is therefore essential that the peak changes in the day by day and the week by week operational throughputs are clearly understood as to the patterns and defined as to the magnitude. The supply chain processes must be designed and planned to minimise these. This is a critical message in the design and operation of a cross dock. The Woolworths Textiles had a predictable peak across the Christmas season and this was generally defined by the disposable income available. The secondary peak was evident across the Easter period. This was far more difficult to define. This was a period when winter clothing was purchased and was a premier holiday period. Sales were dependent upon the severity of the weather within the holiday period as well as the disposable income. The colder the weather, the greater were the sales. In the fresh food market SPAR, Pick 'n Pay and Woolworths show only small changes between months. They are not influenced as severely by weather patterns in the overall quantities sold. Obviously individual products are influenced. The influence of day-by-day fluctuations can be seen in the following table, which is taken from the one SPAR operation that was investigated for foods (Chapter 4). Comparisons of the day by day volume handled was done. The ratio for each day when compared to the lowest day is in the first column, and the same data is represented in column two but relative to the daily average.

Table 13.1: - Daily Fluctuations in Demand

Comparison of Lugs Handled per day

Day	To minimum	To average
Monday	1.0	0.8
Tuesday	1.2	0.9
Wednesday	1.2	0.9
Thursday	1.9	1.5
Friday	1.3	1.0
Saturday	1.2	1.0
Average		1.0

These fluctuations were caused because the operation works for only six days in the week. The stores were serviced three times a week on two cycles. The Thursday peak pick in the operation arises because the largest stores, with the greatest influence in the cross dock operation, originally demanded to be on the cycle that delivers fresh product on a Friday. This is a traditional problem that has remained in the operation for many years, and was not known until this analysis was done. The rationale for the store was that a delivery of fresh produce on a Friday enabled the store to service the peak Saturday customers with fresh produce that was already on the shelves before the store opened. This reflects the old buying patterns where only Saturday morning shopping was allowed on a weekend. The new buying patterns reflect a shift from the restrictive Saturday morning shopping to both Saturday and Sunday shopping where the sales are not very dissimilar for each day, and are the highest sales days in the week. This means the store has older perishable products on the shelves and often some shortages of products by a Sunday. A Saturday delivery is required at least for these stores to offer a competitive, consistent range of products.

13.6 Automated or manual sortation

As discussed in Chapter 10, the size and shape of the cross dock is altered when the sortation and handling method moves from totally manual to semi-automated (i.e. automated movement towards a manual sort) and finally to a fully automated facility. Automation, by its nature, enables the use of the volume of the facility. Because it has to have induction chutes and sort chutes with reasonable inclines it has a great tendency to occupy a greater space than a manual sort would. The use of the vertical height to effect the sort and to give this incline to the chutes makes better utilisation of the volume of the facility feasible.

13.7 Consignment

Items that are unique and do not have to be combined with other items before delivery to a customer make the sortation and receiving processes far simpler. As the balance moves from individual items towards consignments, where individual items need to be consolidated into the consignment, so the complexity of the receiving, sort and checking processes prior to loading into transport increase. It is fairly simple to illustrate this complexity. Where a cross dock is handling standard sized lugs, such as in the perishable food industry, with a delivery information label, the sort is very simple. The label is checked for its destination and sorted to that destination. The load, once complete, comprises these lugs and can be dispatched immediately. When multiple products are sold as a single item, such as a computer and the monitor, then these need to be grouped into a consignment in the cross dock and delivered together. To achieve this, the sort needs to find each of the individual products and to bring these together as a single consolidated unit for delivery to the store. This is far more complex than the simple cross dock sort. In effect, it introduces a secondary sort of the product. The primary sort is from the receipt into the destination or store, and then the secondary is the sort into the consignment for the destination.

13.8 Truck scheduling and door allocation

In the terms of TOC, the bottleneck in the process is the sort capability within the cross dock. The optimal operation of the cross dock then requires that the transport be scheduled such that continuous movement of goods is available to this sort. This implies that sufficient receiving doors are made available to continuously feed this sort. The transport has a utilisation percentage of the door, based on the discussion above, that is dependent upon the cycle of administrative process time and the unloading time and the work associated with the load.

Work has been done by Gue[1] to analytically determine how a cross dock should schedule transport. The obvious initial starting point is first-come first-served (FCFS). While this is adequate for the continual feed to the sort, the door at which the goods are unloaded does have an impact on the total amount of work done. This is particularly true as the size of the cross dock increases. Gue's work showed that the door with the least volume or mass movement distance for the goods from the truck should be used. When a door becomes available to receive a new transport, the transport that is in the yard should be assessed and the one with the least movement-distance for the particular door would be assigned to the door. This minimises the work done by the cross dock. This analytical work locally optimises the cross dock, and in so doing makes the transport highly ineffective in certain circumstances. This is not the supply chain optimisation that is required. The problem from a supply chain viewpoint is that certain trucks may well have to wait long periods before they qualify as the most appropriate truck for the particular door that is open. This is feasible when, for example, a supplier sends three trucks for an order. The supplier picking process has been from largest store order to the smallest store order. The orientation of the facility will be with the receiving doors towards the centre and the largest stores concentrated towards the centre and near the receiving doors. To minimise the move distances within the facility, the third truck with the smallest store loads will take a long while to become the most appropriate truck. In this case, the move distances will be larger due to the preponderance of items for small stores, the doors for which will be at the furthest distances from the receiving door area.

There are a number of alternatives that will improve this situation. The first is to allocate the transport on a FCFS basis to the most appropriate door that gives the lowest movement distance. The transport will then be queued for a door and will only wait for the transport currently being handled at the door to be completed before being attended to. This uses the FCFS to force the trucks not to wait unnecessarily. The other alternative is to limit the choice of the transport to the first five (arbitrary) transports and then to assign the transport with the lowest move distance to the doors as they become available, until all these transports are allocated. A further batch is then chosen. In either case the wait is reduced for the highest movement-distance transports and the supply chain is moved as close to optimisation as possible. This has been applied at Home Depot as a consequence of this research. This has met with success in the operation and is somewhat easier to compute for the supervisor as he has very limited decision support tools. This is particularly important for the Home Depot facility where up to 250 trucks can be in the yard. Computing power is not the issue, but rather the access to the data from a number of sources which takes systems, time and effort. This will be alleviated with a system improvement, but until this is effected, the above method is the simplest to perform with informal systems. With the very high throughput in the Home Depot facility, a delay for a computer system to advise which truck should be brought to the door is not acceptable to the operating staff.

A further method of door allocation has emerged from this research. When consignments are handled, the transport schedule of a transport to a door must primarily be chosen by the transport that completes the largest number of consignments on the floor. These consignments occupy floor area on the dock and, the faster consignments can be completed and moved off the floor, the more effective the operation will become.

Previously we have discussed the principle that the door utilisation needs to be increased as much as possible by doing only the unloading work at the door. Administrative processes before, during and after unloading should be done while the transport is not against the door. Labelling in the CML case has to be done on the floor of the cross dock and reduces the door utilisation considerably.

From the supply chain view, the scheduling is then to ensure there is sufficient transport in the yard to allow a constant flow of items to the cross dock. Effectiveness requires the scheduling of the transports to particular doors to minimise the operating costs by minimising the movement distances for the given load. These both need to be applied to the facility to derive the greatest supply chain value. Too many trucks in the yard will mean there is ineffectiveness as the transport has to wait long periods. The congestion will either make the movement to the doors ineffective, or require more yard space to be effective. Either or both of these are additional costs that scheduling will reduce.

13.9 Shape and Size of facility

The investigations into the five operations reflected in chapters 3 to 7, show very different shapes and sizes for the facility. The cross dock facility needs to have adequate space for the operation to take place without the congestion which leads to the continual decrease in effectiveness as discussed in Chapter 9. The shape and size of the facilities are summarised as follows:

Table 13.1 Approximate Physical Dimensions of Facilities

Company	Facilities	Approx Size (m^2)	Approx Length / Breadth ratio	Shape
Woolworths Textiles	Johannesburg	5,000	2:1	Receiving was added to the main rectanglar facility on the one corner to feed directly to the manual sort carousel on the wall furthest from the despatch doors.
	Durban	2,500	1:1	Doors on one side only
	Cape Town	6,400	1.2:1	Receiving and despatch doors on opposite sides
SPAR	Johannesburg	3,500	1.4:1	Receiving and despatch doors on same side
Woolworths	Durban	2,000	1.1:1	Receiving and despatch doors on same side
Pick 'n Pay Foods	Johannesburg	4,125	1.2:1	Receiving and despatch doors on opposite sides
Home Depot	Florida	15,000	6:1	Despatch doors on all four sides. Receiving towards centre of facility on opposing sides. Two doors on one end for specially bulky product receipt.
Sam's Club	Florida	9,000	1.2:1	Receiving and despatch doors on both sides.

The above table shows a major difference in the ratio of the length to breadth of the facility. This varies between a ratio of 1:1 all way up to a ratio of approximately 6: 1. In the South African operations reviewed, the facilities were not designed with a detailed understanding of cross dock operations. Three were designed as part of distribution centres where a portion of the facility was allocated to cross docking. This seems to be prevalent in South Africa. Because cross docks are not a major component of any distribution centre, nor are they used as stand alone facilities other than in very limited areas of the retail industry (Woolworths Textiles is the exception), they appeared to be allocated an area, and the operation is then made to operate within this area. The review showed that the foods operations in SPAR and the food operation in Woolworths was designed without an understanding of the operational requirements. SPAR and Woolworths operations personnel gave input on the perceived operation space needs, but no knowledge of the fundamental criteria underpinning the design was applied to give a mathematical basis for the design. The Pick 'n Pay operation, as a fully automated operation, was designed to fit around the automated movement and sort materials handling equipment. In this manner the building itself is tailored to the specific operational needs of the materials handling equipment, and as such it does represent a specifically designed facility.

Perhaps the greatest information for the shape and size of the operation in South Africa comes from the Woolworths Textile operations. The three cross docks are interlinked, as each collected goods from the local region, delivered goods to the local region, and dispatched goods for long distance movement to the other two cross dock facilities. The balance between collections, dispatch to local stores and long distance movement were significantly different in each centre. Durban had approximately equal volumes of local collections and local deliveries. It received approximately 80% of the volume to be distributed locally by long distance movements from the other two cross docks and sent an equivalent amount to the other two cross docks. Cape Town collected approximately 70 percent of the entire Woolworths manufactured goods, and distributed only approximately 20 percent to the local region. This cross dock facility was therefore heavily dominated by a large number of inbound collections and a significant long distance movement operation to the Durban and Johannesburg centres. The Johannesburg centre collected only approximately 10 percent of the total Woolworths goods, and received from Cape Town and Durban nearly 90 percent of the goods that it distributed to the local region serviced by this facility. These led to very different designs, which evolved from the operational needs of the facilities.

Collections, de facto, utilise smaller trucks in South Africa as these are needed for the smaller volumes. The density of packing into the collection transport is done to collect the load, not to maximise the volume of the transport. It is the exception, rather than the rule, that the collection will fill a truck exactly. It is therefore inevitable that the density of packing is less for a collection when compared to a high volume, long distance transport. Collection requires more doors because the doors are not able to be utilised as effectively as they would be if large, densely packed trucks were received. Checking of product inbound into the first distribution centre takes more time and effort to ensure quality and quantity are correct from the manufacturer. This results in a requirement for more induction space. The necessity therefore is for a multi-door receiving area with a fairly significant induction space at these doors to undertake the induction work. The local dispatch doors are limited to the area required to assemble the deliveries to the local store or stores on the route for smaller transports. There will be some doors with a large area in front of them in order to assemble loads for high density, high volume, long distance transport deliveries. In the case of the Johannesburg facility where the receiving is essentially all from long distance, high volume transport, the receiving area needed to match the volume of one of these transports and only two doors were required. This enabled one transport to be unloaded and inducted into the facility. While this was taking place a second transport was being prepared. Administrative processes and checks were completed in time to enable the team unloading the current transport to immediately shift from the current transport to the new transport for the unloading process. This ensured a continuous feed into the facility for the lowest number of operational staff. It is fairly evident that purely on the operational logic the shape of the facility is highly dependent upon the source of the goods and delivery of the goods. This reflects the purpose of the facility in the supply chain. This supply chain purpose would determine the number of doors required and the space required in the sort and in front of the dispatch doors. The layout of this facility is then dependent on the stages in the process from prior to the sort to the dispatch, which can be summarised as the: -

- Receiving work;
- Sort to the store;
- Whether there is a secondary sort to consignments within the store allocation;
- Any other VAS work; and
- Assembly of the load in front of the dispatch door prior to loading, if not loaded directly to transport.

Each of the stages require floor space and this needs to be built into the width of the facility. It is primarily orientated towards the width as the movement of the goods is across the width of the facility, with a defined length for each door. The South African cases show that the number of doors and hence the length of the facility are highly dependent on the role that the facility plays in the supply chain. That is specifically how product arrives at the facility and the amount of work that needs to be done on the product before being released into the sort process. Width is dependent on the number of stages in the process of the sort, movement through the VAS processes and into the assembly area for dispatch. The allocation of doors on either side of the facility, or even on the four sides of the facility, is dependent primarily on the type of sortation that is done. This, of course, excludes buildings that were not designed for cross dock operations. The sortation, in terms of a manual process, with individual items being sorted from a supplier consolidation unit into the store consolidation unit, can be orientated in a number of ways within a facility. As the volume and complexity of the operation increases, so the facility tends towards a rectangle. Once the work has been determined for the total number of stages in the sort to dispatch process the width is set, and growth can only be in the length of the facility.

The above logic can be tested in a simple example. The first facility will receive the majority of items from larger volume, long distance transport and has a simple sort to a dispatch lane. It delivers to a limited number of large stores. The second facility has a large volume of collections and needs to do a large amount of preparation before the sort, plus value-added services after the sort and has to use assembly lanes to wait for delivery transport. The first facility will have a much narrower width than the second facility. The number of doors required in the first will be less than the second. The second facility requires far more area to create buffers prior to the sort, to do VAS, to assemble products for the routes it services and then for dispatch than the first example.

Whichever way the facility is designed and as long as there is no physical restriction, the bottleneck is the sort of the product. This is the time where the individual item has to be identified, moved to the appropriate sort point for the customer, and then placed on the consolidation unit for the customer. All these actions are associated with individual items and not with a consolidated group of items on a consolidation unit. As such this requires the greatest amount of time and effort, and has the greatest risk of error in the operation.

Considerable work has been done on the American version of the cross dock which has multiple doors in a long rectangle with a high ratio of length to breadth. This ratio, at 6:1 for the Home Depot facility, indicates that the majority of goods are received and then moved as pallets between the receiving door and the dispatch door, and no value-added work of any significance is done on the floor.

Considerable work has been done on mathematical modelling of this large volume multiple door type of facility by Gue[1], who shows that the most appropriate door for receiving can be calculated and the location of the receiving to dispatch doors can be calculated. The receiving and dispatch doors are shown to be most effective when the receiving doors and the dispatch doors are intermingled, or assigned alternately, around the centre of the facility. The dispatch doors are progressively allocated from the centre of a facility to customers with the highest volumes, outwards to the customers with the lowest volumes. This minimises the volume distance measurement of effectiveness for the facility. The location of the receiving doors as close as possible to the largest customer dispatch doors, means that the volume received is moved the minimum distance possible. Congestion can occur in this high-density central area. As the Gue work is theoretical modelling, this was not considered explicitly in the modelling. Observation of the Home Depot facility showed this was a real problem. The Home Depot facility had a wider additional work area two-thirds along its length which was meant for break bulk goods, but also served to allow any items causing congestion to be moved into the area and out of the way of the mainstream cross dock operation. As the facility grows in length it is feasible that the higher throughput will mean that the receiving doors need to be moved further and further apart to preclude this high-density congestion for a given width in the design. It is therefore evident that much as mathematically the receiving and dispatch doors need to be interspersed to minimise the volume distance moved, the flows and the interference factors as discussed in Chapter 9 need to be taken into account and built into the width of the facility in the design. The work from Gue[1] shows that the size of a facility can only rise to a certain level, after which the length becomes so large that the effectiveness starts to decrease significantly. As the throughput increases, so the facility length will increase in proportion to half the number of doors added, as doors are added on both sides of the facility in this case. Above approximately 150 doors the shape should be altered from a simple rectangle to a T shape to minimise the total volume - distance measurement. At approximately 220 to 250 doors the facility needs to stop growing the Top segment of the T, and add a bottom segment to make this facility into an

I (sometimes called an H) shape. There are small variations to these approximate numbers based on the ratio of the number of receiving to dispatch doors. Gue's work has not determined why the ratio of receiving to dispatch doors alters between various facilities, but the logic in the preceding paragraphs shows fairly clearly that from the facilities researched, this is highly dependent upon the source and delivery characteristics of the facility. It is the role that the cross dock facility plays in the supply chain that is the determinant of the receiving and dispatch ratio.

The above shows that the work in the cross dock facility, as determined by the number of steps of operation that need to be performed from the preparation of the items for the sort, through to the dispatch process, will determine the width of the facility. Each step that requires space or movement must have floor width allocated to it, as the length per door is essentially fixed. The length of the facility will be determined primarily by the number of receiving and dispatch doors required for the operation. The mathematical work of Gue confirms the logic that receiving and dispatch doors should be orientated to be as close to firstly the centre of the facility, so that the distances in overall terms will be minimised, and secondly interspersed with the dispatch doors for the largest customers, so as to minimise the volume distance measurement in the facility. This mathematical confirmation of operational observation and logic, endorses the fact that the cross dock needs to be regarded as a production process where the lean manufacturing concepts, primarily TOC but also including the principles of JIT, are applicable.

13.10 Work at the cross dock facility

The amount of work done at the cross dock is a major determinant of the effectiveness of the cross dock. The work done is centred on the labelling practice, the sort requirements of whether there are consignments or not and any VAS done.

The effect of the different types of cross dock require different amounts of work with the items unloaded. The CML requires time and effort to label every item. This is done while the door is occupied by the transport, thereby reducing the door utilisation. The labelling must be done on the floor of the cross dock and utilises space as the products, once labelled, must be placed on the floor for further movement to the sort process. This is an additional handling process. All this requires personnel, time, a decreased door utilisation and floor space. The previous work in chapter 9 showed that the earlier the labelling took place the more effective could be the overall supply chain.

VAS occupies space, time and personnel. If this is required in the supply chain and the cross dock is the most appropriate place, then the service adds value. However as in the case of the labelling process, if this can be done earlier in the supply chain, then the process at the cross dock is not the most effective for the supply chain. VAS should only be done in the cross dock as a last resort. While conceptually it may be attractive to perform these functions at the cross dock, the implications for the cross dock are significant. The items move rapidly to and through the cross dock, only to be placed on the floor pending VAS work. This makes the cross dock significantly larger and the move distance cost will increase commensurately. The process now becomes two fold – that of the operation of the cross dock to achieve a consistent flow of product to maximise its utilisation and then the totally different function of the VAS followed by the movement of the items for delivery. These are two different focuses and are difficult to achieve within one facility, while aiming for maximum effectiveness.

13.11 Conclusions

The literature does not contain explicit factors that must be incorporated into the design of a cross dock facility and its interaction with the supply chain. This research has developed the primary factors that need to be incorporated into the design. These are above and beyond the physical constraints that will be imposed by existing buildings or from an inadequate design. These can be summarised as follows:

- Size of the load received;
- Number of doors required in the cross dock and the ratio of receiving to dispatch doors;
- Influence of customers on the shape and size of the facility;
- Fluctuations in the work load;
- Automated or manual sortation;
- Consignment complexity;
- Truck scheduling;
- Truck allocation to the doors of the cross dock;
- Role of the facility in the supply chain (receipt from collections or by bulk or for deliveries);
- Frequency of service and load size - assembly into lanes or into transport; and
- Additional work in the cross dock that requires space (VAS, secondary consignment sorts and so on); and
- Systems restrictions.

These all have a direct influence on the design and the layout of the facility. The integration of these into the facility to match the supply chain requirements will determine the effectiveness of the design of the physical facility.

The facility design, good or bad, will be dependent on personnel to operate. The quality of these personnel to cope with and operate under the high speed and continual pressure of the cross dock operation will determine how effective the operation will be. The combination of these two issues of an integrated design into the supply chain and the operating capability will determine how effective the overall supply chain will be.

NOTES

1. Gue, Kevin R. November 1999, pp 419-428

CHAPTER 14
PROCESS FOR THE DESIGN OF A CROSS DOCK

14.1 Introduction

The SPAR business model is to incorporate the store owners as stakeholders and for SPAR to perform the marketing and distribution. Each region has its own grouping and in SPAR parlance this is a Guild. Each Guild has its own Distribution Centre or facility. The South Rand Guild was researched (chapter 4) as to its cross dock operation for Perishable products (Frozen, Chilled and Fresh) where the Fresh products are cross docked. Currently the South Rand facility supplies Fresh products to its own stores as well as stores on behalf of the North Rand Guild, as the North Rand facility does not have a cross dock at present. The supply from one Guild to another Guild's stores is unusual, and has occasioned problems in the past, as the South Rand facility was unable to maintain the service desired by the stores due to a lack of space (see Chapter 4). The South Rand facility services its own stores as well as 55 stores on behalf of the North Rand Guild with Fresh products via its cross dock facility.

The design process is applied to the new SPAR North Rand Perishables facility. In SPAR terms this Perishables facility will handle Frozen, Chilled and Fresh (short life) products. Only the Fresh products are cross docked, and this will be the focus of the design.

The extraction of data from the South Rand operation to reflect only the North Rand operation was problematic. The South Rand operation had tried to send Fresh product though the cross dock to more stores recently, and up to 93 different stores had received Fresh products in the last year. In some cases the stores closed, and in some areas the stores did not continue to order Fresh produce. This was caused partly because of the logistical problems, as these stores received the products later in the morning after early morning shoppers had left the store, and partly because the volume ordered was insufficient to justify the frequent deliveries that the Fresh product requires.

The South Rand and North Rand facilities are further complicated by delivering Frozen and Chilled products utilising the same transport. The South Rand transport was chilled to the 5 °C suitable for the Fresh and the Chilled products, and the frozen products were included as pallets. This requires the pallets of Frozen products to be delivered within a short enough period that the temperature of the frozen products do not increase to a point where they were adversely affected in quality and shelf life.

The data integrity was verified and special extract queries had to be used to extract useful data. The largest problem was invoice dates. The South Rand facility picks product on a Friday, but agglomerates this with the Monday pick for accounting and billing reasons. This has nothing to do with the operation, but this accounting issue skews the data. The data finally used was the orders picked for each day in lugs. A split of the Monday total to the actual Monday and Friday quantities was done based on orders received on each day for each store. The data extracted also reviewed the inbound and outbound flows that define the supply chain, so the facility was designed as an integral part of the supply chain and not as an isolated entity.

The problem with the Fresh product range is the short shelf life. Long distance deliveries are difficult as this limits the store life available, and the product has a low profit margin with a high volume, making the transport expensive. This means that only the stores that have sufficient volume to justify deliveries and that are in reasonable proximity to the distribution centre receive the Fresh range. All stores receive the Chilled and Frozen products. In the case of North Rand only 38% of the stores receive Fresh products.

In all the work done in cross dock design, the extraction of reliable data remains a major problem. As the design is based on data and effectiveness measurements, considerable effort must be expended to improve the data integrity.

14.2 Design aims

The design aims were to utilise the available space to create a facility that would grow to accommodate increased deliveries to a larger quantity of stores. To achieve this as an integrated part of the supply chain, the following criteria were set, and agreed with the client, as the most important design principles: -

- The movement distance of lugs within the sort is minimised;
- The movement distance of pallets is minimised within the facility; and
- Clear flow aisles must allow the Frozen and Chilled products to be handled around the Fresh Cross Dock sort and assembly area without influencing the cross dock sort and receiving.

All three of these design aims will impact on the effectiveness of the facility. The minimisation of the movement distance of the lugs is the primary issue for the sort. The lugs are received on the supplier pallet. These are sorted from the supplier pallet and individual lugs are moved to the store pallets on which the load to the store is being assembled. As this deals with individual lugs, the distance moved is of critical importance to minimise the ineffectiveness in the operation.

The movement of pallets of lugs into the sort area and from the sort area into assembly lanes will determine the effectiveness of the process of receiving and assembly. These need to be minimised for the most effective process. Assembly lanes are required as the transport is utilised for deliveries during the period of the sort. Once transport is available, the lanes are already partially filled with pallets of lugs, and it would be ineffective to add additional personnel to move the pallets from the partly filled lanes into the transport. The correct sequence would be to begin the process of loading the transport once the lane of pallets is filled, or when the last lug has been sorted.

14.3 Design requirements

The client specified what was required in the facility to meets its needs. The author facilitated this meeting to ensure the correct information was elicited. This defines what the current belief is as regards the operation, as well as what is required for the design.

One major issue was discussed extensively. The South Rand facility, as it now operates with North Rand deliveries, has a major problem in balancing its operations. This is discussed in Chapter 4 and recorded as a design criteria in Chapter 13. The essence is that the Thursday sort and Friday delivery is far larger than any other day. The stores wanting a delivery on a Friday, so that stocks in the store will last until Monday or Tuesday when the next delivery occurs, increases this peak substantially. In the case of North Rand this is a peak to average ratio of 1.5 times, which is an enormous range in the operations. This is one of the prime reasons the operation is not as effective as it might be.

14.4 Design parameters

The following summarises the conclusions reached with the client as regards the needs of the business and the principles of operation for the new facility.

14.4.1 Principles

- Receiving will take place continuously over 12 hours of the day. Expected times to be 8:00 to 20:00. It may be extended to start at 6:00;
- Sort must be complete by 22:00;
- Work 6 days per week;
- Peak week demand when compared to the average week demand is as per South Rand at a ratio of 1.25 or a 25% fluctuation; and
- Peak day demand when compared to the average day demand needs to be reduced below what North Rand experiences at a ratio = 1.5 times. North Rand acknowledge the peak is too high. The design will have as a goal a 1.25 ratio, but every effort will be made to reduce this further as it impacts on the effective utilisation of the floor as described earlier.

14.4.2 Cycles

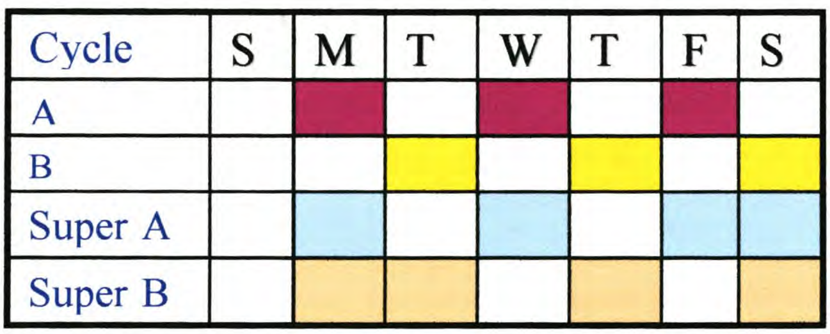
The supply chain must be made to work at as consistent a level as possible in the day by day operation. This allows effectiveness in the supply chain and the cross dock operation. The peak from the North Rand operation must be removed to enable this. To achieve this, two new cycles, called Super A and Super B are introduced to supplement the normal A and B cycles. The difference is an additional delivery per week for these Super Cycles as shown in Figure 14.1. This will be given to the largest stores only. The effect of this is fairly significant to the operation as it: -

- Reduces the peak to average ratio, thereby making the operation easier to manage;

- Reduces the largest assembly lane size, thereby reducing the required floor space; and
- Creates an opportunity to balance the loads on the maximum and the minimum days.

All these benefits, with an opportunity to enhance the service delivery to the top stores, are a major opportunity for the new North Rand Perishables facility. The only cost is one additional delivery to each of the six Super Cycle stores per week.

Figure 14.1 Proposed Cycles for North Rand



14.4.3 Receiving

As the sort is the bottleneck, a buffer of stock must be provided immediately upstream or between the receiving area and the sort. It is estimated by the facility management that the maximum period the product will not be available from inbound transport to feed the receiving buffer stock will be 1 hour. The design will be conservative and work on a 1.5 hour buffer of inbound stock. No additional product will be brought into the system other than what can be handled in the buffer.

14.4.4 Scheduling

It is essential to schedule loads so that the sort is fed continuously throughout the operating period. The sort should be manned so that the sort never ceases to operate, as this is the bottleneck for the entire process. Some form of flexible working needs to be arranged, even at the expense of receiving. It is feasible that, if the operations are staggered, the sort can continue by using the receiving staff, while the sort staff have breaks.

14.4.5 Stores

Currently there are 55 stores receiving Fresh from the cross dock. The maximum number of stores for the design is 80, which is assumed to be sufficient for the growth forecast for the next five years.

14.4.6 Sort

The sort is done manually from the Supplier Pallet to the Store Pallet, and this takes place in the sort aisle.

14.4.7 Receiving bays

A minimum of two doors per product, being Frozen, Chilled and Fresh, are required for continuous offloading. One door will have a transport unloading, and the alternative door will have a transport that is being prepared for offloading. Six doors are therefore required, two each for Frozen, Chilled and Fresh products.

The Chilled and Frozen products that are sent to stores not receiving Fresh products, require two doors for daytime deliveries, which will occur while the Fresh sort is operating.

14.4.8 Freezer and chiller

Product will be received only to feed the buffers for the put away work in the Chiller and Freezer. A small buffer quantity of chilled product will be maintained in the chilled area to feed the put away process in the chiller. The Frozen products will be unloaded onto the chilled floor for labelling and checking and then immediately moved to the buffer area in the freezer for the put away of stock in the freezer. This will restrict the receiving area for Frozen products to no more than one transport load on the chilled floor for checking and labelling. Transport must not be unloaded unless the buffers can receive additional pallets.

14.4.9 Pallet positions

No pallet or Cold Box can be placed on the floor unless in a designated space. The designated spaces marked on the floor for pallets will assist in enforcing this principle.

14.4.10 Aisles

All movement will take place along clearly defined aisles.

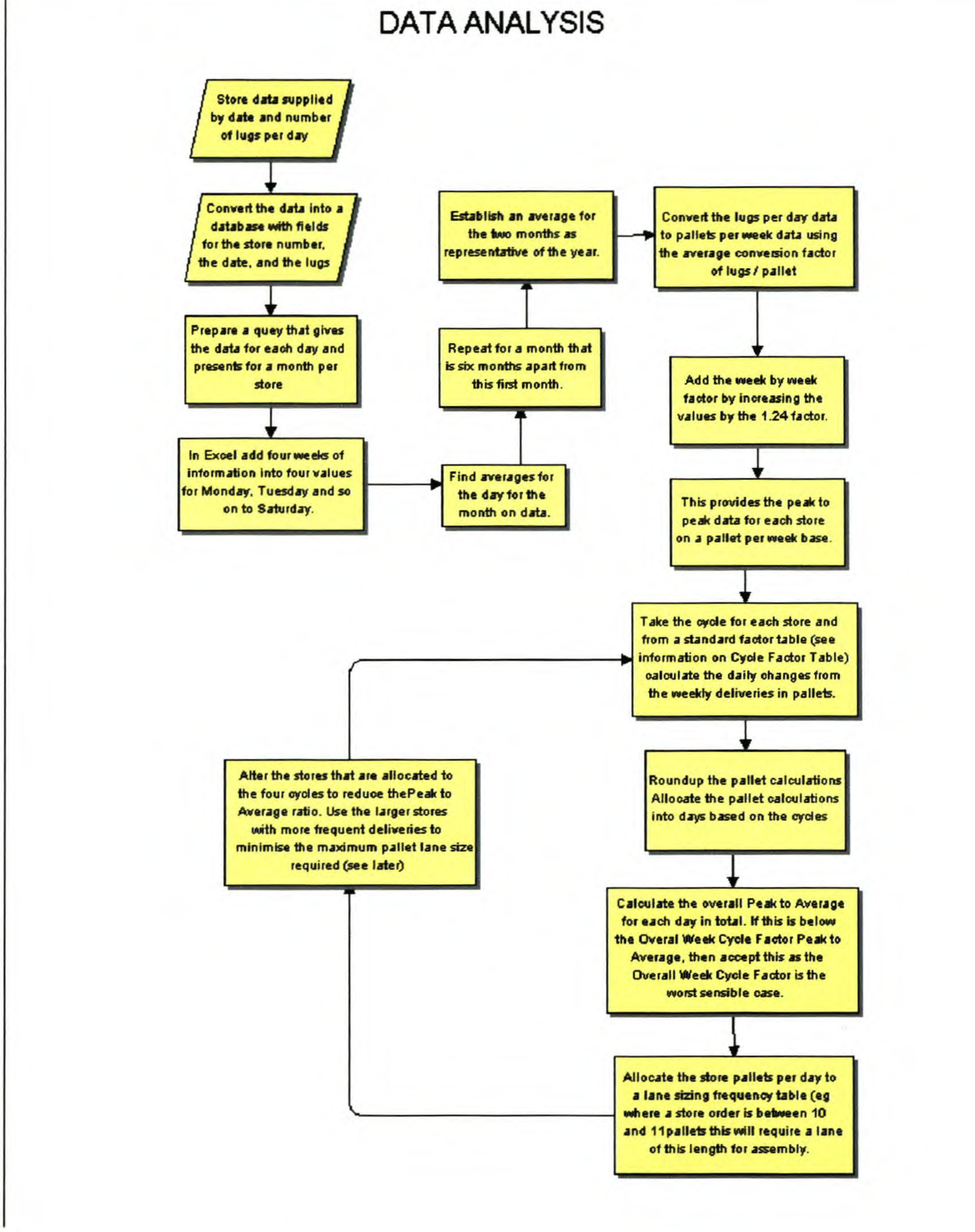
14.5 Process of Design

14.5.1 Data

The design process was complicated by the extraction of data for North Rand stores from the South Rand operations data. The South Rand operation allocated the North Rand stores to cycles in order to suit the operation of the South Rand cross dock. The new operation will be significantly different and the data is therefore only valuable in terms of the total quantities delivered. The data also exhibited large changes in the number of stores that received Fresh product through the cross dock. Over 90 stores received product in the last year. Ten of these stores have closed and therefore do not receive product. The remainder appear to be attempts to get stores to take Fresh product, which failed. This appears to be done to pacify the stores where problems have occurred in other operations, and a wish to expand the product distribution to a greater quantity of stores. This was done without understanding the costs associated with delivering Fresh product that has a large volume and low profit, and this led to cessation of deliveries to a number of the stores when they did not order sufficient volume.

The data can be extracted for the 55 stores that are receiving the product regularly and consistently. The data is in lugs, and needs to be converted to pallets to reflect a true volumetric measure. The only data that accurately reflects the operation is the daily sort through the facility by store. This data was extracted and fed into a database created for the North Rand facility. This data was then manipulated to remove the stores that did not receive Fresh product consistently. The data conversion into information is depicted in the Figure 14.2 below:

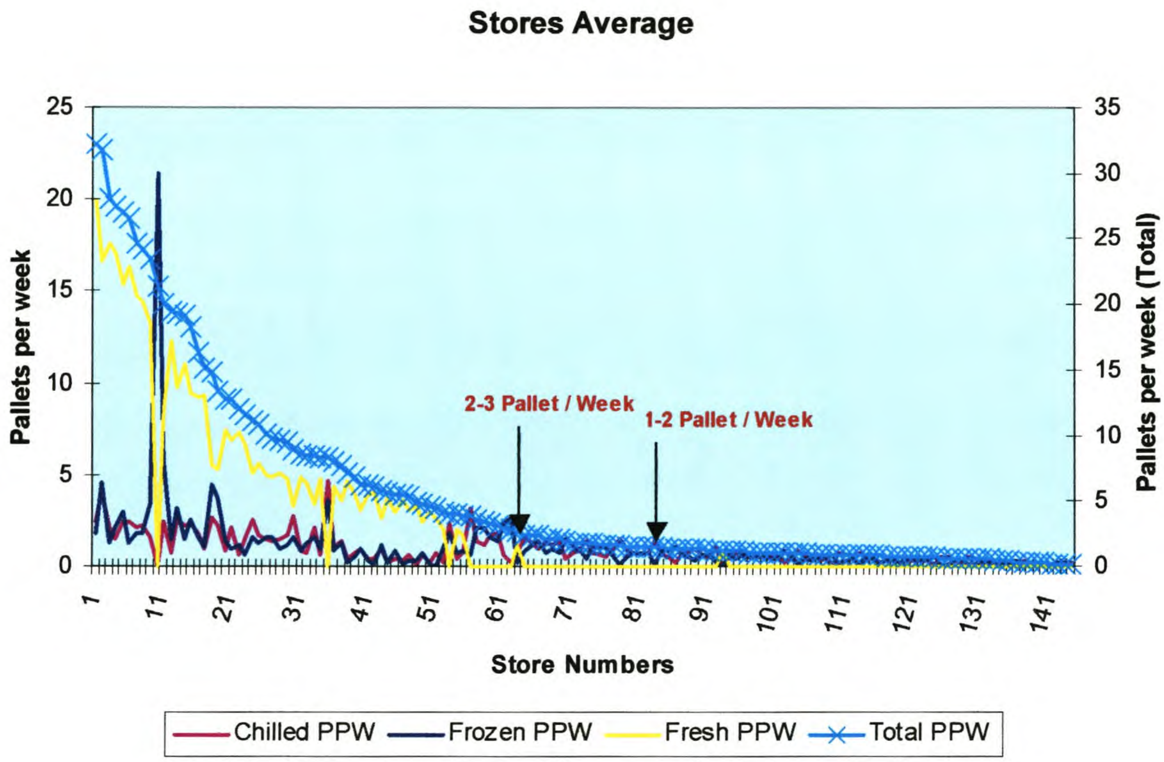
Figure 14.2 Data Analysis Process



14.5.2 Store Analysis

The design is aimed at satisfying the clients, which in this case are stores. It is appropriate to analyse the store range to determine the quantities of products ordered and the size range of these stores. The sizes of stores will influence the lane orientation in the sort area. The large stores will influence the walk distance in the sort and the floor area that needs to be allocated to the assembly lanes. These will be explored in detail in this chapter. The stores can be shown as in Figure 14.3 with data from North and South Rand facilities.

Figure 14.3 Store Analysis

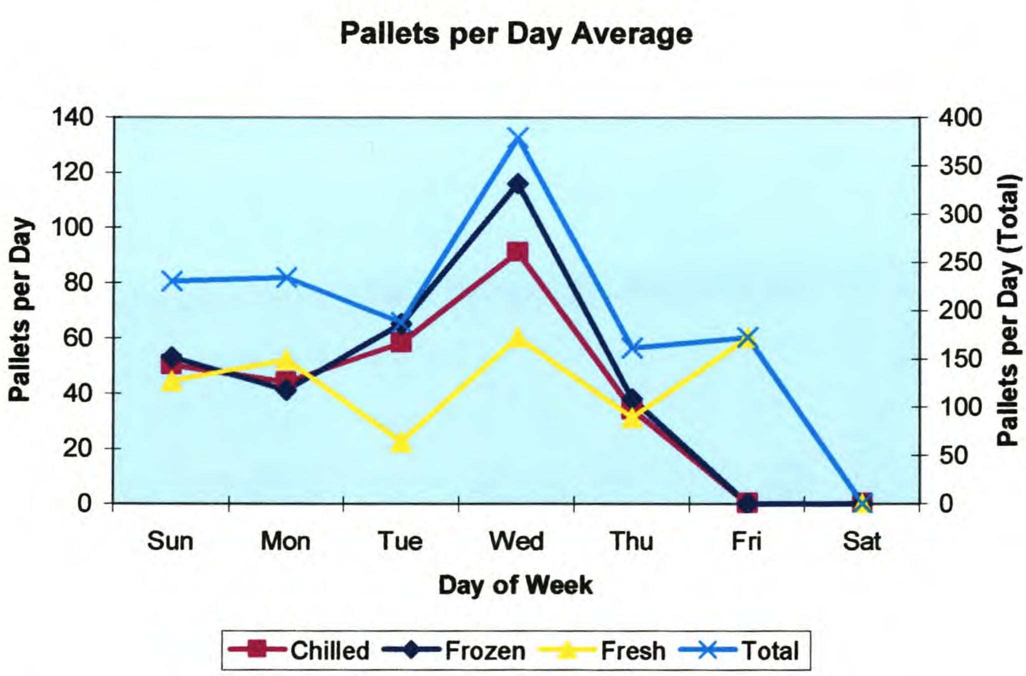


It is evident that a large number of stores receive one or at most two pallets. These break points are marked on the graph. This shows the approximate ratio of small stores to medium and large stores. It also shows there are very few really large stores in this profile, so the need to allocate long lanes for assembly is for only a few stores. This needs to be considered in the design as the exponentially decreasing store profile means that the assembly lanes could occupy unnecessary space if they do not follow this profile.

14.5.3 Cycles and peak to average ratio

While the data conversion into useful design information is complex, one area is of primary importance as a base for the design. While realistic data can be extracted and converted into information for the design, the effect of the cycles on the supply chain cannot be explored with this data. South Rand has not used the cycles designated as Super A or Super B. The effect of these cycles will be to give benefits to the design as well as the service offered by North Rand. The effect of these need to be determined for the design before operations commence. The move of the North Rand stores from the South Rand delivery process to the new North Rand facility will require each store to be given a new cycle, be it A, B, Super A or Super B cycle. The current cycles cannot be retained, as the information extracted shows that the North Rand Stores receive completely unbalanced deliveries for all the different products, with a peak in the Wednesday deliveries. This is shown in Figure 14.4 below. This day by day variation in load has to be significantly reduced to make the supply chain more effective. This can only be achieved in this case by re-engineering the cycles on which the stores place orders, and hence the quantity the stores order each day. To determine this day by day operational load fluctuation, a model was created so that the effect of the stores allocated to different cycles can be simulated.

Figure 14.4 Pick of Product For North Rand Stores in the South Rand Operation



The model is predicated on the principle that the order size will be based on two factors. The first is the average weekly orders in total. The second is that the order for the day will be larger if fresh product was not delivered to the store the day before. In some cycles there are two days between deliveries where no delivery takes place. To reflect this a loading schedule was created based on these two principles. This schedule is shown below in the base and the normalised version, and these day by day factors are then applied to the weekly order value to determine the day by day loads for a store. The cycles proposed are set out in the four proposed cycles of A, B, Super A and Super B. The model assumes the order increases by 50% if the store did not receive fresh product the previous day. Similarly, if the store did not receive product for two days previously, the order is increased by 100%.

Table 14.1 Cycle Factors per Day for Load Simulation

Assumptions

Days between Deliveries	Factor
day =	1
2 days =	1.5
3 days	2

Loads based on Assumptions					
Deliveries per week		4	4	3	3
Cycle Name		Super A	Super B	A	B
Sunday	1	0	0	0	0
Monday	2	1.5	0	2	0
Tuesday	3	0	2	0	2
Wednesday	4	1.5	0	1.5	0
Thursday	5	0	1.5	0	1.5
Friday	6	1.5	1	1.5	0
Saturday	7	1	1	0	1.5
	Total	5.5	5.5	5	5

Load factors normalised					
Deliveries per week		4	4	3	3
Cycle Name		Super A	Super B	A	B
Sunday	1	0.0	0.0	0.0	0.0
Monday	2	0.3	0.0	0.4	0.0
Tuesday	3	0.0	0.4	0.0	0.4
Wednesday	4	0.3	0.0	0.3	0.0
Thursday	5	0.0	0.3	0.0	0.3
Friday	6	0.3	0.2	0.3	0.0
Saturday	7	0.2	0.2	0.0	0.3
	Total	1.0	1.0	1.0	1.0

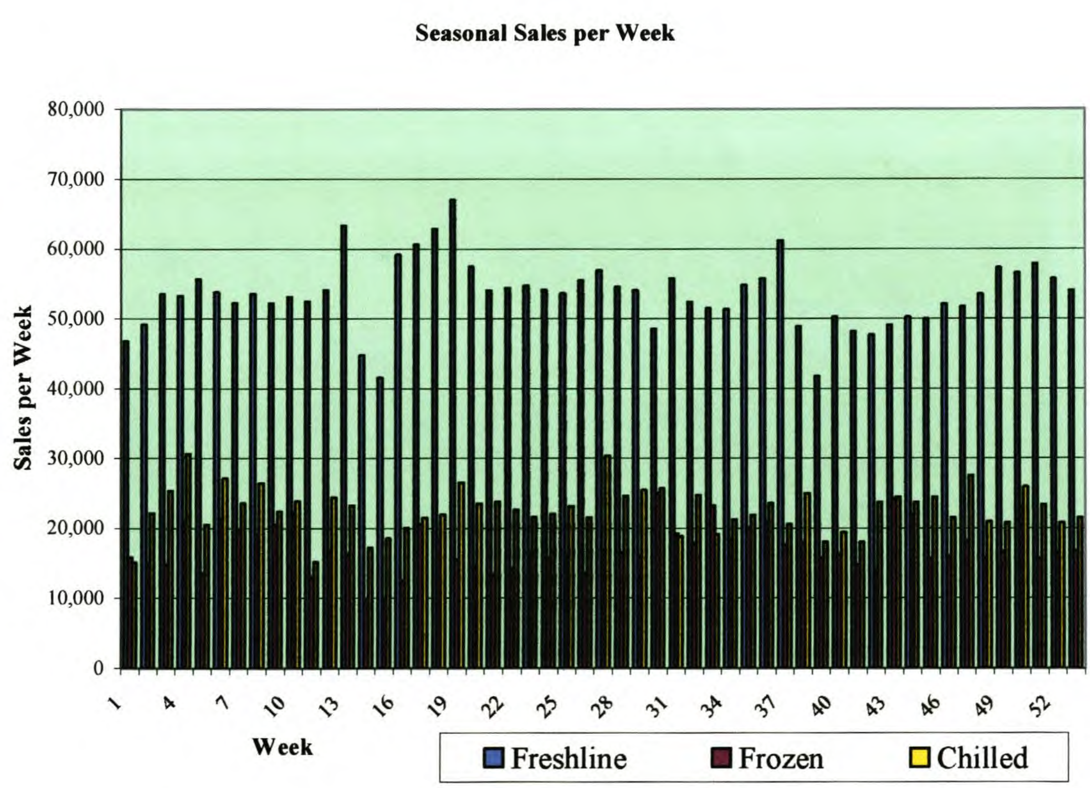
Based on this loading schedule a model was created that allows the effect of particular stores assigned to particular cycles to be determined. The total quantity delivered for each day can then be calculated and the result will reflect the peak to average ratio to determine how much variation will exist in the operating load. Even more advantageous, is that the stores can be allocated to the cycles and changes can be effected to determine quantitatively what the impact on the design and operation will be. This gives a quantitative base for allocating stores to particular cycles.

14.5.4 Fluctuations in work load by week

It is interesting to note that week by week there is a trend of sales, as can be seen in Figure 14.4. The sales are highest in the week in which the 25th of the month falls and there is a second, lesser peak in the week in which the 30th / 31st of the month falls. The weeks from these to the last week before the week containing the 25th of the month show a continual decrease in the sales volume. This is consistent with the primary payment of salaries being on the 25th and a secondary payment on the 30th / 31st of the month, followed by a continual decrease in cash for purchasing through the remainder of the month.

There is also a month by month variation with the Christmas period as the peak.

Figure 14.5 Trends in Sales of Perishable Products



These trends when analysed show an approximate 1.25 variation in peak to average factor.

14.5.5 Receiving

The receiving process is designed in terms of the principle of providing a continuous flow of labelled lugs on pallets to the buffer for the sort. This buffer must be maintained at all times to ensure the sort works at a constant rate. The buffer size is such that there is sufficient pallet space to give, if it was full, a 1.5 hour of feed to the sort. This is the agreed design size of the buffer stock.

The receiving will require scheduling of deliveries to be effected and to be adhered to. The scheduling needs to be done on a pallet measure and not on the number of transporters. Different transports will deliver different quantities of pallets, and the period the receiving door is occupied by the transport will be dependent on the transport size. The larger the transport size the less time the transport will be against the door, per unit unloaded, as the proportion of unproductive paperwork and preparation time to the total time against the door will be lower. This is discussed in chapter 13.

The process is described in detail later, but the sort label needs to be added to every lug. The label allows for a double check of what is delivered at item level, if the quantity of labels that are printed are equal to the quantity of each product reflected on the delivery note. Thus the order is amended to reflect the delivery note in the WMS. The correct numbers of labels are printed. The labels are placed on the lugs and, if all the labels are utilised, then the correct quantity of each product is present. A shortage or surplus of labels indicates a problem immediately.

To accommodate this, four labelling positions are designated between the receiving door and the buffer stock area. The buffer stock area is laid out in lanes to allow the lanes to be filled with pallets of lugs from this labelling area, and then the pallets are drawn out to the sort area from the opposite side. The work associated with the labelling area is such that two labellers can perform the work and maintain a consistent and sufficient flow to the receiving buffer area. This will include occasional checks of quality on the floor and the rectification of problems if there is a label shortage or surplus. The preparation of the transport for unloading, including quality checks such as temperature measurements, in the transport, the capture of amendments to the order in the WMS and the printing of labels must be done by a separate team.

The receiving area can then be calculated as per Table 14.2 and Table 14.3 below: -

Table 14.2 Throughput Calculation

Throughput		Average	Peak
Weekly throughput	pallets / w	467	582
Daily Throughput	pallets / d	78	111

From this throughput it follows the receiving needs to be designed to handle the peak throughput of 14 pallets per hour. This results in a need for the continuous utilisation of 0.6 doors. The areas for the check and buffers are calculated as well:

Table 14.3 Receiving Calculations

Receiving

		Average	Peak
Buffer	hours	1.5	
	pallets		13.9
No of doors required			0.6

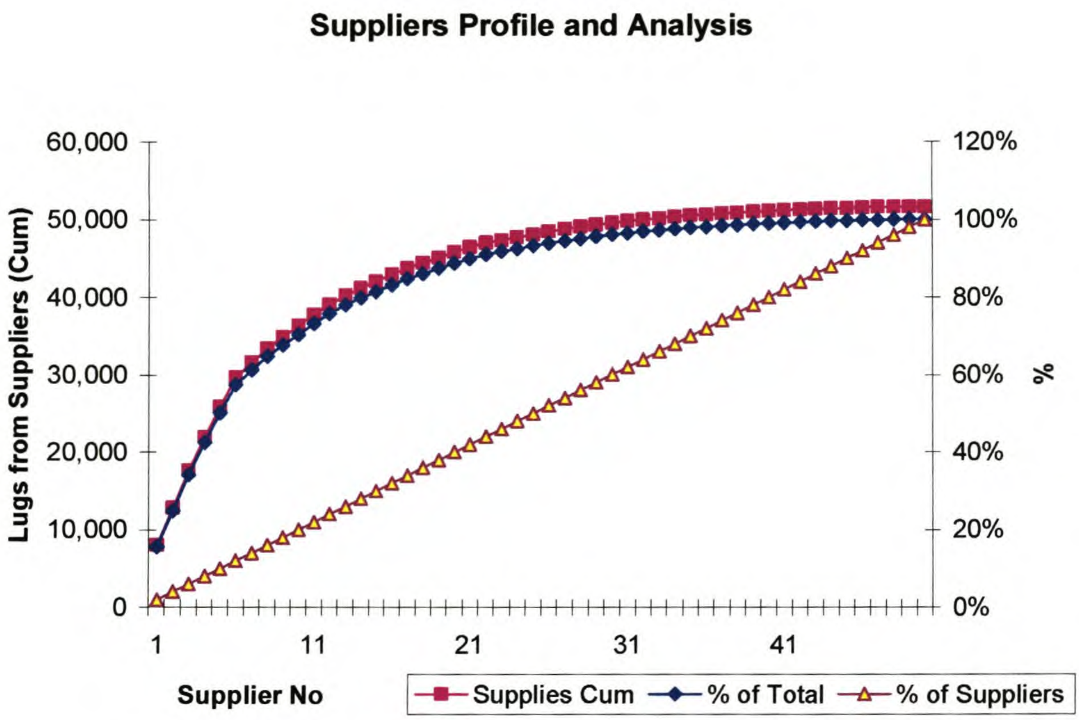
Check	Width (m)	Length(m)
Aisle - working	1.2	1
Pallets		1
Aisle - working	1.2	1
4 pallet positions	4.8	
Spaces between pallets	3.6	
Total	**10.8**	**3**

Buffer		
3 rows of 6 pallets	**Width (m)**	**Length(m)**
Aisle	2	1
Pallets	3.6	6
Between pallets	0.2	0.5
Aisle	0.2	2
Total	**6**	**9.5**

14.5.6 Number and types of doors

The scheduling of the suppliers is of prime importance. If the suppliers are correctly scheduled, the buffer of lugs in the receiving area can be maintained and a constant feed to the sort achieved. To achieve this constant flow into the buffer, in an effective manner, will require only a limited number of transports in the facility yard waiting for offloading. Thus the supply chain can be operated close to optimum with the least waiting time for transport, the least inventory in the inbound transport and the least inventory in the cross dock facility. This is important, as the supply chain is the primary focus of all the parties in the chain, not local optimisation. The current practice in South Rand of taking any transport and accepting the lugs is making the South Rand facility highly ineffective, and the transporters more effective. What is happening is transporter optimisation rather than supply chain optimisation.

Figure 14.6 Suppliers Profile and Analysis



The number of suppliers and the profile of these suppliers is of importance. While the calculation is that one door is sufficient, the issue is that at least two doors are required. The need is to achieve continual feed to the buffer and this is achieved where the one transport is being unloaded, while the next transport is being prepared. This preparation of the next transport is absolutely necessary if the unloading period of the current transport is short. The size of the transport is also of importance, as this affects the physical dimensions of the door and ramp to the door. As can be seen from the supplier profile in Figure 14.6, the first 8 or 9 suppliers are large in the quantity delivered; thereafter the size of delivery reduces significantly. In the last twenty or so suppliers the delivery will be done in smaller sized transport, and this will require a separate door sized to take small vehicles. The scheduling should ensure that one transport is always unloading and one is prepared before the completion of the transport currently unloading.

14.5.7 Sort area

The sort area is the bottleneck. It also needs to be designed in terms of the criteria reflected in section 14.2: - Design Aims as recorded previously in this chapter, which will ensure the most effective design of the facility. The area that is available for the design is almost square and the arrangement of the sort and the receiving and assembly lanes needs to be done, so as to optimise these Design Aims. The most effective facility will be where there is in total: -

- Minimum pallet movement distance; and
- Minimum lug movement distance.

In an approximately square shape one can logically argue and prove the following:

Minimum Pallet Movement Distance

The full pallet process is to take the supplier pallets from the receiving buffer, move them to the sort area, perform the sort of lugs from the supplier pallet to the store pallet, and then to move these full store pallets to the assembly lanes. To minimise the distances the full pallets move, we can use the movement distance criteria of measurement. If the area is almost square, let us assume the length is equal to the breadth and is depicted by $2x$ for convenience.

The facility has transport doors on one wall. The sort can be placed in three locations; along one side wall, along the rear wall or in the centre of the facility. A sample calculation of these is shown in Table 14.4. This estimates the distances that the full pallets will move and shows the value of the overall movement distance factor for each of these options. These are estimates only, but the centre option is sufficiently better than the other options, so the conclusion is that this is the most effective layout, from this point of view. There are other factors which will affect the design and these need to be considered in conjunction with this criterion.

Table 14.4 Sort placement options: - minimisation of full pallet movement

Size is 2x

Options	% Movement Allocated	Distance x moved	Totals	Cumulative Move Factor
Sort against the one side wall				2.51
Receiving to sort	100%	1	1	
Sort to Assembly Lanes				
Largest	50%	0.3	0.15	
Medium	30%	0.6	0.18	
Smallest	20%	0.9	0.18	
Assembly Lanes to Doors	100%	1	1	

Options	% Movement Allocated	Distance x moved	Totals	Cumulative Move Factor
Sort against opposite wall to doors				4
Receiving to sort	100%	2	2	
Sort to Assembly Lanes				
Largest	50%	1	0.5	
Medium	30%	1	0.3	
Smallest	20%	1	0.2	
Assembly Lanes to Doors	100%	1	1	

Options	% Movement Allocated	Distance x moved	Totals	Cumulative Move Factor
Sort in Centre				2.15
Receiving to sort	100%	0.75	0.75	
Sort to Assembly Lanes				
Largest	50%	0.5	0.25	
Medium	30%	0.5	0.15	
Smallest	20%	0.5	0.1	
Assembly Lanes to Doors				
Largest	50%	0.75	0.375	
Medium	30%	0.75	0.225	
Smallest	20%	1.5	0.3	

Minimum Lug Movement Distance.

This is the essence of the correct sort. The sort is performed by taking labelled lugs from the supplier pallet and then placing these on the correct store pallet. The original method was to do the sort directly into each of the assembly lanes, but the distances are excessive if this is done. The store pallets must be moved from the sort area and wrapped and checked, and then placed in an assembly area. Movement space must be provided for the wrap and check area, the movement of supplier pallets along the sort aisle, and the return of the empty pallets. The two options for the sort are as shown in Figure 14.7 (a) and 14.7 (b). The black squares depict pallets onto which the lugs are sorted, with one pallet for each store. Movement aisles are shown as pallets with movement arrows.

Figure 14.7 (a) Sort on One Side

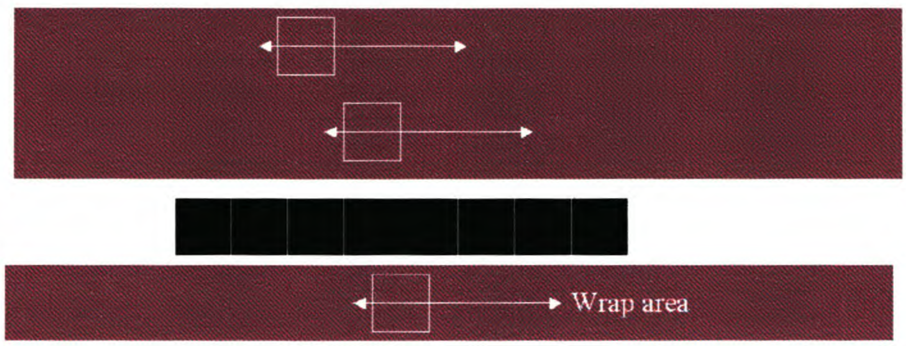
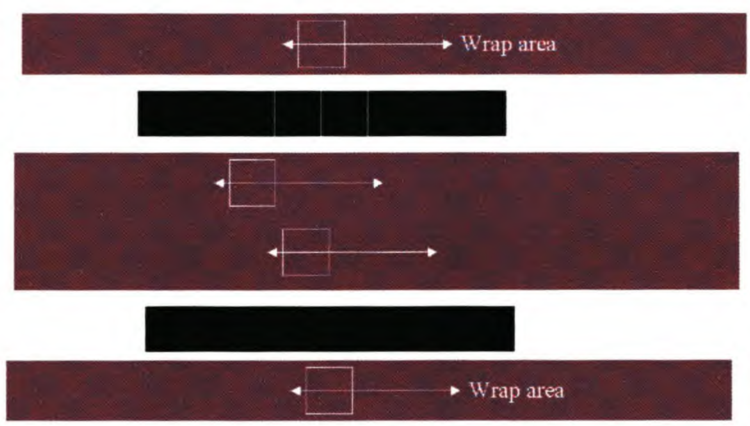


Figure 14.7 (b) Sort on Two sides



Two methods can be suggested for the sort that need to be considered. The first is the sort is performed down one side of a long row of store pallets as per figure 14.7 (a). The second is the store pallets are placed in two parallel lines, as per figure 14.7 (b). The choice between the single straight line of store pallets and the double, or more, lines of store pallets is to an extent dependent on the shape of the facility. However, where there is no physical restriction, the sort is far more space effective and movement efficient if it is done within the parallel store pallet lanes. The space effectiveness is obvious in that the sort aisle is used for a sort on two sides, so the total area is reduced by 50% of the sort aisle per line of store pallets. The movement efficiency is determined from the buffer as the source of pallets, which is in a specific, single place in this design. The buffer can be seen in Figure 14.10 as the designated pallets spaces for Frozen, Fresh and Chiller Receiving. Pallets must move from the buffer to the sort and then the sorter must return to the buffer for the next pallet. This return walk distance is shorter if done in a U between the two lines and not in a single long line of sort and then a long return with empty pallets. The relative merits of these two methods of laying out the sort area are shown in Table 14.5, where it is evident the area utilised is less in the case of the sort to both sides (254.8 m^2 versus 317.2 m^2).

Table 14.5 Comparison of Sort Layout Areas

Sort on One Side

	Width	Length	Measure
Sort Aisle	3.5	52	m
Pallet	1.1		m
Aisle - outer	1.5		m
Total	6.1	52.0	m
Total Area		317.2	m^2

Sort on both sides of sort aisle

	Width	Length	
Aisle - outer	1.5	26	m
2 Pallets	2.2		m
Sort Aisle	3.5		m
Pallet	1.1		m
Aisle - outer	1.5		m
Total	9.8	26.0	m
Total Area		254.8	m^2

The extent the sort moves down the row will be dependent on two factors: -

- the order quantity; and
- the size of the store.

The sort pallets are allocated to the stores in descending order of quantity ordered, with the largest stores being closest to the receiving area. There is a finite quantity (40) of lugs on a supplier pallet. This quantity of lugs will be sorted to a limited number of the larger stores as larger stores take more lugs per order. In the case of the smaller stores, one supplier pallet could conceivable supply the smallest 40 stores with one lug each. Thus for the larger store area, a pallet of lugs will only be sorted to a small number of stores, and the sorter will return quickly to the buffer. The small stores will require continual movement of the pallet as the sorter moves the lugs to the store pallets, and the return will take a lot longer. As the size of the order increases, so the more the one pallet will service less stores and the sort will be done in less distance down the aisle.

The walk distance is highly variable dependent on these two issues. There is a case to make that the sort should not be the traditional S path of sort, but a simple U shape along one side of the aisle in the parallel sort pallet configuration. This allows a supplier pallet to be sorted to the large stores on one side of the sort only, in easy reach of a supplier pallet in the sort aisle, and placed centrally between the stores. In the case of the small stores, the pallet will have to be repeatedly moved.

In the case of the S pick, the distance moved into the sort is reduced as the pallet is only going to supply a limited number of stores on either side of the aisle. The S pick will minimise the number of times the supplier pallet would need to be moved to minimise the lug movement distance during the sort.

While there is no major difference in this design situation, the issue is decided by two issues: -

- The length of the sort aisles; and
- The assembly lane configuration.

To minimise the walk distance in the assembly area, it is attractive to have more than one sort aisle as the buffer feed is from one location and shorter aisles will be more effective. The introduction of two back to back aisles minimises the movement distance for the sort process. It also favours an S pick as the aisles are shorter and the store pallet moves can be reduced with the S pick. The allocation of stores to the pick pallets in the sort area must minimise the store pallet move distance. This requires the largest stores to be closest to the transport doors. This is a supporting reason to use the S pick which favours this movement distance minimisation in this case.

To minimise the pallet move distance means the largest lanes for assembly of the pallets must be in the front of the facility, and due to the sort configuration, on one side of the sort. This is explained in the next section on the lane layout.

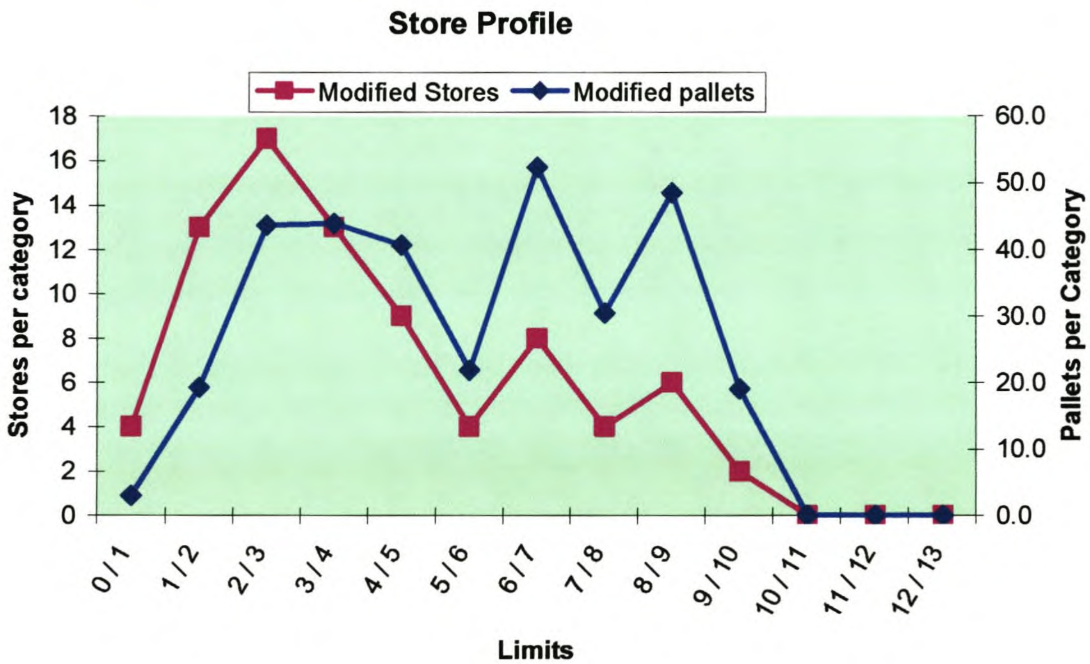
14.5.8 Lane layout and sizing

The layout of the lanes is dependent on the cycles that the stores are given. With a cycle of four deliveries per week introduced into North Rand the size of the largest lanes will reduce by a factor of 25%. This is a significant reduction in floor area. The lanes need to be done on the daily peak of the pallet demand for the stores. This occurs when the average store order quantity is increased by the week by week factor and then the day by day factor is added to determine the maximum store usage. Thereafter the design needs to create lanes where the maximum store quantities can be assembled. A table reflecting this is shown in Table 14.5. The limits reflect the number of pallets between which the maximum order on the peak day for a store falls. Thus if a store has a maximum of between 4 and 5 pallets, the store will be added to the count in the 4/5 section. The stores and pallets are reflected as modified, and this is done as the data was increased pro-rata to move the count from 55 stores to the design of 80 stores. This was done by increasing the number of stores in each category by the ratio of 80/55. This has a slight bias to the larger store sizes, which ensures the design is conservative by creating more longer lanes than may be required. The relative stores and number of pallets per day maximum is shown graphically in Figure 14.8.

Table 14.6 Stores Count for Pallet Quantities Delivered to Stores

Limits in pallets	0 / 1	1 / 2	2 / 3	3 / 4	4 / 5	5 / 6	6 / 7	7 / 8	8 / 9	9 / 10	10 / 11
Stores (modified)	4	13	17	13	9	4	8	4	6	2	0
Pallets (modified)	0	19.3	43.7	43.9	40.7	21.9	52.3	30.4	48.5	19.0	0.0

Figure 14.8 Number of stores receiving pallet quantities



The above reflect the lanes for every quantity of full pallets. This was done for analysis purposes. It is not sensible to create lanes for each of the full pallet limits shown here. The creation of lanes into sensible groups is shown below in Table 14.7.

Table 14.7 Proposed Lane Quantities and Lengths In Pallet spaces

Limit Lower >	0	1	3	5	7	9	>12	Stores
Limit Upper <=	1	3	5	7	9	10		
Lanes	4.0	30.0	22.0	12.0	10.0	2.0	0.0	80

These groups of lane lengths can now be configured for the operational design in groups of a particular length. The length of the longest lane is 10 pallets. If the cycle had not been altered to 4 times per week, the largest would have been over 13 pallets long.

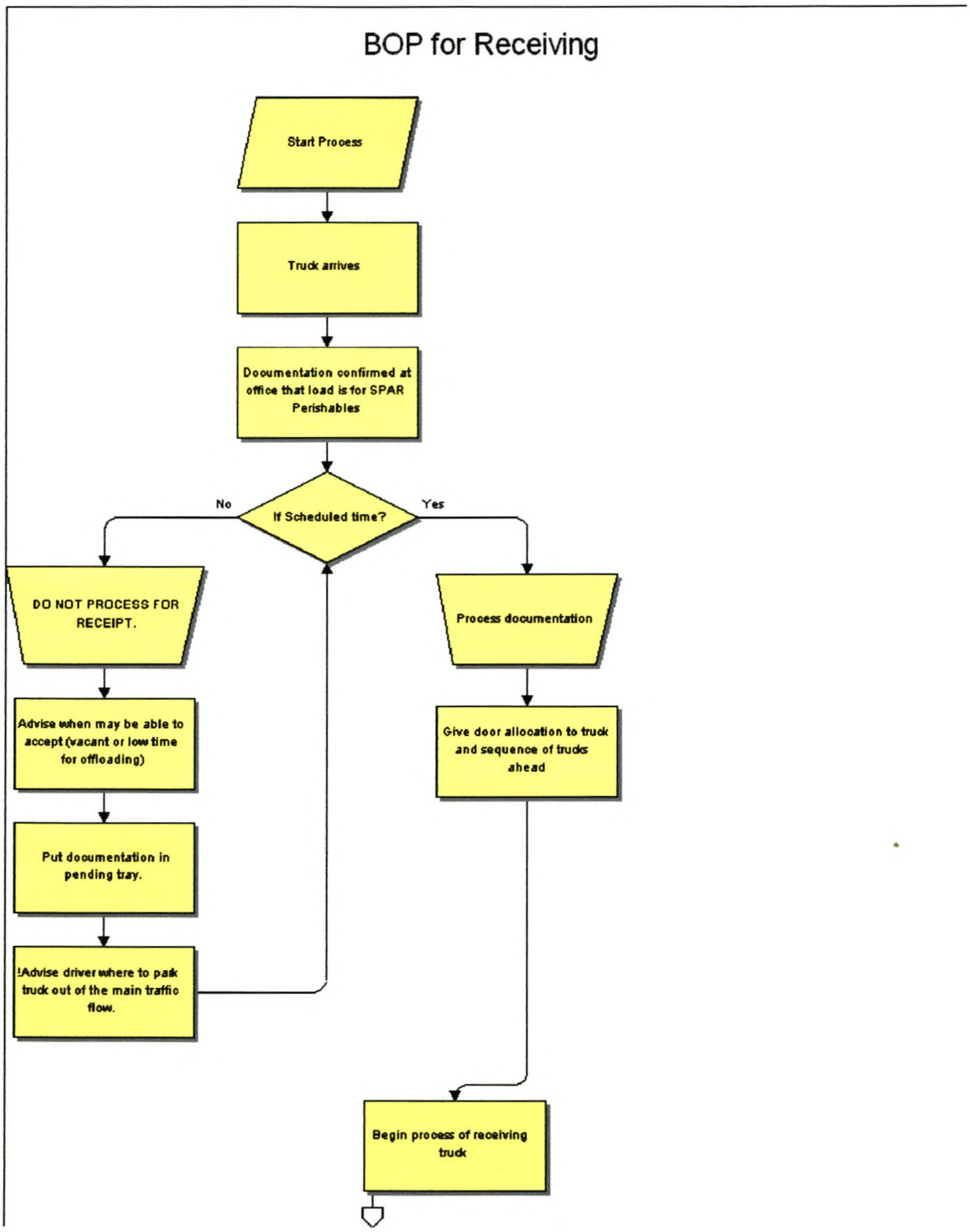
The two sort aisles are placed in either half of the sort area as per figure 14.9. The optimum design for the minimum pallet distance move will be if the banks of sort pallets are arranged with the longest lanes (largest stores) placed closest to the transport receiving doors, reducing the store size as the distance from the transport doors increases. This implies the sort will be a S path, which is the most effective sort method in this type of operation. Thus with care the sort can be optimised and the pallet assembly lanes can be optimised as well.

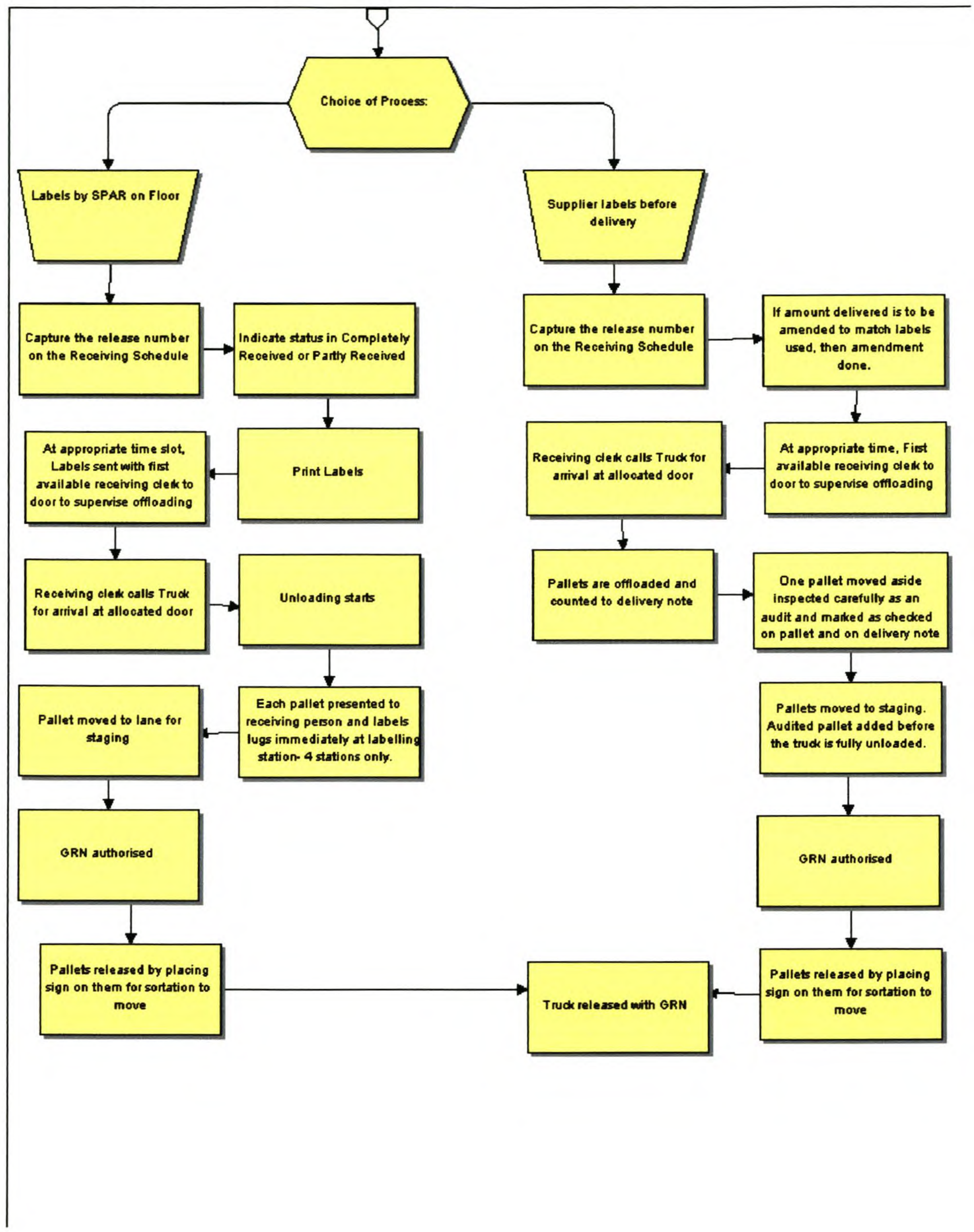
14.6 Process

The design is one aspect. The argument from previous chapters is that the personnel are critical to the operation. The simpler the operation, the more effective the personnel can be in operating the facility. The test of the design is to have a simple process of operation, and that the process recorded is always adhered to.

A Best Operating Practice (BOP) is produced for the design. This includes the principles of the label being added at the cross dock or being added to the lugs by the supplier. It is of interest to note that SPAR had previously been asked to explore this opportunity. The internal purchasing team from South Rand found no favour in the principle and have ignored the need to label at the supplier. In discussions with them for this dissertation and this design, it became apparent they had misunderstood the process. The SPAR understanding communicated from the operating to the purchasing team was to have labels placed on the lugs and then the sort done onto pallets for each store, all by the supplier. This would be a SML process. This is erroneous, as the store pallets would be for one store only, and would be of varying size for each store. The transport effectiveness would be severely reduced as, at a minimum, the transport would have to move a less than full pallet to every store that is served by the order. This reduces the need for the sort area for these pre-labelled and pre-sorted products, but introduces a major consolidation requirement in the assembly lanes. Once the concept of labelling the lugs on pallets was explained, without any sort by the supplier, the enthusiasm was rekindled and the major suppliers will be approached to implement this.

**Figure 14. 9 (a)		Receiving Best Operating Practice (BOP)**





Choice of Process:
Labels by SPAR on Floor
Supplier labels before delivery
Capture the release number on the Receiving Schedule
Indicate status in Completely Received or Partly Received
Capture the release number on the Receiving Schedule
If amount delivered is to be amended to match labels used, then amendment done.
At appropriate time slot, Labels sent with first available receiving clerk to door to supervise offloading
Print Labels
Receiving clerk calls Truck for arrival at allocated door
At appropriate time, First available receiving clerk to door to supervise offloading
Receiving clerk calls Truck for arrival at allocated door
Unloading starts
Pallets are offloaded and counted to delivery note
One pallet moved aside inspected carefully as an audit and marked as checked on pallet and on delivery note
Pallet moved to lane for staging
Each pallet presented to receiving person and labels lugs immediately at labelling station- 4 stations only.
Pallets moved to staging. Audited pallet added before the truck is fully unloaded.
GRN authorised
GRN authorised
Pallets released by placing sign on them for sortation to move
Truck released with GRN
Pallets released by placing sign on them for sortation to move

Figure 14.9 (b) Sort and Wrap and Check

Figure 14.9 (b) 1 Sort

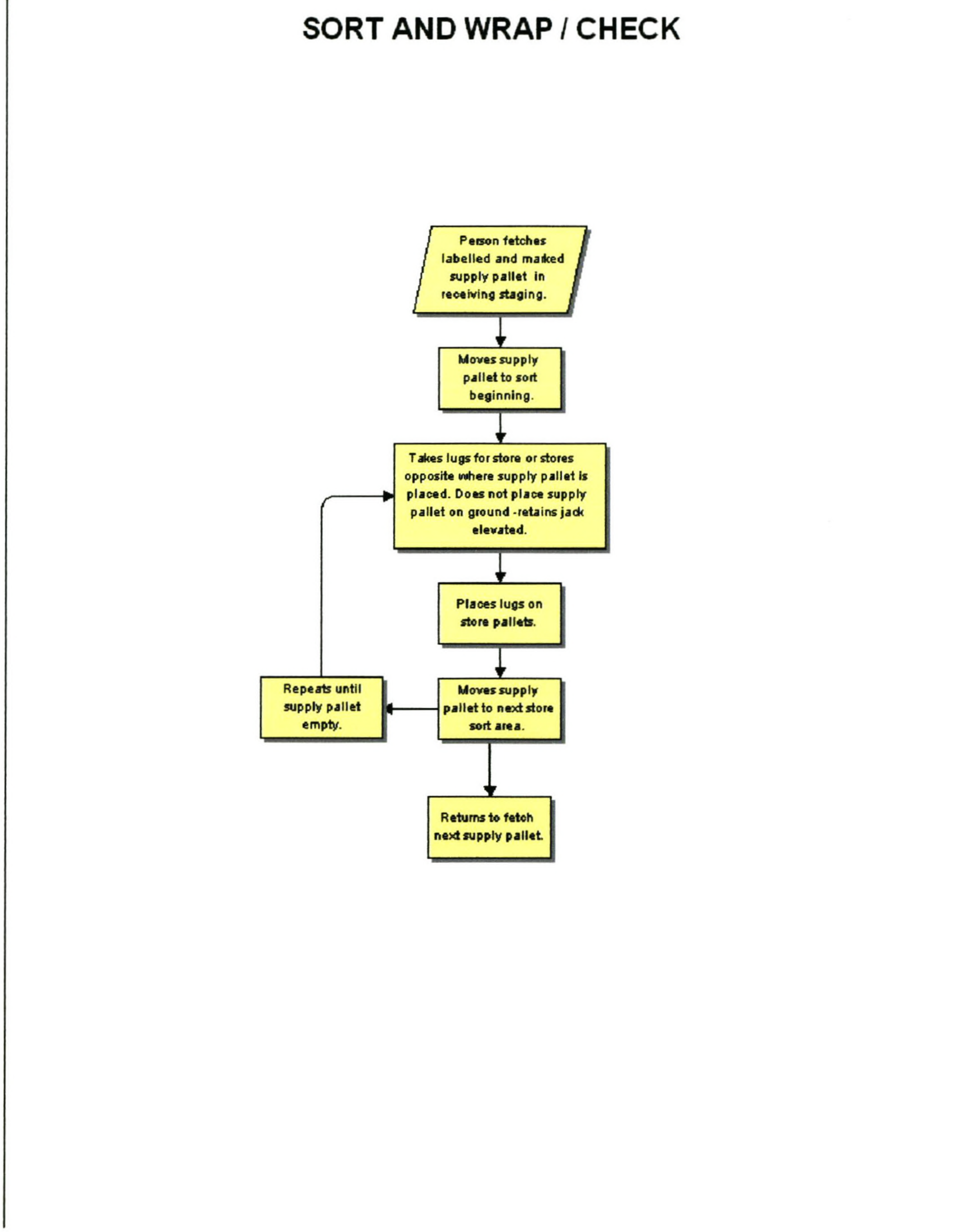
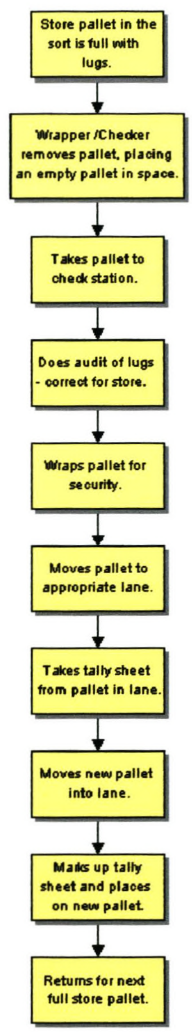


Figure 14.9 (b) 1 Wrap and Check



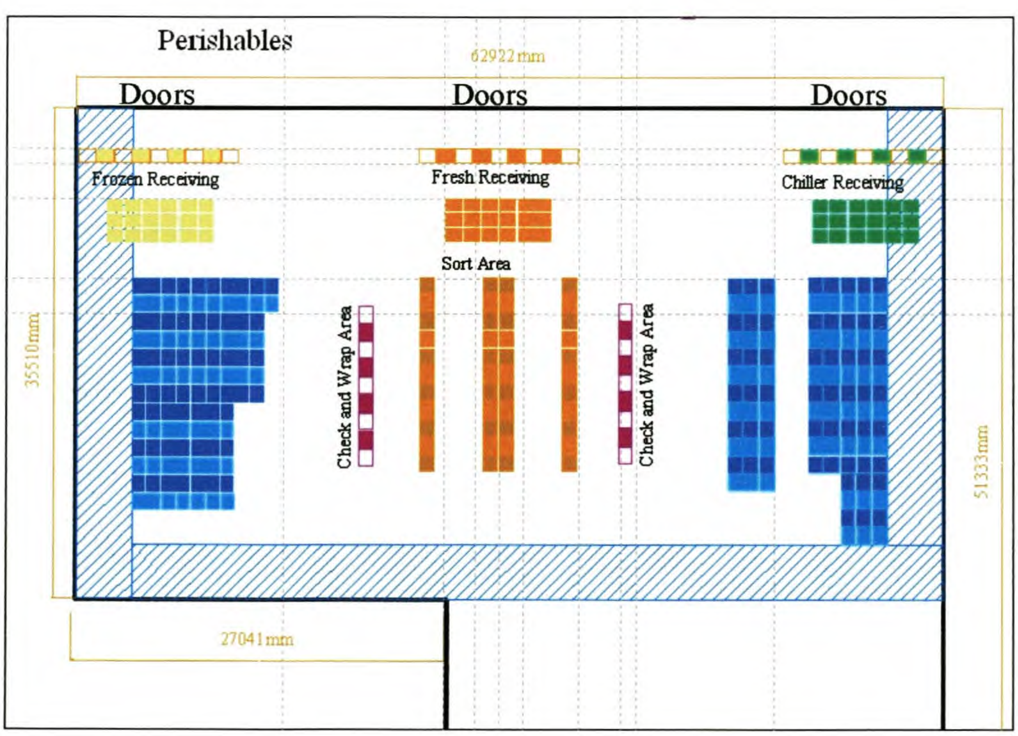
It is important to note the BOP includes all the options for labels that are feasible. The check, wrap and assembly lane process is done by one person. The pallet is checked to ensure the sorter placed only lugs destined to one store on the pallet. This checked pallet is then placed into the assembly lane for the store and tallied. The tally into the lane then records the check and wrap process completion and the responsible person for the final pallet in the lane. One person links the process from the sort, through the check to the correct placement of the pallet in the assembly lane. This is important as it makes personnel responsible for correct work and allows errors to be driven out of the system with correct measurements.

14.7 Design layout

The design layout for this facility is shown in the diagram 14.9 below. The layout follows the principles discussed in this dissertation and the detailed design of this chapter. More importantly the design not only minimises the two effectiveness criteria of minimised movement of full pallets and the minimised movement of lugs in the sort area, but it accords with all the requirements from the client SPAR.

The areas marked in hatching are flow areas to other parts of the facility that are not cross dock areas – primarily the chilled and frozen storage areas.

Figure 14.10 Layout of the New Facility



14.8 Conclusions

The research knowledge is applied to an actual design. This is a major extension to the knowledge of the cross dock as the process shows how to undertake the design in detail, as well as to integrate the cross dock design into the total supply chain based on factors identified by this research. There is no reference in the literature that suggests the concept of simulating a customer load and using this to predict the supply chain order fluctuation and then to use this to design the delivery schedule to smooth the fluctuations in the supply chain and the cross dock. This is a unique method to make the supply chain and the cross dock more effective.

The view of changing the length of the assembly lanes to match the store profile is unique to this research. This offers space optimisation in the facility and produces a far more effective design.

The concept of dual sided, multiple sort aisles is unique to this research. It offers the most effective layout for the smaller facilities.

Overall a detailed design process, building on the extensive knowledge recorded and extended in this research, has been proven to be effective in improving the effectiveness of a cross dock facility and tested in practice.

The research has also given all the factors that need to be considered in the design process, as each design will have different circumstances and must cater for all the pertinent factors.

The research links the design and the operational capability together with a Best Operating Practice.

This design methodology represents a detailed and extensive increase in the knowledge for cross docks.

CHAPTER 15
KNOWLEDGE EXTENDED BY THE RESEARCH

The research objective was to expand the knowledge of the grocery and retail supply chain incorporating a cross dock facility. There was a need for a clear understanding of the success factors for the effective operation of the cross dock coupled with the design principles for such a cross dock facility and how it integrates into the supply chain.

This research extends the knowledge in these areas significantly. The following is the knowledge produced by this research.

15.1 Classification of cross docks

The research investigated the factors characterising the cross dock in the supply chain. A detailed process analysis was performed. It was determined that three significant factors will identify the types of cross dock. From these factors, three practical types of cross dock were proven to exist. A new classification of cross docks, based on this analysis, is proposed and used in the remainder of the research. The cross docks are classified as:

- CML – Cross dock managed load;
- JML – Joint managed load and;
- SML – Supplier managed load.

Further analysis was done to support the hypothesis that the earlier the identification of the item is done in the supply chain, the more effective will be the supply chain. The research showed this to be correct. As listed above, these classifications of the supply chain incorporating a cross dock facility were determined to be from the least to the most effective.

15.2 Cross dock operation

The characteristics of successful operation are consistent for all the operations researched.

15.2.1 Operational focus

The characteristics of the more successful operations, when compared with the less successful, were that the management and operators were focussed on performing the operation with: -

- Discipline (adherence to processes);
- Fast decision making;
- Elimination of errors; and have
- Continuous improvement methods.

15.2.2 Technique for improving the operation

The cross dock is likened in the published literature to the JIT process in manufacturing. It was reasoned that this was not correct. The more useful and appropriate method is that of TOC. This was tested and found to be correct. Successful operations were applying elements of the principles of this technique, without understanding the logic or the total technique. This research supersedes the current thinking reflected in the literature.

15.2.3 Consignment complexity

Consignments are where two or more items must be delivered together. The most complex situation is where multiple suppliers deliver the items that constitute the consignment. The research proved that this affected the information that needs to move along the supply chain. It also introduces a secondary sort in the cross dock. The ASN information is a prerequisite to achieve co-ordination of the various items.

15.2.4 Operating errors

The effect of errors in a cross dock is far more severe than in a warehouse. The cross dock cannot reconcile stock as there is no storage, the time scales are hours, not days and the items are not identified as specific products. The only identification is the delivery location for the item. Errors in the cross dock are therefore very difficult to detect retrospectively.

15.3 Material handling

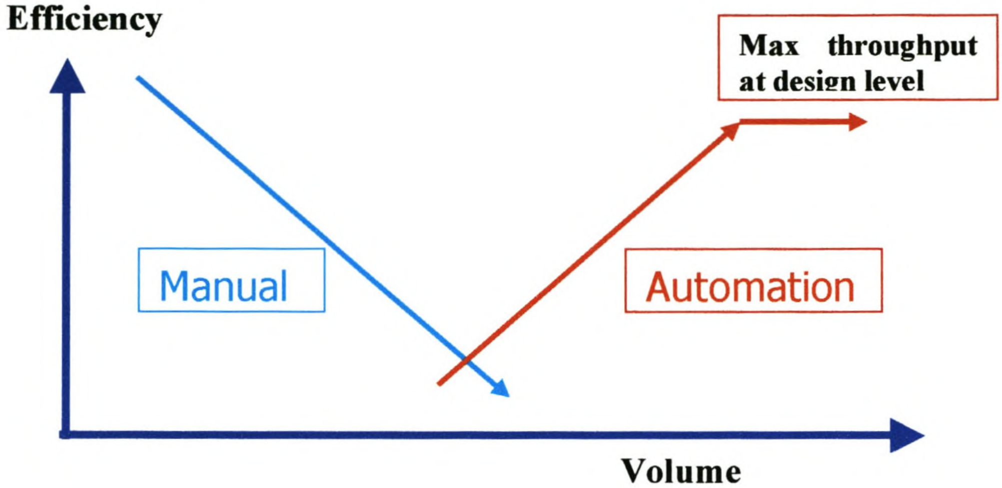
For automation to be feasible, the vast majority of the products to be handled must be suitable for an automation method. Automation is a long term commitment to a specific range of product size, shape and mass. This was ignored in two facilities encountered during the research, where automation was installed and later removed.

Automation should be chosen only when the throughput volume requires this method. The following issues influence the point where the volume will require automation:

- VAS work that needs to be done (difficult with automation);
- Throughput fluctuations which makes automation even more expensive; and
- Operating flexibility required (extremely limited with automation).

These are reflected in figure 15.1 as a composite review of the choice between automation and manual processes.

Figure 15.1 Automation and manual processes



Manual

•To match throughput fluctuations:
- Hours worked can fluctuate
- Staff levels can fluctuate

•High flexibility
•Low capital cost,
• - high operating cost
•Supports VAS

Automation

•To match throughput fluctuations, the rate of induction is altered to match the throughput
•Maximum speed set by automation
•Fluctuations increase the capital cost of equipment
•Limited flexibility
•High capital cost ,
• - low operating cost
•Difficult to introduce VAS

15.4 Management systems and barcodes

The item must be identified in the supply chain and labelled. The research showed that the barcode should be an identification number, if the data could be securely passed between the operating entities in the supply chain. If the data transmission between supply chain entities was not feasible, the barcode had to be more extensive than an identification number and had to carry the information required by the supply chain.

The minimum information required in the supply chain is:

- Order number;
- Customer number and address;
- Supplier number;
- Consignment number of item;
- Item number in the consignment

With the following of considerable value: -

- Physical properties, such as mass or dimensions;
- Priority code; and
- Billing information.

Three system capabilities are required to run an effective cross dock. These are the Order Management System (OMS) with an Advanced Shipping Notice (ASN), the Yard Management System (YMS) and the Warehouse Management System (WMS) with a Track and Trace (T&T) function. The ASN information from the OMS is required to allocate transport to the most appropriate receiving door, which makes the overall process the most effective.

15.5 Personnel

The fast time scales make the cross dock work onerous. Personnel must be able to cope with the high volume, continuous operation of a cross dock.

The cause of errors in this type of operation was identified from the empirical evidence as the combination of the person's ability, the speed with which work arrives, and the training the person has received. The work shows that it is important that the personnel do the work consistently right the first time. To do this, operators must be formally trained as to the only correct method of operation. The training must make the personnel capable of performing the tasks with a very low error rate, consistently and for long periods. This requires formal training to move the person's skills level far down the skills learning curve. The training must make them able to do a wide range of the relevant jobs, so there is flexibility.

Management can introduce further effectiveness by understanding and applying the principle of TOC to eliminate the bottlenecks before they impact on the throughput of the operation.

The operation of the cross dock therefore requires personnel that have a: -

- Disciplined approach;
- Ability to perform procedures continuously and correctly; and
- Work consistently under time pressure all the time.

15.6 Physical design and personnel influences on the cross dock

The combination of physical design and personnel capabilities and the effect of these two primary factors on the supply chain incorporating a cross dock facility, can be related as shown in figure 15.2.

Figure 15.2 Physical design and personnel influences on the cross dock.

Physical design effectivemness	Hi	**High potential, poor results**	**Highly effective and efficient facility**
	Lo	**Failure**	**Good people, poor results**
		Lo	**Hi**
		Personnel capability	

15.7 Design criteria development for cross docking

The design criteria and the underlying issues that must be considered were developed. This is unique to this research. These criteria are in brief:

15.7.1 Source of the product

The total work to be done in the facility is a function of the: -

- transport size (larger size, less administrative work per volume moved);
- number of items per delivery;
- complexity of identifying the item; and
- work to be done to sort the items.

This complexity is synthesised as below: -

Figure 15.3 Complexity for volume of the load and the work for each item

Load volume	*Large* ↑	**Simple handling; Efficient doors; Moderately complex flow balancing.**	**Difficult handling; Efficient doors; Very complex flow balancing.**
	↓ *Small*	**Simple handling; Inefficient doors; Easy flow balancing**	**Difficult handling; Inefficient doors; Difficult flow balancing.**
		Easy, few ←	→ *Difficult, many*
	Work to handle the item		

15.7.2 Customers

The service standard and hence frequency of delivery, plus the volume per day per customer will influence whether there are assembly lanes, the area allocated to the assembly lane, and the number of dispatch doors.

15.7.3 Fluctuations in the work load

The supply chain work needs to be forecast for the day. The work (see source of the product and the receiving which sets the level of work) then needs to be scheduled (see transport scheduling) in order to make the chain operate at a more balanced level to achieve effectiveness. The day by day supply chain fluctuations must be managed for effectiveness. This may require the supply chain to be modified, in order to optimise the effectiveness for the chain.

15.7.4 Automated or manual sortation

Choose the most appropriate from the principles identified in the researched process.

15.7.5 Consignments

These require additional work in the form of a secondary sort, which requires additional space and personnel in the cross dock.

15.7.6 Transport scheduling

The scheduling of the inbound transport to give a constant flow of work (not items or transport) to the sort is required. The allocation of the transport to the appropriate door to make the process the most effective or to complete the largest number of consignments requires ASN information.

15.7.7 Shape and Size

The function the facility will perform in the supply chain (distribution of small loads or large for example) will alter the shape and size. The function influences both the width and length. Automation or manual material handling will also alter the shape and size.

15.7.8 Type of cross dock operation

Each of the three types has different space requirements in the facility.

15.7.9 Work at the cross dock

The width of the cross dock can be determined from the VAS work required and the type of cross dock operation (which determines the work associated with labelling and sorting and hence the area required), and the function the facility performs in the supply chain.

These factors can be used to establish an effective design for a cross dock and its operation within the associated supply chain.

15.8 Design process for a cross dock

All the above design principles, plus the preceding work on the effective operation of a cross dock, were used to perform a design of the new cross dock facility. The shape was predetermined, but the orientation and processes were not. The process is given in summary. The supporting calculations to highlight the inter-relationships are given in Chapter 14. The design is predicated on the principle of a continuous flow of items to the sort, which is the bottleneck, as per the TOC work done in the operation.

15.8.1 Design requirements

The design requirements from the Client were decided. These included the use of an existing space, and the requirement to adhere to the current method of unloading the transport using the transporters' staff. This means a third party on the floor that must be kept away from the operation.

15.8.2 Design aims

The design aims were to minimise the pallet move distance and the individual item movement distance. The methodology to measure this was identified.

15.8.3 Fluctuations in the work load

Fluctuations in the work load were investigated. The supply chain was found to have large fluctuations. The supply chain was modelled and then re-engineered to significantly reduce these. This re-engineering introduced different service cycles, and minimised the fluctuations as far as possible without affecting service standards. A buffer was created between the receiving area and the induction to the sort in terms of TOC principles.

15.8.4 Source of the product

Analysis of the deliveries from suppliers led to the correct number and type of receiving doors.

15.8.5 Inbound transport

Scheduling to provide a continuous flow of work to the sort was agreed.

15.8.6 Sort location and layout

Sort location and layout was decided with mathematical models to ensure these were the most effective. A number of variations were proposed, tested and refined. These were done within the constraints of the building shape and size.

15.8.7 Additional work

Additional work including VAS led to the creation of the check and wrap areas.

15.8.8 Assembly lanes

Assembly lanes were calculated to make the assembly feasible with the least pallet movement for any cycle and any day.

15.8.9 Flows

Flows were catered for with simple flow directions, no overlaps or crosses and no counter-flows.

15.8.10 Personnel

Personnel and training were considered with a detailed Best Operating Practice (BOP) process. Personnel were formally involved in creating the BOP and all were trained on the rudiments of TOC.

15.8.11 Layout

A final, optimised layout was implemented. The measurements confirm this is the most effective possible design. It has proven to be so in its operation from commissioning in November 2003.

15.9 Conclusions to the research

The research extends the knowledge of the cross dock in the supply chain considerably. The research has resulted in: -

- New classifications for cross docks have been derived;
- A new method of improvement and operation of the cross dock based on TOC principles has been shown to be of the greatest value;
- The choice of material handling in the cross dock is made by following a series of decision steps;
- The systems required for the effective operation of a cross dock are described along with the information that is required from these systems;
- The use and value of the information in the supply chain and its movement along the supply chain using either data transfer between the systems in the supply chain or the barcode is defined;
- The type of personnel is identified. Errors are related to the capability of the personnel and their workload. Formal training is a prerequisite for effective operation;
- Detailed criteria for the design of the cross dock were developed. This detailed procedure will guide a detailed cross dock design which will be the most effective possible; and
- The design of a new cross dock using these criteria is concluded in the research. This operates as a very effective operation.

The work reflected above, other than the size and shape of the facility, is all part of this research. The knowledge of the design principles and the success factors for cross dock operation in the grocery and the retail supply chain has been significantly extended. A new classification for the cross dock in a supply chain is derived and presented as new research.

The research centred on the use of the operation of cross docks in the grocery and retail industries. However, the principles of the research are essentially applicable to most situations in any industry where the operation and design requirements include a cross dock in the supply chain. Wherever a large transport is used to move the goods to a depot and these goods are then immediately moved via another transport to new destinations, these are cross docks and the research is applicable. For example, there are applications in railway depots and port depots, where large quantities of items are moved into the depot and are then arranged to move in much smaller quantities to specific locations. For example in the USA new cars are currently distributed by train initially and then by other modes after passing through a depot which is in essence a cross dock. This research would be applicable. In every port that handles containers in particular or even break-bulk cargo, the principles would also be applicable in the container terminal.

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