Investigating the feasibility of integrating operations within Allwear by means of Facilities Planning.

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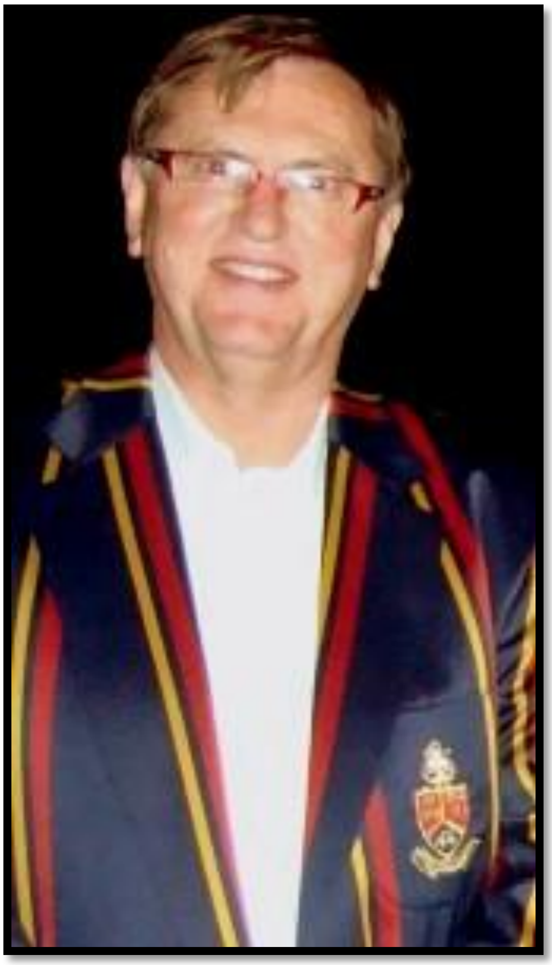

This project is done in honour of Dr. Jan-Henk Boer who passed away earlier this year. Dr. Jan-Henk Boer was the CEO of Allwear and the initiator of this project. He was not only a mentor but also a dear family friend.

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Executive Summary

Allwear is a company that operates in a niche market of the South African Clothing Manufacturing industry. Allwear produces mainly woven school wear over the full spectrum of products for boys and girls. Allwear's operations currently reside in three factories namely the main factory, the warehouse and Beetex. Of these three factories two are owned by the company whilst Beetex is rented.

The problem at hand is that the lease of the Beetex factory is an unnecessary expense for the company in terms of rent, water and electricity. The capacity of the space rented is not fully utilized, whilst capacity in the other two factories is not effectively utilized.

The aim of this project is to investigate the feasibility of integrating the operations currently residing in the leased factory into the two factories owned by the company. This will serve as a basis for decision making on whether to consolidate and reorganize current operations.

The investigation and proposed solution will include a comprehensive operational improvement plan utilizing Industrial Engineering methods such as facilities planning, logistics, warehouse management and inventory control.

The steps followed to execute the final project are as follows:

- Analyse Current operations
- Determine Design Criteria
- Develop Design Alternatives
- Evaluate Alternative Designs
- Select and Refine Best Alternative
- Justify and Sell Implementation Plan

The results of the analysis prove that the integration of operations is feasible. The solution is an improved layout of the warehouse containing Knitting operations from Beetex and the Tracksuit operations can be integrated into the main factory. By relocating the operations an immediate saving of R47 000 per month will be made on rent, water and electricity.

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Chapter 1: Introduction

1.1. Background

1.1.1. BMD Textiles (Pty) Ltd trading as Allwear

Allwear operates in a niche market of the South African Clothing Manufacturing industry. The original company was founded on 7 December 1939 as the Volkshemde en Klerefabriek Beperk, Veka. The purpose was to provide work to Afrikaans speaking girls. The factory commenced work in Fordsburg, Johannesburg with seventeen workers. At that point in time the price of a sewing machine was £60 and production output was a hundred work trousers per week.

Shares were privately offered to the public and during the first year approximately 1 000 shares of £1 each were sold. By 1942 Veka was in deep financial trouble and Dr. Albert Wessels was appointed as manager to rescue the company.

Over time the white workforce changed to coloured and later black workers. The result being the manufacturing shifted to where labour was readily available and plants were built in Charlestown and Newcastle. The company could in this way benefit from decentralization incentives and became one of the largest South African manufacturers of suits, blazers, trousers, shirts and school wear. The next step was the purchase of M. Bertish & Company, a leading manufacturer of men's fashion in Cape Town. In 1983 it was decided to close down the head office in Johannesburg and to decentralise operations as follows:

- School wear in Newcastle
- Fashion in Cape Town

Charlestown was closed down.

After severe foreign exchange losses taken in the mid eighties, Veka had to sell the Cape Town Factory to Pep Stores.

In 1989 Wesco sold its shares in Veka to a consortium of businessmen. The name of the company changed to Allwear Ltd. Over the next seven years the majority shareholding was bought in the market by Hicor Ltd and during July 1997 Hicor Ltd made an offer to the 39%

minorities. This offer was accepted by more than 90% of the minority shareholders and consequently Allwear was delisted.

Assets and liabilities were transferred to Hicor Trading Ltd, a subsidiary of Hicor Ltd. On 1 April 1998 Allwear was sold to Waverley Blankets Ltd. A large competitor in Kimberly, Markstan, was bought and integrated with the Newcastle plant in 1999. On 1 October 2007 Allwear was sold to BMD Textiles (Pty) Ltd and has since operated as this company's sole operating factory. The company owns two factories on the Newcastle property. After the integration with Markstan the two factories lacked capacity and an additional factory, known as Beetex, was leased.

1.1.2. Current Operations at Allwear

In general Allwear produces mainly woven school wear over the full spectrum of products for boys and girls. Clothing manufacturing is fairly flexible. If orders become available it is possible to expand capacity rapidly or to switch capacity from one line to another. Overtime also assists in flexibility. Table 1 exhibits production levels and capacities.

Production Line	Standard Capacity (Units per day)	Capacity Used (Units per day)
Blazers/Jackets	550	400
Trousers	2000	500
Shorts/Slacks	1500	1000
Skirts	1000	1000
Dresses/Tunics	1600	1250
Shirts	5000	2400
Jerseys	1200	800
Tracksuits	400	300

Table 1: Production Levels and Capacities

The production of winter products are done in Beetex, this consists of jerseys and tracksuits and makes up roughly 15% of daily production. The remainder of the products are made in the main factory, whilst the third factory is currently used as a warehouse for storage of finished goods and old machinery. An illustration of how the factories are situated can be seen in Figure 1.

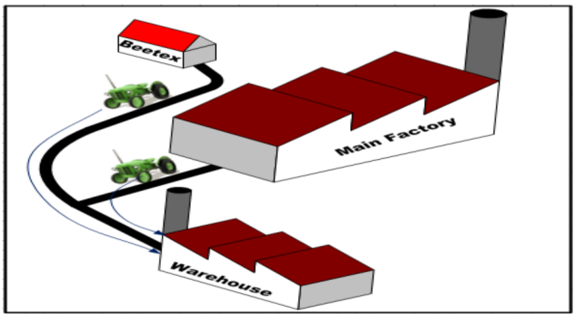

Figure 1: Illustration of Factories

1.2. Problem Statement

The problem at hand is that the lease of the Beetex factory is an unnecessary expense (Accounts can be seen in **Appendix D**) for the company in terms of rent, water and electricity. The capacity of the space rented is not fully utilized, whilst capacity in the other two factories is not effectively utilized. After the move from Kimberley, as mentioned in the introduction, the operations that could not fit into the existing two factories were "dumped" into Beetex without accurate planning. The current warehousing and material handling techniques are ineffective for optimal space utilization.

1.3. Project Aim

The aim of this project is to investigate the feasibility of integrating the operations currently residing in the leased factory into the two factories owned by the company. This will serve as a basis for decision making on whether to consolidate and reorganize current operations. As discussed in the introduction, the main factory does the bulk of the clothing manufacturing whilst Beetex is responsible for the winter clothing manufacturing and the third factory is used as a warehouse. The investigation and proposed solution will include a comprehensive operational improvement plan, addressing the following objectives:

- Improve and enhance on-site transportation and circulation.
- Effectively utilize space, equipment, people and energy.
- Improve product flow.
- Improve material handling systems and material control.
- Maintain flexibility in production capacity.
- Enhance inventory management regarding policies, allocation and optimum levels.
- Reduce costs and grow the supply chain profitability.
- Increase return on assets by maximizing continuous improvement.
- Increase return on assets by minimizing obsolete inventory.

There is definite room for improvement although the survival of the company does not depend on it. This improvement plan will thus be used as a contingency plan for management. A contingency plan is a coordinated and organized combination of steps taken in the event of an emergency. The plan can be used to ensure the future viability of Allwear in the face of growing competition from local competitors and imports.

1.4. Project Scope

The scope of the project involves the redesign of the facilities within the company. The project will commence by studying the current facility layouts and understanding the methods of manufacturing within each facility. The warehouse needs to be studied from a supply chain point of view as it is used mainly for storage and packaging. An inventory analysis in conjunction with an age analysis will be carried out to study current policies on stock levels within the warehouse, including finished goods, raw material and work in progress.

Once the current conditions are fully understood, new designs can be generated. Other constraints that need to be taken into consideration regarding the new facility designs include:

- Expenditure: Cost of implementation of feasible design and the impact on production.
- Size and layout of existing facilities.
- Security, since knitting is a 24 hour operation.
- Eradicating existing overhead electricity cables in warehouse.
- Set height of storage racks.
- Rental contract on Beetex.
- Raw material used is imported which affects:
    - Lead time
    - Safety stock
    - Material stock levels
    - Order sizes
- Orders are specialized not generic for mass production.
- Insufficient material handling equipment.
- Certain amount of inventory needs to be kept in warehouse.
- Management wants areas such as production and storage fenced off which, in turn, makes implementation of facility redesign more challenging.

The project scope excludes the practical implementation of the new facilities plan, and will only consider whether such a plan is feasible.

1.5. Project Approach

Key Phases of Project:	Activities and Tasks:	Deliverables:
1. Analyse Current operations	1.1. Get to know facility and staff.	1.1.1. **Comprehensive background of company.**
	1.2. Measure size of operations and departments within facility.	1.2.1. Detailed facilities plan of current layout for all three factories. 1.2.2. Material flow diagram for Beetex.
	1.3. Study current facility layout.	1.3.1. Photos of existing facility.
	1.4. Gather data on volumes of output for different factories in different seasons.	1.4.1. Annual production report. 1.4.2. Statistical analysis of annual production.
	1.5. Research stock policies used by company.	1.5.1. Detailed summary of inventory policy used by Allwear.
	1.6. Find current expenses for Beetex including rent, water and electricity.	1.6.1. Indication of amount that can be saved if operations are taken out of Beetex.
	1.7. Interview employees in Beetex.	1.7.1. List practical limitations and employee requirements concerning Beetex.
2. Determine Design Criteria	2.1. Define problem at hand.	2.1.1. Problem Statement.
	2.2. Determine design constraints.	2.2.1. Thorough list of design constraints.
	2.3. Meet with management to establish design criteria.	2.3.1. List of management requirements. 2.3.2. Agreed weighted design criteria.

3. Develop Design Alternatives	3.1. Create activity and space relationship diagrams for Beetex.	3.1.1. Activity relationship diagrams. 3.1.2. Space relationship diagrams.
	3.2. Obtain space requirements needed for operations in Beetex.	3.2.1. Space requirements needed.
	3.3. Design new facility layout alternatives for Beetex.	3.3.1. New facility layout alternatives.
4. Evaluate Alternative Designs	4.1. Rate alternatives according to weighted design criteria.	4.1.1. Weighted factor comparison of each alternative.
5. Select and Refine Best Alternative	5.1. Select best alternative.	5.1.1. Best alternative.
	5.2. Discuss best alternative with management.	5.2.1. Refined alternative.
6. Justify and Sell Implementation Plan	6.1. Prepare final project report.	6.1.1. Final project report.
	6.2. Prepare presentation.	6.2.1. Presentation to management of Allwear. 6.2.2. Presentation to Industrial Engineering Department.

Table 2: Project Approach

Chapter 2: Literature Review

2.1. Strategic Facilities Planning

In the past ten years facilities planning has taken on a whole new meaning (Thompkins et al., 2010). Facilities planning was mainly considered to be a science in the past. In the competitive global marketplace of today, facilities planning is a strategy. For many years the subject of facilities planning has been a popular topic. Facilities planning has broad applications, but will be discussed from a business process reengineering point of view and two different techniques are examined, namely Computer Integrated Facilities Planning and Murther's Systematic Layout Planning Procedure.

According to Wrennall (1997) through business process reengineering widespread opportunities such as the skills and techniques required for business restructuring has been provided for industrial engineers. In order to gain from this theoretical structure, there has to be an enabling physical presence of a competitive operation. Strategic facilities planning has been restructured from the traditional systematic facilities planning, which sustains a company's competitiveness.

The result of a company's physical assets includes all the inputs of facilities design. The operational capacity of the organization is provided by these assets, now and in years to come. In addition to the investments committed to buildings, equipment, land, and the physical plant, the result – the facilities design - ascertains the opportunities and constraints of the operation's future productivity. (The lean operations generic project model can be seen in **Appendix A.)** Yet, more often than not, this design is poor, and the facility which is the result thereof is either not fully functional or suffers for years. Although the key to future operational success seems to lay with sound facilities design, it often does not receive the required attention. A reason for this is that knowledge in the field of operations management is less systematic than in a field such as accounting for example.

Facilities design is a complicated task for management, with an assortment of multiple and often contradictory inputs that engender the value of products customers buy. In order to sufficiently manage this complicated task, it is essential to recognize and apply not only the know-what of operations, but include the know-how. It is vital to add facilities design to our operational strategy, and the reengineering operations that have to be converted into a facility plan with a supporting layout. Strategic facilities planning is not only the foundation of the business process reengineering pyramid, as depicted by Figure 2, but also a competitiveness enabler.

According to Foulds (2011) the important industrial problem of plant layout has received noteworthy attention over the last two decades. Here it is assumed that the location of the facilities is on a simple-connected plane region such as a flat building site or a factory floor. This problem has been given different names by different authors e.g. "plant layout", Foulds and Robinson, Apple, Moore, Hillier and Connors; "facilities allocation", Buffa, Armour, and Vollmann; "economic activity location", Koopmans and Beckmann; and "layout planning", Muther.

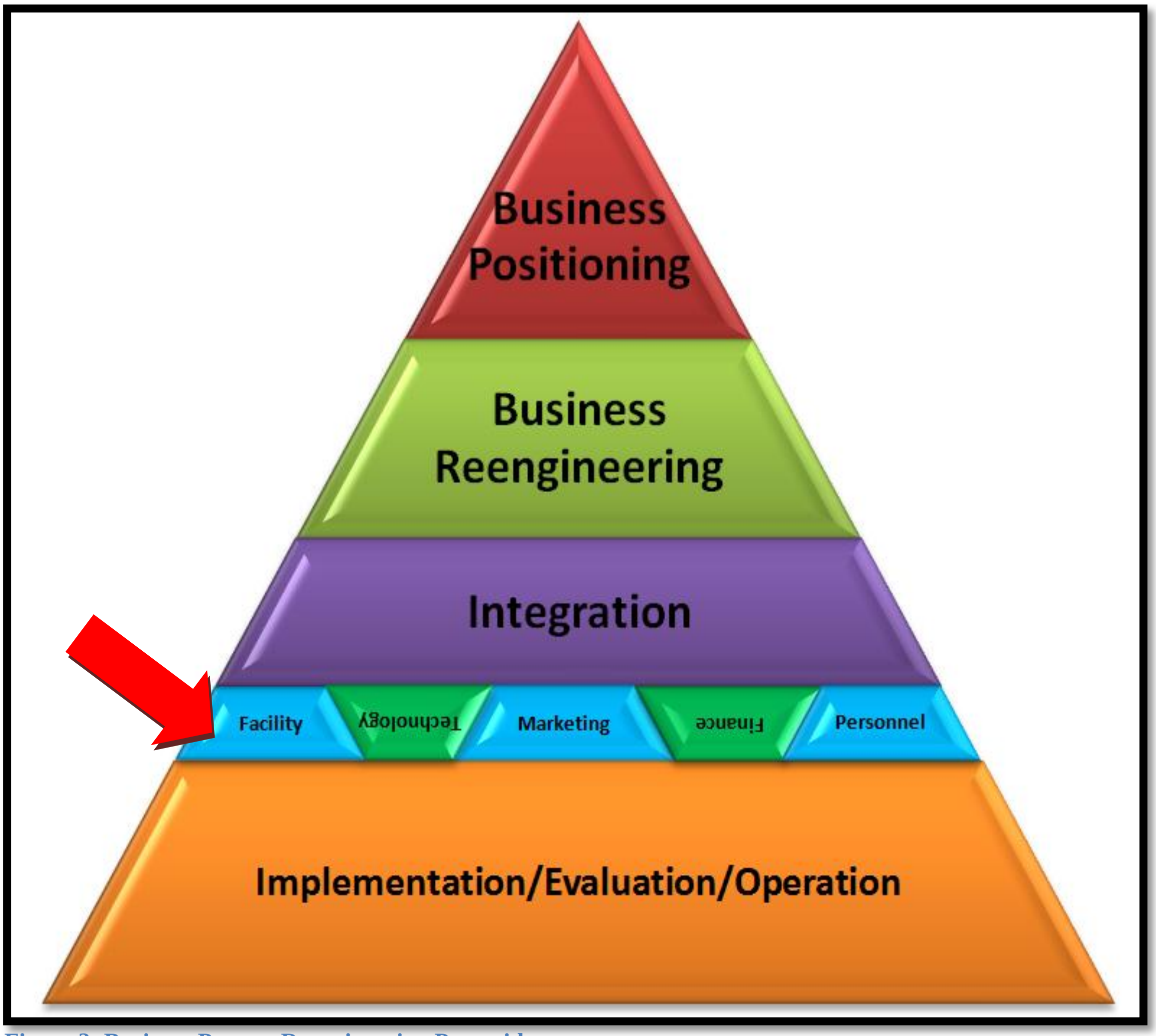

Figure 2: Business Process Reengineering Pyramid

According to Gopalakrishnan (2004) the automatic generation of facility layouts using computer-based models has been shown to afford substantial benefits to the industrial community for the development and planning of facilities. The computer-based model examined concentrates on the concept of integrating the areas of material handling, warehousing and plant layout in terms of raising overall effectiveness.

Momentous disadvantages will be experienced by companies when inept action plans are developed in an integrated facilities environment, which results in reduced throughput, lower operational flexibility, higher capital expenditure, poor space and equipment utilization, higher operating costs, poor working conditions and a decline in productivity. From this perspective, decisions made in terms of process planning, product design, production schedules and facilities planning and design should be made an in integrated manner so as to achieve results that are assured to further the organization's business objectives.

It is imperative that the most apt techniques are used for modelling purposes when investigating the integrated facilities design approach. Potential modelling procedures include trial and error, cluster analysis and simulation. The trial and error method (Ceglarek et al., 2001) is based on the utilization of previous experience and common sense in optimizing the conceptual model. The cluster analysis method is related to the grouping of objects into homogenous clusters based on some mutual features or activities. All of these methods are intended to decompose a complicated problem into subsystems so as to render it in more manageable terms (Irani and Huang, 2000). Simulation is generally used as a stochastic model to asses a proposed materials handling system in which there exists a randomness of events. Simulation forecasts the behaviour of intricate manufacturing systems by establishing the movement and interaction of system components. It is capable of aiding in the design of the most complex automated materials handling systems and also allows the user to evaluate alternative solutions and to examine the flexibility of a design (Eneyo and Pannirselvam, 1998).

The value of a computer-based model and the complete system to facilities management lies in its ability to recognize and concentrate on the key governing factors in each aspect of the facility that can be enhanced to contribute towards the overall maximization of benefits and minimization of costs.

According to Chien (2004) even though various new technologies have been developed in facilities planning, the Systematic Layout Planning (SLP) Procedure by Richard Muther is the most extensively used among enterprises and the academic world. Traditional SLP procedures as depicted by Figure 3 can be broken into eleven steps. Step one is the input of data namely product (P), quantity (Q), route (R), support (S) and time (T).

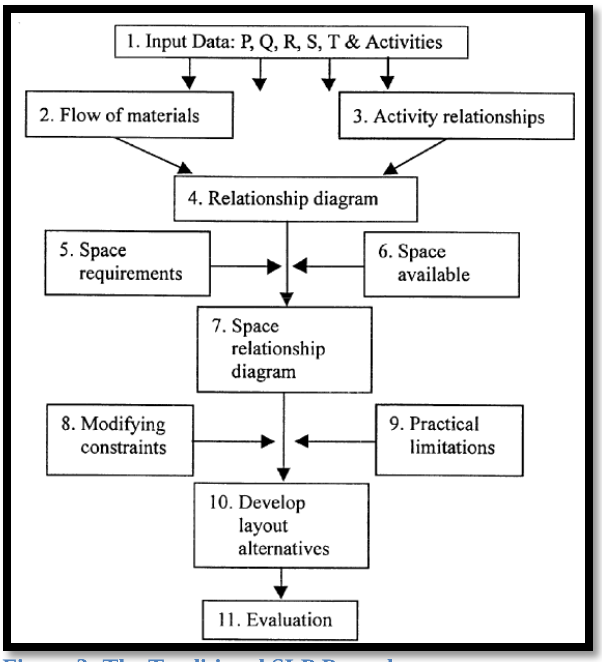

Figure 3: The Traditional SLP Procedure

Muther's SLP procedure has been extensively used during previous decades. It has been proven to be a valuable technique in factory plotting practically and academically. Complications arise in practical operation from increasing activity and unavailability of effective plotting. Because of this enterprises repeatedly convene meetings for collective discussion to minimize any plotting negligence. Their assumptions are often affected by personal favour and experience. While the use of computer-based techniques may provide an "optimum" proposal under certain conditions, it fails to deal with human experience and discretion facilitating an "optimum and reasonable" proposal (Francis et al., 1992; Tompkins et al., 2010). The seven modified methods and concepts introduced to SLP can efficiently eliminate this fault. Figure 4 illustrates the modified SLP procedure. These methods and concepts can simultaneously advance the designers to manipulate the logical and accurate corresponding position between each activity group before the designing process steps into "space relationship diagram".

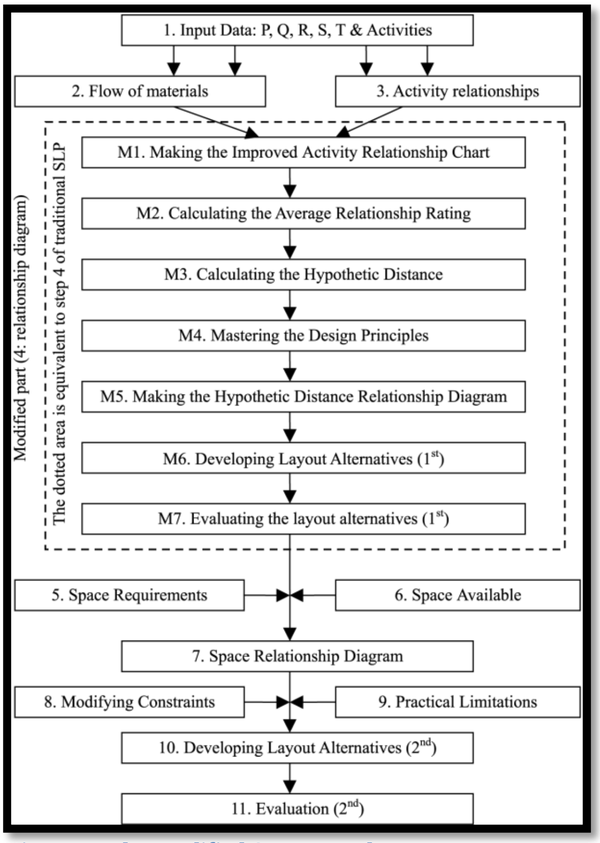

Figure 4: The Modified SLP Procedure

Once the appropriate information is collected, a flow analysis is merged with an activity analysis to develop the space relationship diagram, adapting considerations and practical limitations. Various alternative layouts are designed and evaluated.

After examining facilities planning as a strategy and studying two techniques it is evident that a sound foundation for computer-based approaches has been provided by the systematic manual procedures of SLP. Duplication of input and the likely exclusion of crucial information is eliminated by the integration of processes. By integrating the requirements for materials handling, raw materials and warehouse inventory levels with the aim of producing a facility layout that minimizes overall materials handling costs and floor space requirements a superior facilities design system can be developed.

Facilities planning is the foremost method to solve this particular problem. The methods that go hand in hand with this technique namely material handling and inventory management are crucial to its success.

2.2. Material Handling

When considering the overall facilities design, the design of the material handling system is an important component. The material handling system design and the layout design are undividable. In the design of a new facility it is crucial that there is integration between these two design functions.

According to Thompkins et al (2010) in a classic industrial facility, material consists of 25% of all employees, 55% of all factory space, and 87% of production time. The total cost of a manufactured product is estimated to be made up of 15 to 70% material handling. As stated by Material Handling Institute of America "material handling is the art and science associated with the movement, storage, control and protection of goods and materials throughout the process of their manufacture, distribution, consumption and disposal."

2.2.1. Current Material Handling within Allwear

Raw material is brought in to Beetex by means of boxes, these boxes are placed in the storage area where they are stacked on pallets as seen in Figure 5. The boxes are transported by means of trolleys depicted by Figure 6. The main material handling equipment used within Beetex is trolleys.

Figure 5: Boxes Stacked on Pallets

Figure 6: Trolley Used to Transport Boxes

The problem with stacking boxes on top of each other is that the stack becomes top heavy. This puts a constraint on the amount of boxes that can be stacked. Vertical space can thus not be effectively utilized within the storage area and boxes have to be stacked on the outside. The red area around the storage area that can be seen in Figure 10 is the excess space used for storage. The flow of material in Beetex can be seen in **Appendix B.** Material is transported with plastic crates on trolleys after the raw material has been processed.

On the production line in the main factory the material is transported in two ways namely material crates by means of roller conveyors and an Eton system from one operation to the next. Jackets, dresses and trousers are assembled on Eton Unit Transporters while shots, shirts, skirts and tunics are assembled and transported using plastic crates on roller conveyors. The Eton system is a computerized overhead conveyer with individually addressable workstations. The system eliminates manual transportation between workplaces as well as non-productive operator time. The Eton system transports all the pieces of one complete product through the manufacturing process. An addressable product carrier takes all the pieces of one entire unit (i.e. for trousers – backs, fronts, pockets etc.) through the different steps of production. Operations are performed at individual workstations. (See Figure 7)

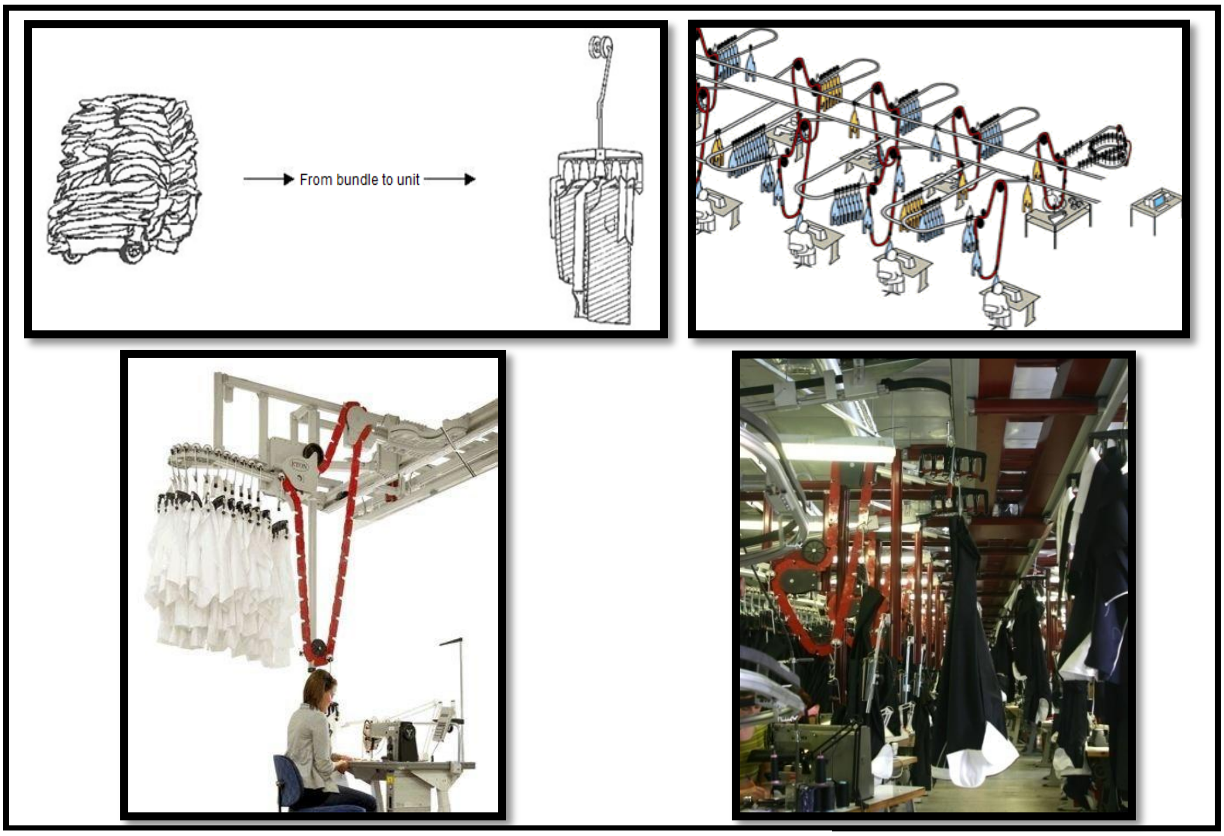

Figure 7: How Eton Production System Works

Figure 9: Tractor for Finished Goods

Figure 8: Trailer for Finished Goods

Tractors as seen in Figure 8 are used to transport finished goods from Beetex and the main factory to the warehouse. When there are too many boxes for one trailer, numerous trailers are used as depicted by Figure 9. Once boxes have been unpacked in the warehouse and the various orders have been sorted, the boxes either go into racks or are transported directly to finished goods section via a roller conveyor as seen in **Appendix B.** A rack system is essentially a storage mechanism for finished goods within the warehouse. Activities relating to storage and retrieval should be effectively accomplished. Racks should be spaced at a predetermined distance from one another to accommodate material handling equipment for unit load retrieval. Figure 12 illustrates the floor plan of the warehouse where it can be seen that not all racks are equally spaced, this needs to be changed. The material handling equipment used in the warehouse to store boxes is bin shelving. Bin shelving is the oldest and most popular equipment alternative used for small parts order picking. It has a low installation cost and is easy to install and reconfigure. The easy reconfigurability is advantageous for this project. Trolleys are used to transport boxes within the warehouse and clothing rails are used to transport hanging clothing. For the storage of boxes, the factors that will be used to determine the amount of racks needed is the height of the rack and the load per meter that can be stored in a rack for standard box sizes. The rack arrangement also needs to be decided upon according to the material handling requirements. Information gathered from inventory management and scheduling are crucial in the space determination.

2.3. Inventory Management

According to Hedrick et al (2008) successful inventory management involves balancing the costs of inventory with the benefits of inventory. A few crucial concerns are as follows:

- ✓ Maintaining a wide variety of stock, without spreading rapidly moving stock too thin.
- ✓ Increasing inventory turnover without sacrificing the service level.
- ✓ Keeping stock low without sacrificing performance or service.
- ✓ Obtaining lower prices by purchasing in volume without ending up with slow-moving inventory.
- ✓ Having an adequate inventory on hand without gathering obsolete items.

Inventory management also has to do with keeping accurate records of finished goods that are ready for dispatch. Inventory kept in the racks inside the warehouse is mainly generic stock such as white shirts and grey pants for example. Generic stock is kept for schools that do not have a specialized school uniforms. Calculating buffer stock is crucial to effective inventory management. Essentially, buffer stock is additional units above and beyond the minimum number of units required by the company. The amount of standard stock with added buffer stock is further discussed in Section 3.3.

2.3.1. Allwear's Inventory Policy

Allwear has a make-to-order inventory policy since it operates in a niche market. Customers are served on a First Come First Served bases. Before a delivery date is promised to a customer, a check for material availability is done first. The average lead time for an order is given to customers as six weeks. For priority customers Allwear will shorten lead time on request at no extra cost. The top ten customers take priority and their order is done first. Products are manufactured according to when they were ordered. The product with the soonest delivery time is manufactured first. Planners check for similar products in orders each month and bundle it together. Orders are made and kept as inventory well in advance.

Chapter 3: Analysis of Current Operations

3.1. Clothing Manufacturing Environment

Allwear operates in a niche market of the South African clothing manufacturing industry producing mainly woven school wear over the full spectrum of products for girls and boys.

As a manufacturer there are general manufacturing functions within a factory that are related to the actual production of garments and they consist of the following:

- Cutting room
- Sewing room
- Pressing room
- Finishing
- Final inspection
- Packing

Once the garments have been packed, they are transported to a warehouse. The same planning and thought should be given to a warehouse as is given to other production systems as it is an integral link in the manufacturing chain. The layout and planning of a warehouse would allow for the following:

- The kind of garments that have to be warehoused and if they are stored in a boxed or a hanging form, or a combination of both.
- The amount of garment traffic in and out at peak times.
- The maximum stock levels that need to be kept in the warehouse.
- Equipment and working areas for bulk packing, ticketing and bagging.
- The allocation and sorting facilities needed if minor orders of several different styles have to be prepared and combined for individual orders.
- A layout of the stores to promote an uninterrupted flow of garments from receipt to dispatch.
- The logical position of sufficient space for the receipt and dispatch of merchandise.

3.2. Layout of Current Facility

3.2.1. Beetex

Up to date floor plans are not available at Allwear. Thus the layout of each factory was physically measured with a tape measure and drawn up using Visio. The Beetex plant layout can be seen in Figure 11. Diagrams with flow of material and dimensions can be seen in **Appendix B**. When considering the flow diagrams, Beetex evidently has a process layout. In a process layout similar activities are grouped together according to the process or function that they perform. Optimal solutions are difficult to achieve and most process layouts are designed through intuition, common sense and systematic trial and error. In process layout, similar manufacturing processes (in this case knitting, cutting, assembly, etc.) are located together to improve utilisation. Each department has workers that are skilled at operating the specific equipment. It is important to note that tracksuits and knitting are two separate operations and are not dependant on each other.

A process layout has the advantage of flexibility. The layout type is advantageous for the purpose of this project. Since none of the machines used are built into the facility it can be moved from one facility to another with relative ease. Although within Beetex itself electricity points are located on the floor and this prevents operations to be moved around in a more suitable fashion. Areas depicted as one department can be separated by operations. A process layout also makes it easier to supervise equipment and operations. Jersey Finishing consists of the operations depicted by Figure 10. The shape and size of the department can thus be altered to suit the needs of a new facility.

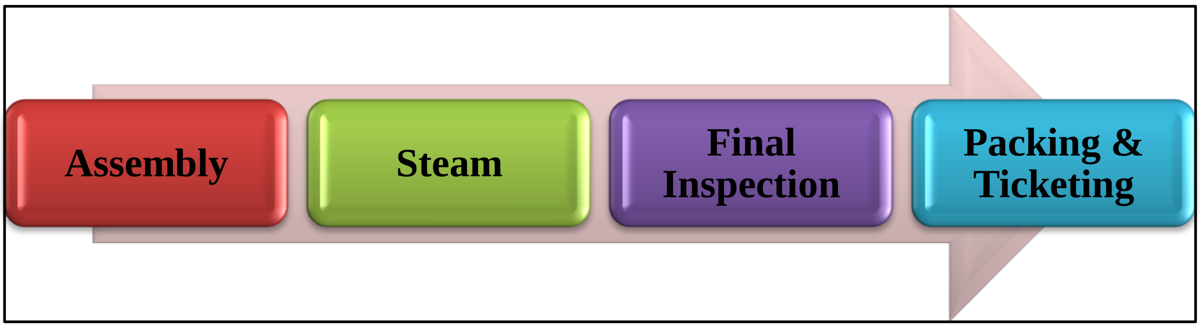

Figure 10: Work Flow of Operations in Jersey Finishing

A disadvantage of the process layout is inefficiency. The inefficiency is a result of jobs that do not flow in an orderly fashion, this causes backtracking and high work-in-progress. In such a layout “idle time” might be experienced by workers when waiting for work to arrive from different departments or bottlenecks form between operations. Figure 30 in **Appendix B** illustrates the material flow for knitting within Beetex. Material storage space must be large to accommodate the vast amount of in-process inventory, this occurs because material moves from work centre to work centre waiting to be further processed.

Boxes of raw material in for knitting contain a fixed amount of spools, not all of these spools are used at once. Boxes are very heavy and no specific material handling equipment is used to move it within the storage area. Boxes containing left over spools are taken back to storage in the original size boxes they were received in. As discussed in Section 2.2.1. storage space in Beetex is a problem since boxes are stacked on top of each other and not on shelves, which limits space. The partially full boxes waste a great deal of space in the storage area. Left over raw material should be placed in smaller boxes or added to other partially full boxes. These possibilities are currently being investigated by management for better space utilization within the storage area.

The Storage & Packing area in Beetex is used to store idle knitted panels that have to be cut. Knitted panels heap up before they are taken to cutting tables. Knitting is a twenty four hour a day, seven days a week operation, causing a bottleneck to arise at cutting. If more cutting tables were present and they were closer to the knitting area, the bottleneck would decrease. Tracksuits need more space than knitting to accommodate cutting of fabric.

Inventory of finished goods is low because goods are being made for particular customers. Finished goods are packed according to order and sealed before transported to warehouse. Goods are not sorted in the warehouse like goods from the main factory.

Considering the current Beetex operation, there is definite room for improvement and the relocation to a different facility will provide the opportunity to reorganise operations and equipment to be more effective, partially since electricity points in other facilities are overhead. Since knitwear and tracksuits are two independent operations, they can be moved into separate facilities.

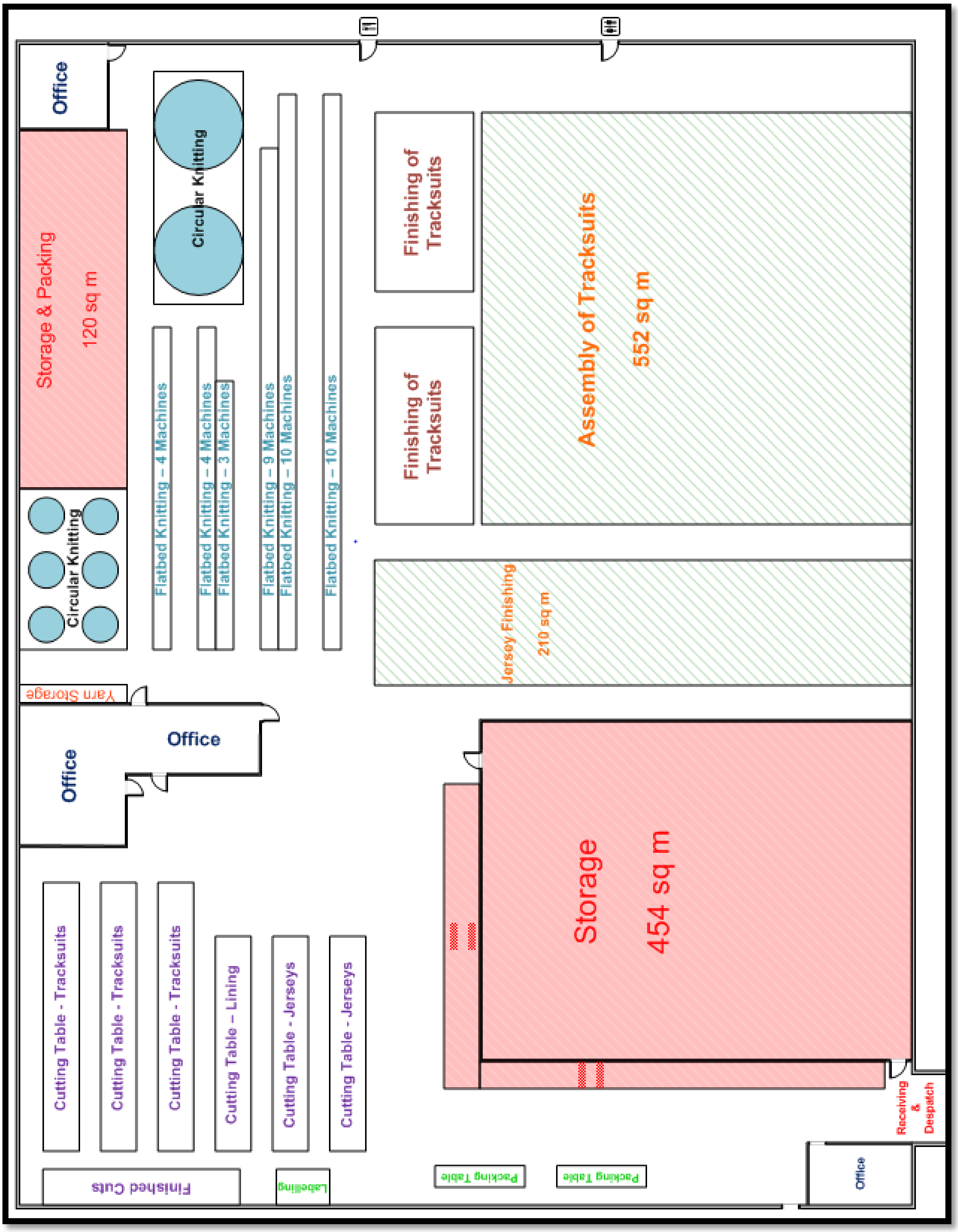

Figure 11: Floor Plan of Beetex Factory

3.2.2. Main Factory

The floor plan of the main factory can be seen in Figure 13. The main operations can be seen in more detail in **Appendix B**. The main factory has a production line product layout which is also known as assembly lines. In a product layout activities are arranged in a line according to the sequence of operations that need to be performed to assemble a particular product. Each product has its own line. This layout is suitable since Allwear does mass production where the operations are repetitive. The product layout in the main factory is more autonomous than the process layout in Beetex. The general flow of the assembly lines can be seen in Figure 12.

Figure 12: Work Flow of Assembly Lines in Main Factory

The advantage of the main factory layout is its efficiency and ease of use. The disadvantage is its inflexibility. Each product has a completely different assembly-line set up. The major concern in a layout such as this is balancing the assembly line to prevent a bottleneck at any one workstation which holds up the flow of work through the line. There is a vast amount of work in progress along the assembly lines.

The production in the main factory has scaled down considerably but the space has not. (Refer to standard capacity compared to used capacity in Section 1.1.2.) This leaves room for added products and flexibility. The assembly line can be condensed by means of lean manufacturing to make space for operations from Beetex. Allwear currently has a consultant applying lean manufacturing techniques on the assembly lines, specifically on the Jackets and Long Pants assembly lines. The Sample Room is becoming obsolete as a new system is being implemented where photos are taken of samples and stored on a database instead of making and keeping each sample. This will leave added room for raw material storage. Each rack in raw material storage holds one set of rolls, which can be accessed from both sides of a rack. Racks can be moved together in pairs in order to maintain more space.

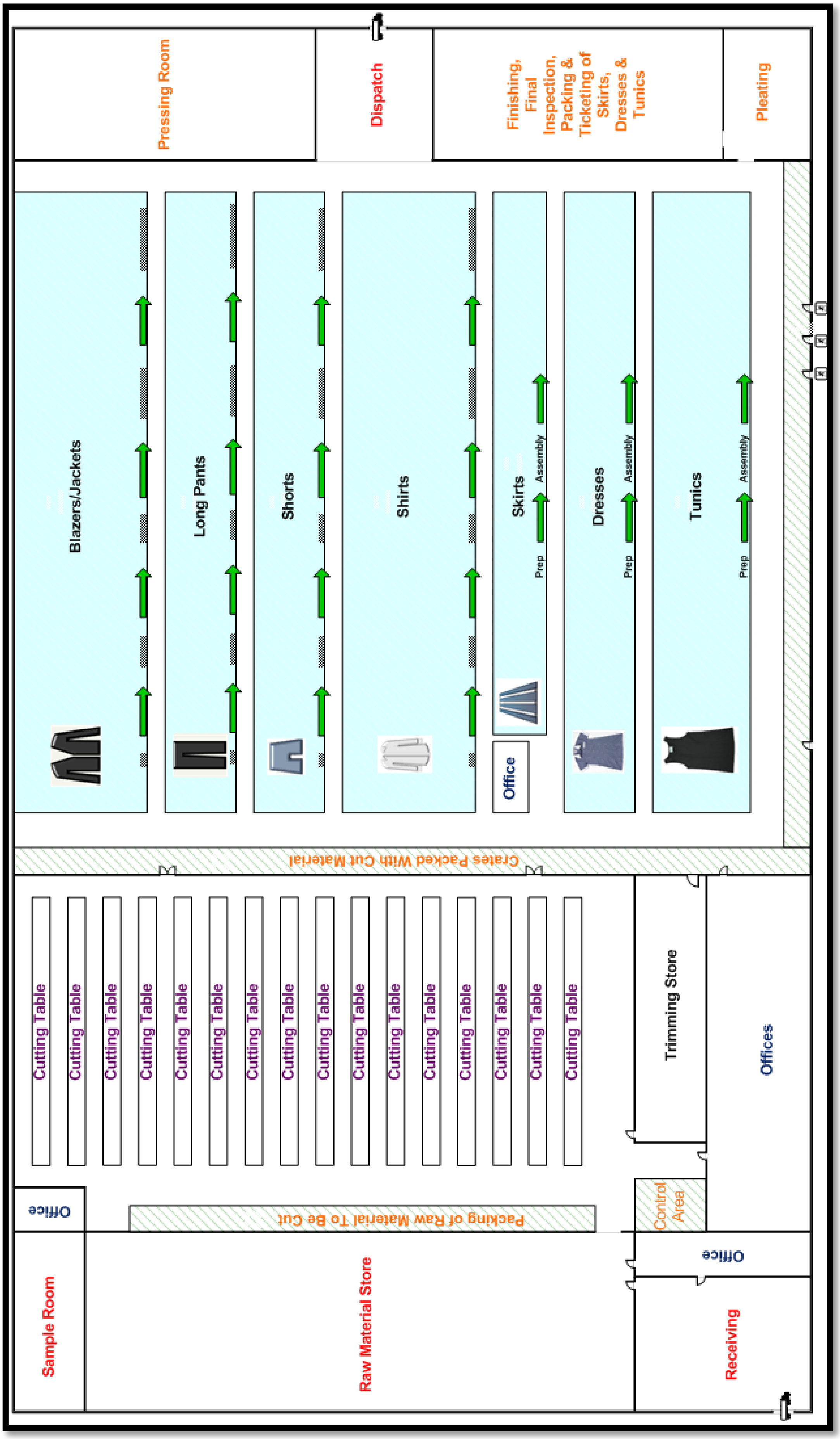

Figure 13: Floor plan of Main Factory

3.2.3. Warehouse

The floor plan of the warehouse can be seen in Figure 15. The warehouse has the following purpose:

- Housing inventory
- Small factory shop for sale of rejects
- Sorting of orders from Main Factory
- Storage of old machinery
- Dispatch of orders
- Storage of new boxes

The core activities of the warehouse are portrayed in Figure 14. From when the goods arrive at receiving to when they are shipped at dispatch.

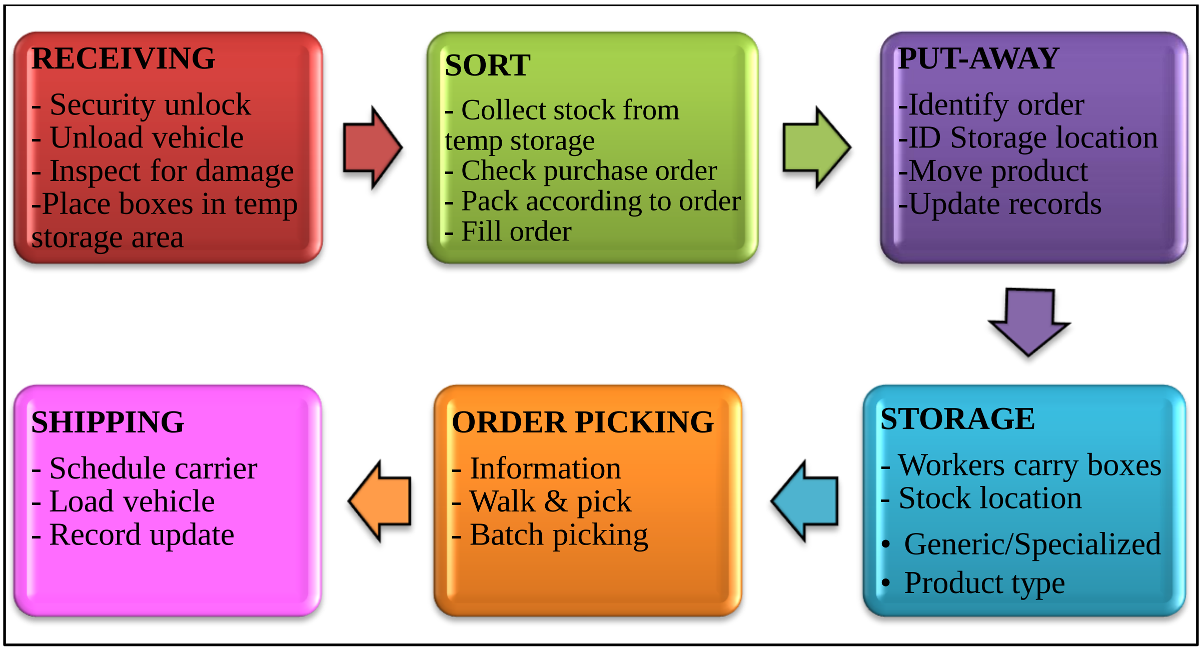

Figure 14: Warehouse Operations

Aspects to consider with regards to the facility:

- Archive takes up space and can be made paperless, but this takes time and is labour intensive.
- The warehouse has a lot of open space available for movement.
- Racks are not built in and can be moved around.

- Racks are only two metres high, while the ceiling is just over three metres high, resulting in unused vertical space. The space can be used but problems arise namely:
  - Higher shelves means workers cannot reach boxes and will need ladders.
  - Woman, who are not as strong, work in warehouse.
  - Safety becomes an issue.
  - There is no material handling equipment readily available.
  - Lights are low and are in the way of higher packaging
- Racks are not equally distanced from each other.
- Racks are not all the same length.
- A cage is present in loading area where old unnecessary stock is kept, it can be tidied and dead stock on racks can be transferred to cage.

A big advantage of the warehouse is that there is a lot of room for movement. Although employees do not want to give up "their" space, the current space is not utilized effectively. After consulting with management it has been agreed upon that the two storage cages and storage space for old machinery can be cleared out to make space for operations from Beetex. The old machinery is archaic and can be sold for scrap metal, and the storage cages contain nothing of substance. In Section 3.3 and 3.4 incoming inventory and the actual amount of space needed will be investigated.

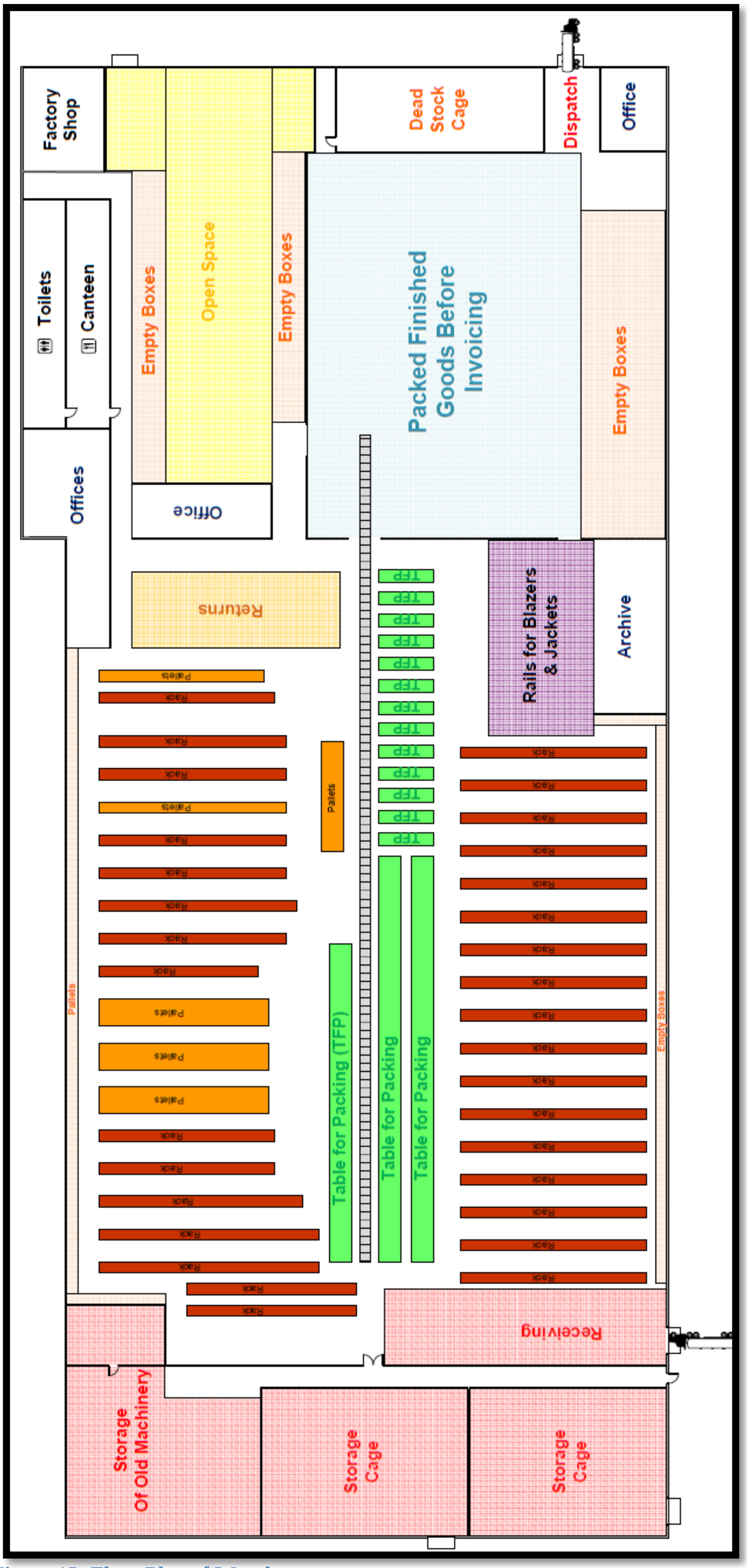

Figure 15: Floor Plan of Warehouse

3.3. Statistical Analysis of Inventory

A statistical ananlysis of inventory was done to determine the amount of finished goods that enter the warehouse per month from Beetex and the main factory. The objective is to determine the amount of space needed to store the finished goods. As discussed in Section 3.2.3 it is evident that there are an excessive amount of racks within the warhouse. This analysis will aid in determining the amount of racks essentially needed. Production levels are measured in units of output. The units of output for 2010 can be seen in Table 3. The output for each factory was anyalysed seperately as seen in Figure 16 and 17. A statistical analysis was done as seen in Table 4.

Inventory of Finished Goods for 2010			
Month	**Main Factory**	**Beetex**	**Total**
January	137060	24369	161429
February	135689	19763	155452
March	143797	18280	162077
April	146293	19555	165848
May	179517	21301	200818
June	154504	19487	173991
July	151133	18768	169901
August	152111	20966	173077
September	151579	23038	174617
October	141427	23123	164550
November	150906	18978	169884
December	156011	23370	179381

Table 3: Inventory of Finished Goods for 2010

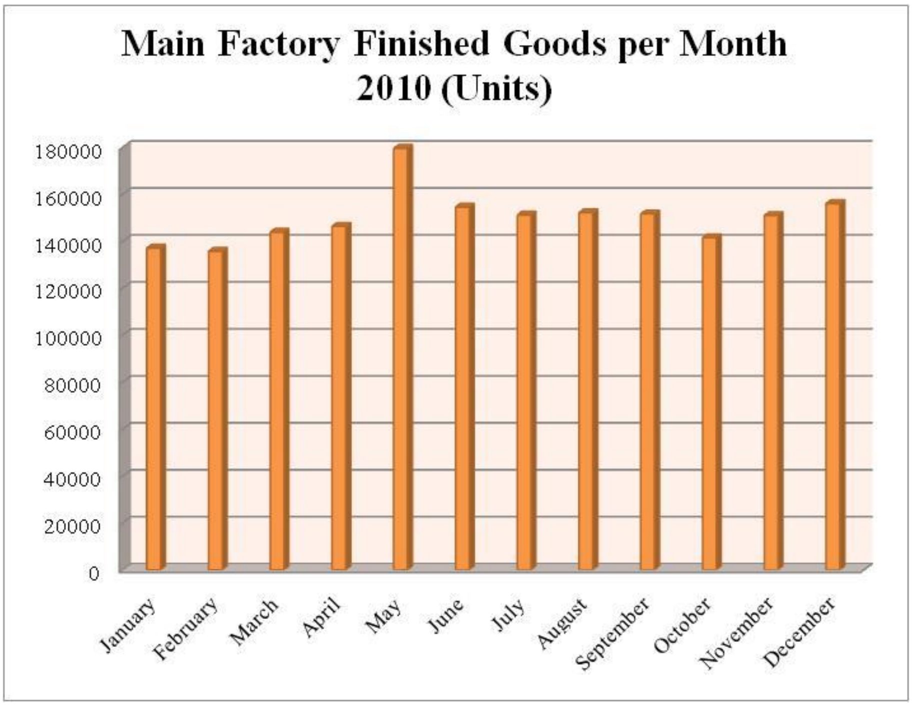

Figure 16: Graph of Main Factory Finished Goods per Month 2010

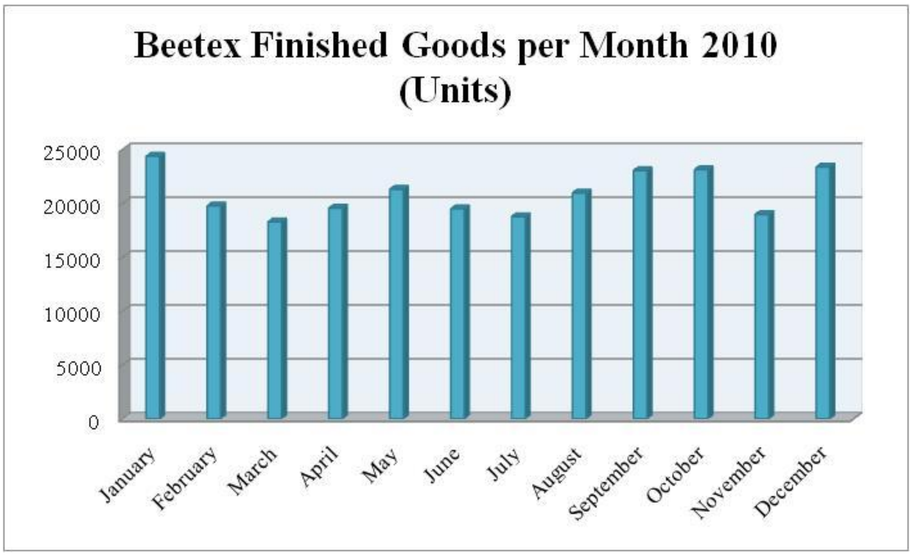

Figure 17: Graph of Beetex Finished Goods per Month 2010

Summary of Statistics			
	Beetex	Main Factoy	Total
Mean	20917	150002	170919
Median	20365	151020	169893
Standard Deviation	2089	11420	11557
Sample Variance	4364709	130426287	133561900
Range	6089	43828	45366
Minimum	18280	135689	155452
Maximum	24369	179517	200818
Sum	250998	1800027	2051025
Count	12	12	12

Table 4: Summary of Statistics of Inventory

School wear is not a steady market, since learners do not buy new school wear as often as they would normal clothing. The market constantly fluctuates and has a seasonal sales pattern. The summary of statistics (Table 4) was done to calculate the average amount (in units) of stock that is transported to the warehouse taking fluctuations throughout the year into account. The maximum total amount of units is used to calculate the space requirements for the warehouse in Section 3.4.

3.4. Warehouse Space Analysis

As seen in Section 3.3 stock is measured in units of output for the respective factories. Allwear does not only manufacture specialized orders but also keeps standard stock on hand as discussed in Section 2.3. The standard items and the amount of each can be seen in **Appendix C**. Certain assumptions have been made to calculate the space available in the current warehouse. The assumptions can be seen in Table 5 below.

Assumptions on Average	
Units per box	20
Boxes per stack	7
Boxes per Meter	3
Boxes per 1m Rack	21
Units per 1m Rack	420
Racks	30
Length per rack (m)	17
Packing sides per rack	2
Total Length for Packing	1020
Total Unit Space	428400

Table 5: Assumptions Regarding Racks in Warehouse

Due to specialized orders, the amount of units per box varies from one unit per box to seventy units per box. After discussions with the logistics manager of Allwear it was decided that an average of twenty units per box is feasible. Boxes are a standard size. Racks also vary in length, but an average of seventeen meters was used.

Maximum Incoming Units	200818
Total Standard Stock	25178
Total Unit Space Needed	225996
Total Meter Space Needed	538

Table 6: Calculation for Needed Space in Warehouse

The total rack space needed in the warehouse as calculated can be seen in Table 6 above. The total maximum length of rack space needed is 538 meters. This is a 48% reduction from the current available 1020 meters. Reducing the excess racks will free space for other operations within the warehouse and will be further discussed in Chapter 4.

Chapter 4: Development of Improved Layout and Alternatives

4.1. Design Criteria

Design criteria are requirements that are specified for the design that will be used to make decisions about how to design the resulting facility. After a discussion with management a certain design criteria was established. The criteria are as follows:

1. Reduce Costs
2. Better utilization of floor space
3. Improved productivity
4. Eradication of duplicate operations
5. Better control over operations

4.2. Division of operations in Beetex

The operations within Beetex consist of knitting and tracksuits. The two operations are independent as discussed in Section 3.2.1. Management maintains that the main factory has the capacity to integrate tracksuit operations from Beetex within existing assembly lines such as Jackets and Long Pants as discussed in Section 3.2.2. The work flow of tracksuits is consistent with the existing assembly lines within the main factory. The integration will ultimately eradicate duplicate operations. The remaining operations for knitting consequently have to be moved to the warehouse. Only knitting operations will therefore be further analysed.

4.3. Activity Relationships

Murther's systematic layout planning procedure uses the activity relationship chart as its foundation. According to Thompkins et al. (2010) measuring the activities among different departments is an essential element in the layout of departments inside a facility. Activity relationships must be established to evaluate alternative arrangements. There are two ways to specify activity relationships, namely in a qualitative or quantitative manner. Qualitative measures may vary from an absolute necessity for certain departments to be close to each other to a desire for certain departments not to be close to each other. Whereas quantitative measures may include distances between departments, pieces moved per hour or moves per day. A facility will most often have a need for both qualitative and quantitative measures of flow. Both measures are used in this instance.

A relationship diagram will be developed from the analysis carried out. Activities will be positioned spatially. The next step involves determining the amount of space each activity will be assigned. After the space has been assigned, space templates are developed for the different departments to acquire the space relationship diagram.

4.3.1. From-to Chart

The flow between departments may be done quantitatively in terms of the distance travelled between departments. The quantitative flow measurement is done by using a from-to chart. A from-to chart is a square matrix but can be symmetric. Distances (in metres) from one knitting operation to the next were measured and since no on-way isles are used within Beetex the chart is a symmetric matrix. The from-to chart was done to perceive whether distances travelled between operations can be minimized when integrated into a different facility. The from-to chart can be seen in Figure 18 below.

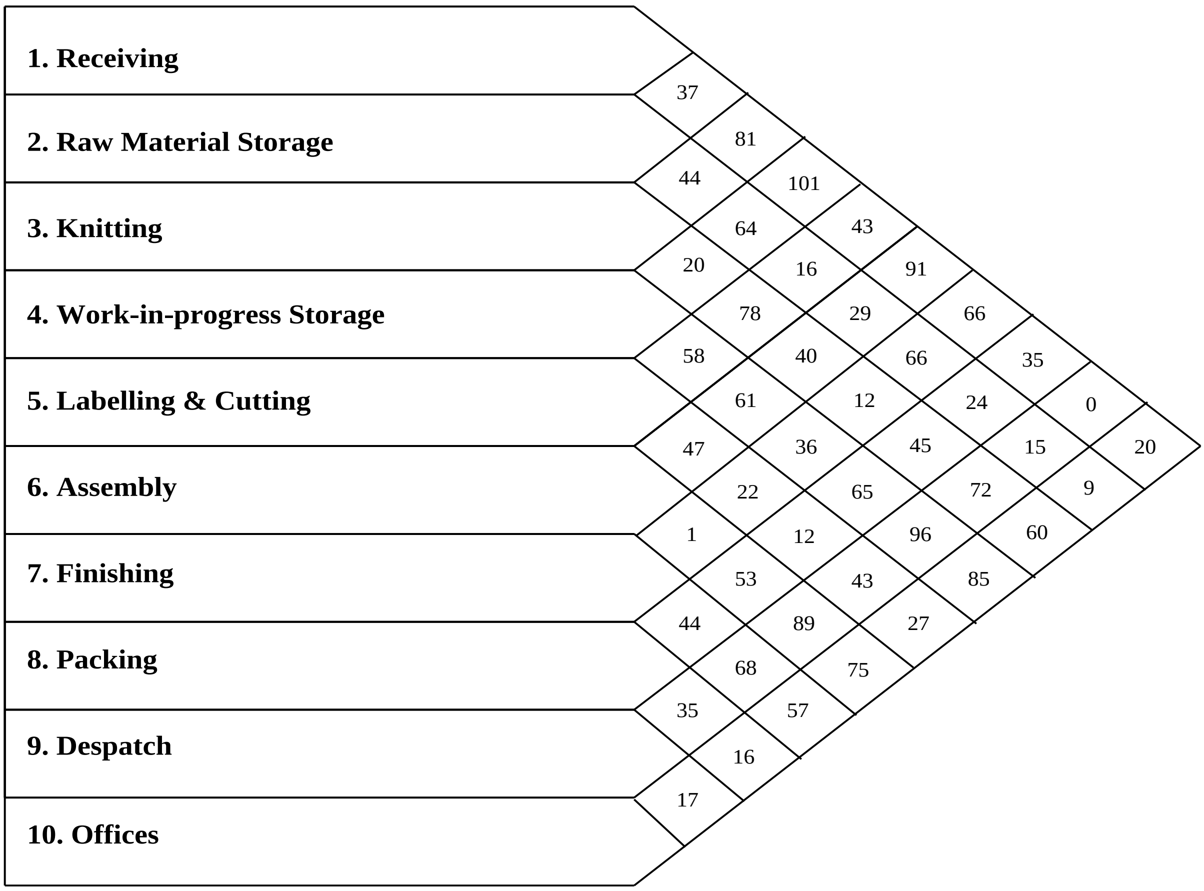

Figure 18: From-to Triangular Distance Chart for Knitting Operations

4.3.2. Activity Relationship Chart

In order to measure flows qualitatively the closeness relationship values (given in Table 8) that were developed by Murther were used. These values were used in combination with the reasons for the closeness value (given in Table 7) in the activity relationship chart.

Value	Closeness
A	Absolutely Necessary
E	Especially Important
I	Important
O	Ordinary Closeness OK
U	Unimportant
X	Undesirable

Table 8: Closeness Relationship Values

Code	Reason
1	Flow of material
2	Ease of supervision
3	Same personnel
4	Contact Necessary
5	Inventory control
6	Same deck

Table 7: Reasons for Closeness Relationship Value

The activity relationship chart is created as follows:

1. List all departments on the relationship chart.
2. Conduct interviews with individuals from different departments as well as managers responsible, listed on relationship chart.
3. Define the criteria for assigning closeness relationships and add the criteria as the motive for the relationship values on the relationship chart.
4. Determine the relationship value and the motive for the value for all connected departments
5. Discuss the development of the chart with all individuals involved and allow an opportunity for evaluation and necessary changes.

The activity relationship chart created is illustrated in Figure 19.

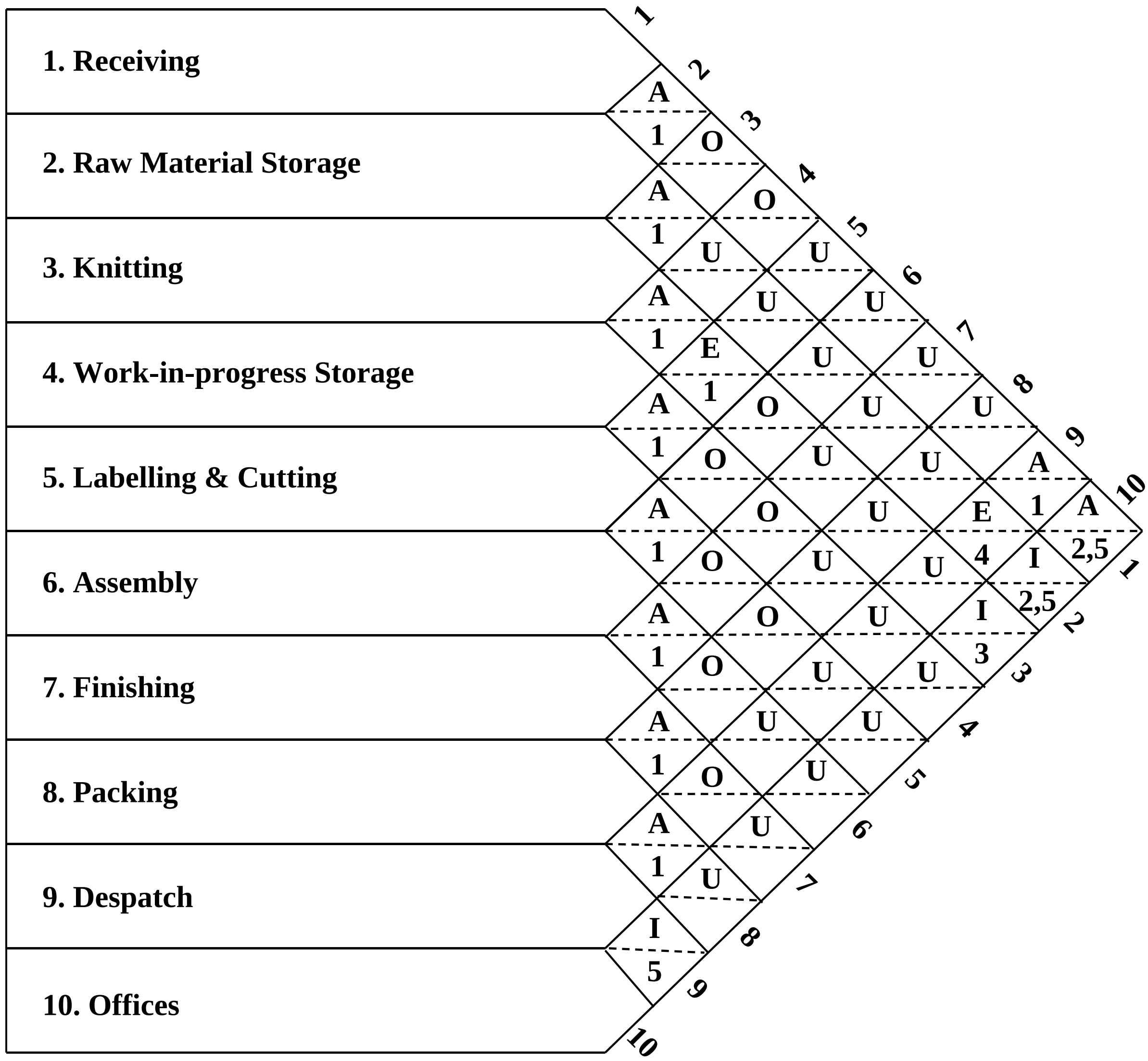

Figure 19: Activity Relationship Chart for Knitting Operations in Beetex

4.3.3. Relationship Diagram

The relationship chart is drawn up using the information gained from the activity relationship chart. The relationship diagram is in effect a block diagram of the different departments that need to be placed in the layout. The relationship diagram can be seen in Figure 20. The departments are shown linked by colour coded lines seen in the legend in Figure 20. The line colour and thickness represents the importance of the relationships between departments. Only the important ratings were considered namely Absolutely Necessary, Especially Important, Important and Ordinary Closeness OK.

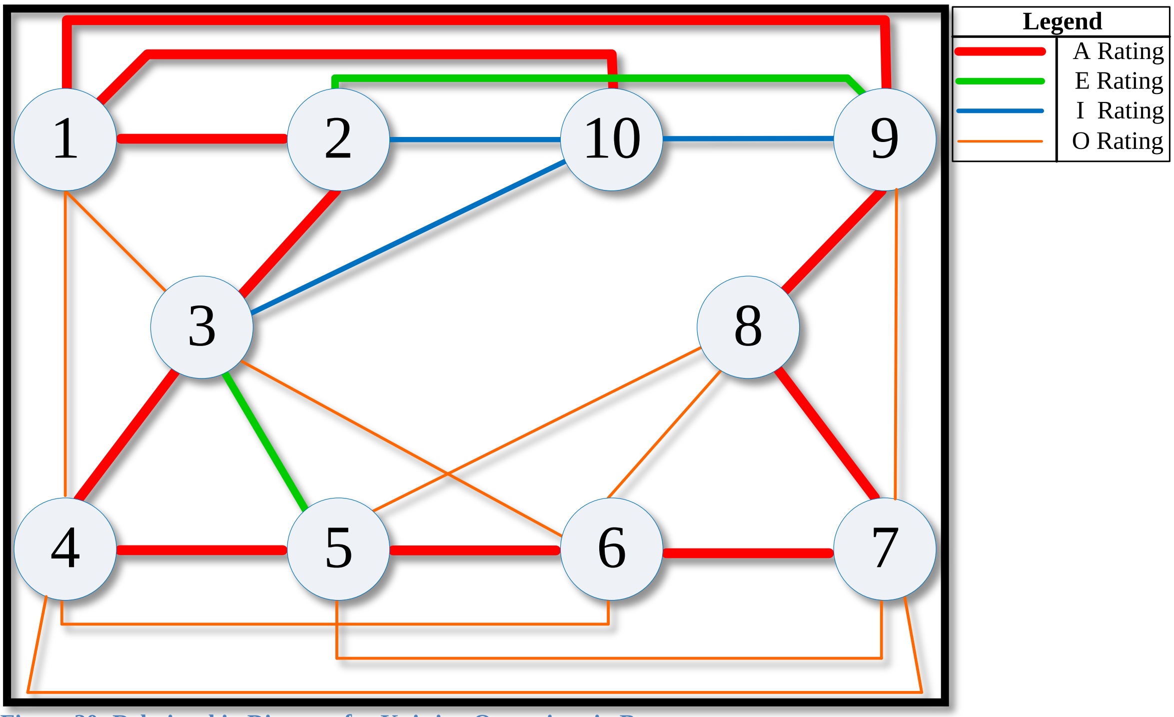

Figure 20: Relationship Diagram for Knitting Operations in Beetex

4.3.4. Space Relationship Diagram

In order to develop a space relationship diagram the relationship diagram needs to be combined with departmental space requirements. The blocks are scaled to display the space needed in the layout. The space relationship diagram can be seen in Figure 21.

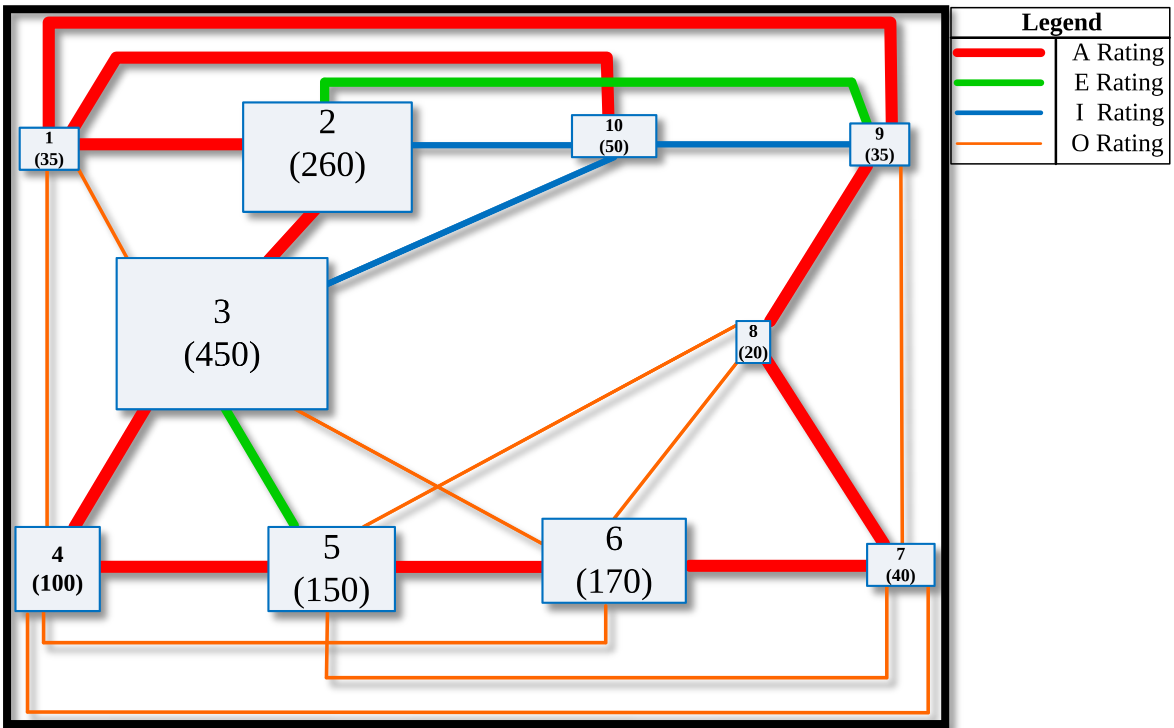

Figure 21: Space Relationship Diagram of Knitting Operations in Beetex

4.4. Available Space in Warehouse

Based on the space analysis of the warehouse in Section 3.4, it is evident that the storage capacity exceeds what is required. There is 1020 metres of racks available, but only 538 metres is required. The pallets in between the racks used for storage were not included when available space was calculated and can thus be removed in conjunction with the excessive racks. Once the additional racks and pallets are removed there is a considerable amount of space available for knitting operations that need to be moved from Beetex. The adjusted layout can be seen in Figure 22. The available space is highlighted with red. The storage cages in the warehouse are presently separated by fences which can be adjusted with relative ease to accommodate a new design.

Another adjustment to the layout was done regarding empty boxes that are currently stored in the area of the packed finished goods. The empty boxes can be moved to the open space neighbouring the rest of the empty boxes stored. The empty space was previously used for government tenders that have since been discontinued. Moving the empty boxes creates more space for the packing of finished goods which in turn creates more space on racks for incoming inventory. It is more convenient and practical to have all empty boxes in one area. Currently empty boxes are brought into the warehouse through dispatch. This means that operations overlap, which is something management wants to avoid. There is an existing door big enough to accommodate the receiving of empty boxes in the area.

A number of the excessive racks that will be removed from the warehouse can be used in the new raw material storage area for the knitting operations. As discussed in Section 2.2.1 boxes of raw material in Beetex are currently stacked on top of one another which limits vertical space utilization. By placing racks in the raw material storage area if it is moved to the warehouse, space utilization will be improved and additional raw material can be stored compared to before.

Some of the excessive racks can also be used in the main factory for the added raw material that will be present if the tracksuit line is moved there. As discussed in Section 3.2.2 the sample room is becoming obsolete leaving room for additional racks and raw material.

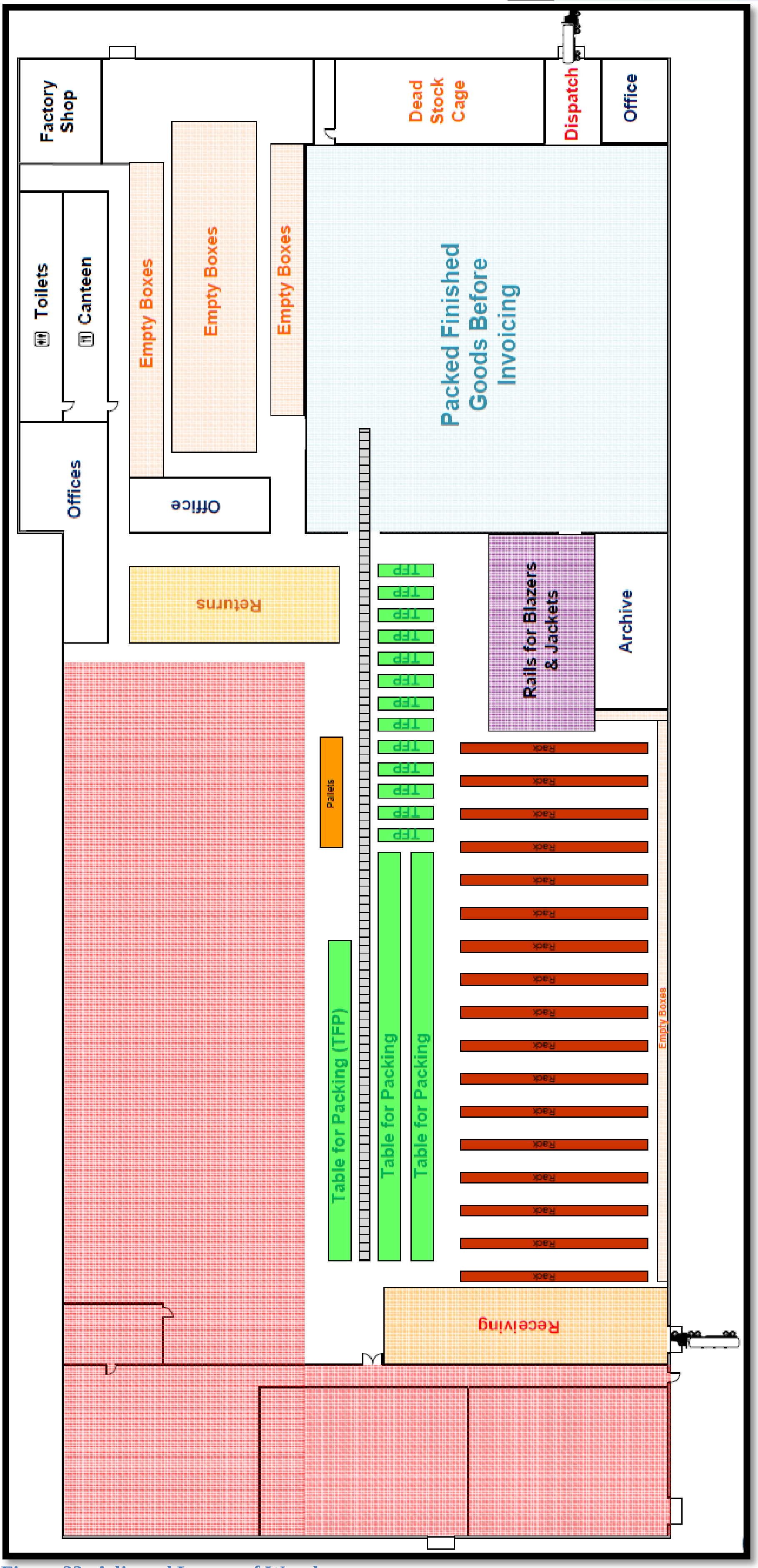

Figure 22: Adjusted Layout of Warehouse

4.5. Alternative Layouts

The area of space available in the warehouse exceeds the requirements for the knitting operations from Beetex. Two alternative layouts were created using information gained thus far. Alternative 1 can be seen in Figure 23 and Alternative 2 can be seen in Figure 24.

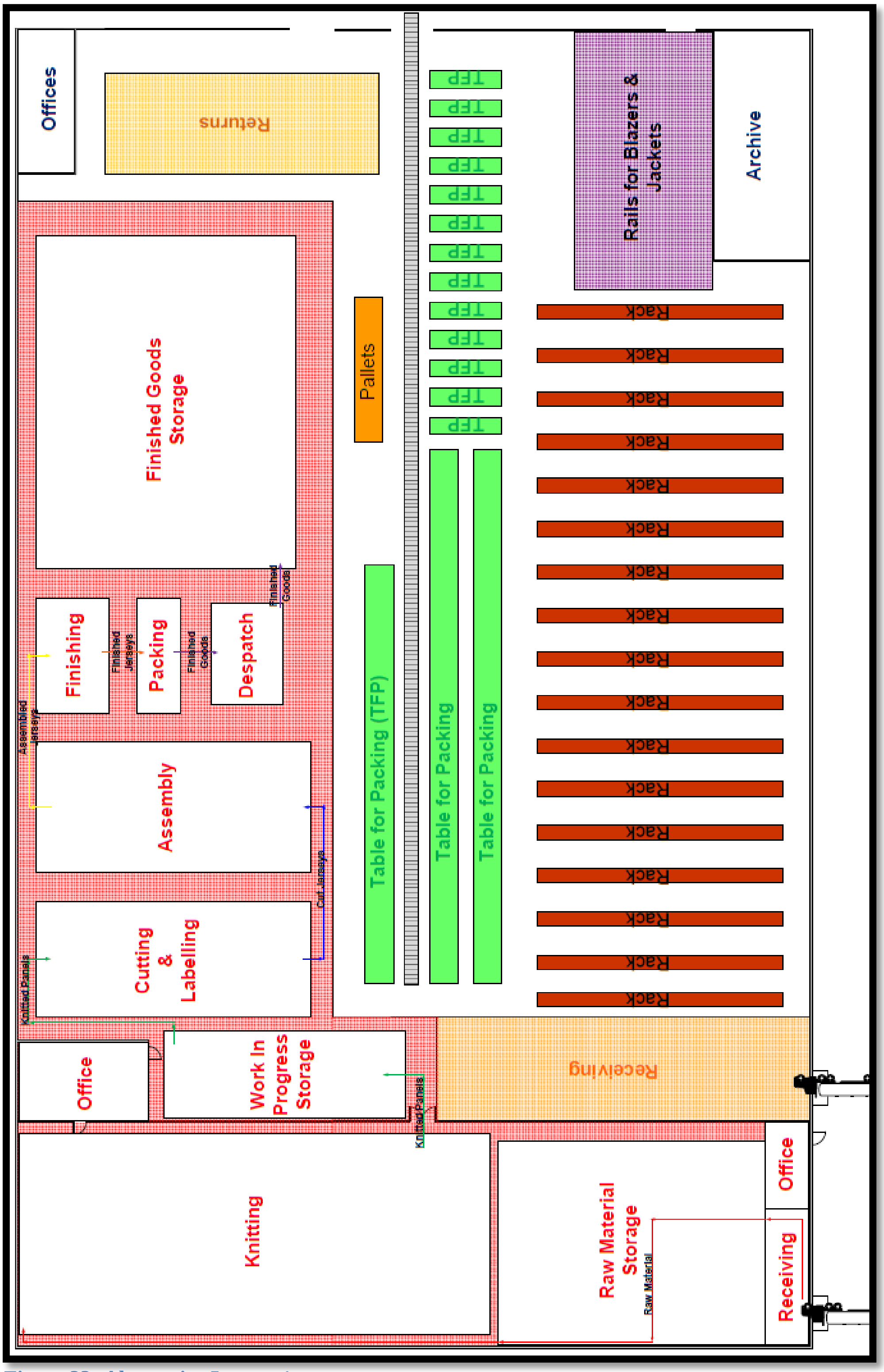

Figure 23: Alternative Layout 1

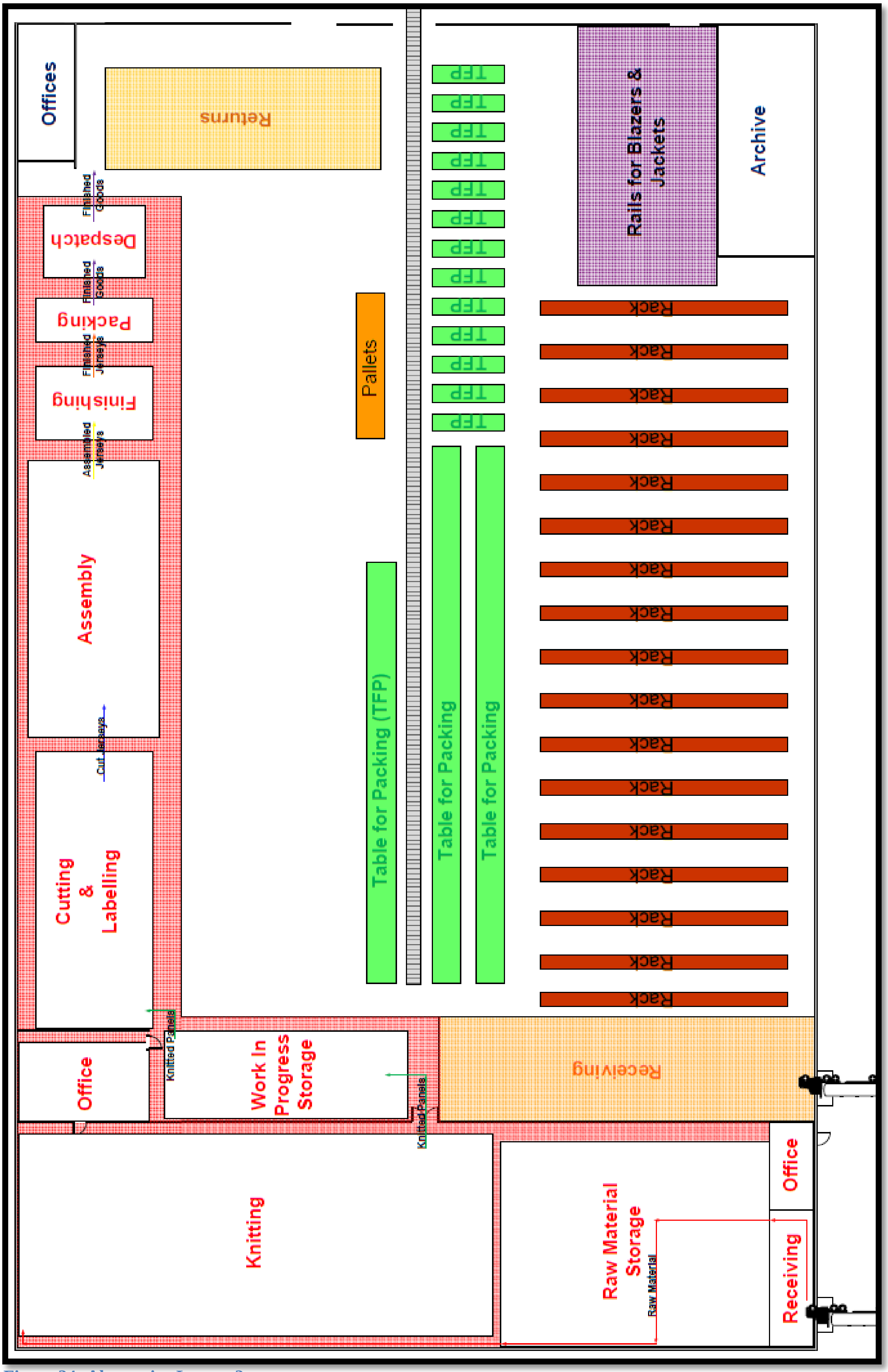

Figure 24: Alternative Layout 2

Chapter 5: Evaluation of Alternatives and Final Design

5.1. Evaluation of Alternatives

In order to evaluate the two alternatives a weighted factor comparison method was used. The method provides an explicit method for integrating the rankings. Numerical values were assigned proportionally to each factor based on its degree of importance. The factors are based on the design criteria established in Section 4.1. A numerical score was assigned to each alternative based on its performance against a particular factor. The scores were multiplied by the weights, and the products were summed over all factors to obtain the total weighted score. The weighted factor comparison can be seen in Figure 25 Below.

		Alternative Layout 1			Alternative Layout 2		
		Performance Measurement			Performance Measurement		
Design Criteria	Weight	Fails to Meet Requirements	Meets Requirements	Exceeds Requirements	Fails to Meet Requirements	Meets Requirements	Exceeds Requirements
Reduce Costs	3	0	5	**10**	0	5	**10**
Better utilization of floor space	3	0	5	**10**	0	**5**	10
Improved productivity	2	0	**5**	10	0	**5**	10
Eradication of duplicate operations	1	**0**	5	10	**0**	5	10
Better control over operations	1	0	**5**	10	0	**5**	10

Figure 25: Weighted Factor Comparison of Alternatives

The reasons for the score awarded to each alternative are as follows:

Reduce Costs - Both alternatives reduce costs considerably. Money will not only be saved in terms of rent for Beetex, but logistics costs will be significantly lower if operations are moved to the warehouse.

Better utilization of floor space - Alternative 1 utilizes the floor space better, since the available space is used to improve flow by placing finished goods storage specifically for knitting operations in line with the work flow.

Improved productivity - Both alternatives follow line flow patterns compared to the tree flow pattern presently followed in Beetex. The line flow pattern is most effective for assembly line type production. Alternative 1 has a W-flow, while Alternative 2 has a combination of I & W Flow.

Eradication of duplicate operations - Duplicate operations still exist such as packing and dispatch which is already present within the warehouse. Combining the operations would mean an overlap between departments which is something management wants to avoid.

Better control over operations - For both Alternatives operations will be fenced off. Better control exists since only knitting operations will be done in this area instead of knitting and tracksuit operations similar to the current Beetex facility.

The result of the weighted factor comparison indicates that alternative 1 is the best alternative with a score of 75 out of a 100 compared to alternative 2 scoring 60 out of a 100.

5.2. Final Design

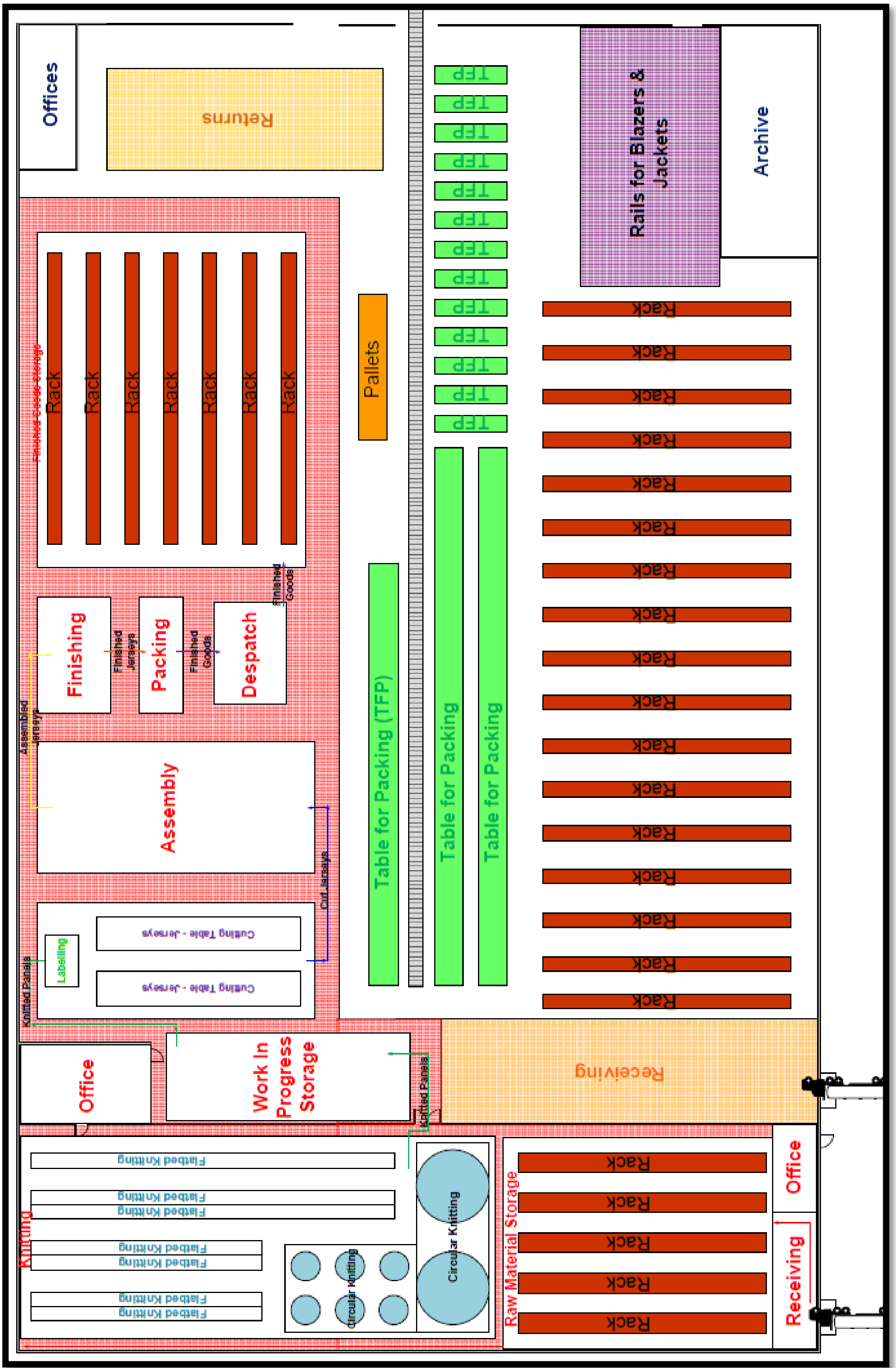

Figure 26: Final Design of Warehouse

The final design can be seen in detail in Figure 26. The area containing the knitting operations will be fenced off from the rest of the warehouse operations for security reasons. There will be a single door for the removal of finished goods for despatch at the end of finished goods storage. The flow of the new layout is more efficient than it was in Beetex. Consecutive operations are placed next to each other for continuous flow. The use of racks in the raw material storage ensures better space utilization since boxes of raw material can be packed in the in the racks instead of stacked on top of one another on pallets. Raw material will also be more organised when packed in racks. The racks that will be used in this design are the racks that would be removed from the warehouse thus putting them to good use.

Fences will need to be erected within the warehouse. In order to relocate moving trucks would need to be rented. All the machinery used in the knitting operations are mobile and can be moved using trucks. The relocation would interrupt production for approximately two days.

Chapter 6: Recommendations and Conclusions

Operations within Beetex can be split and integrated into the main factory and the warehouse. It is recommended that the tracksuit operations are incorporated into the main factory. Alternative layouts were developed for knitting operations in the warehouse. A weighted factor comparison (seen in Figure 25) was done to evaluate the two alternatives. Alternative one scored the highest and was used for the final design illustrated by Figure 26. The final design is recommended as a comprehensive operational improvement plan that adheres to the design criteria specified by management. By relocating the operations an immediate saving of R47 000 per month will be made on rent, water and electricity.

The benefits of relocation are as follows:

- ✓ On-site transportation will be improved since finished goods won't have to be transported from Beetex to the warehouse.
- ✓ Space in the warehouse will be effectively utilized.
- ✓ The flow of production for knitting operations will be improved.
- ✓ Inventory management will be enhanced within warehouse.
- ✓ The supply chain will be more profitable.
- ✓ Money will be saved on rent expense for Beetex.
- ✓ Duplicate operations will be eliminated.

In conclusion, the investigation proved that it is feasible to integrate the operations currently residing in the leased factory Beetex into the main factory and the warehouse both of which are owned by Allwear. The solution will be used as a contingency plan to ensure the future viability of Allwear in the face of growing competition from local competitors and imports.

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Appendices

Appendix A:

Lean Operations Generic Project Model

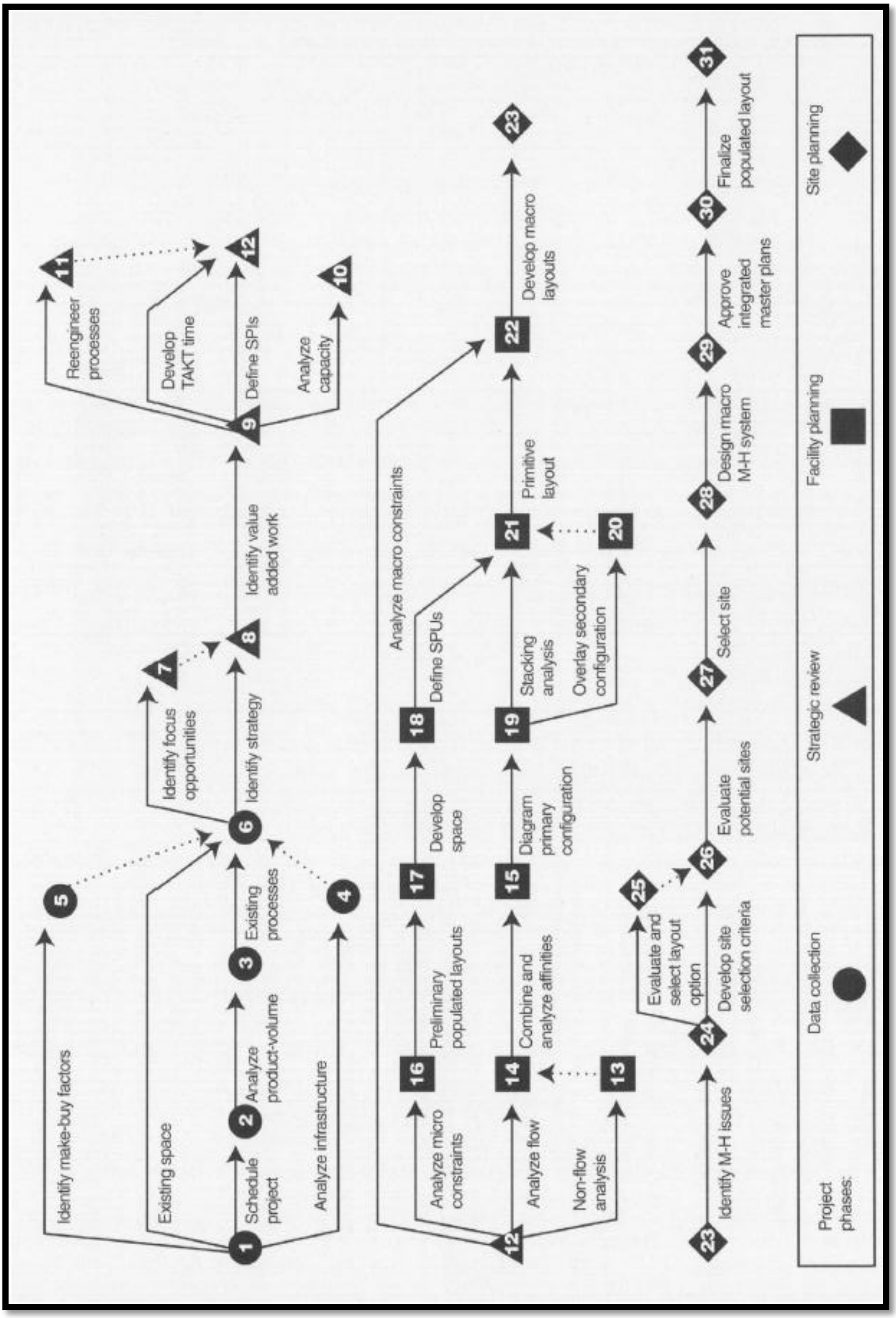

Figure 27: Lean Operations Generic Project Model

Appendix B:

Factory Layouts

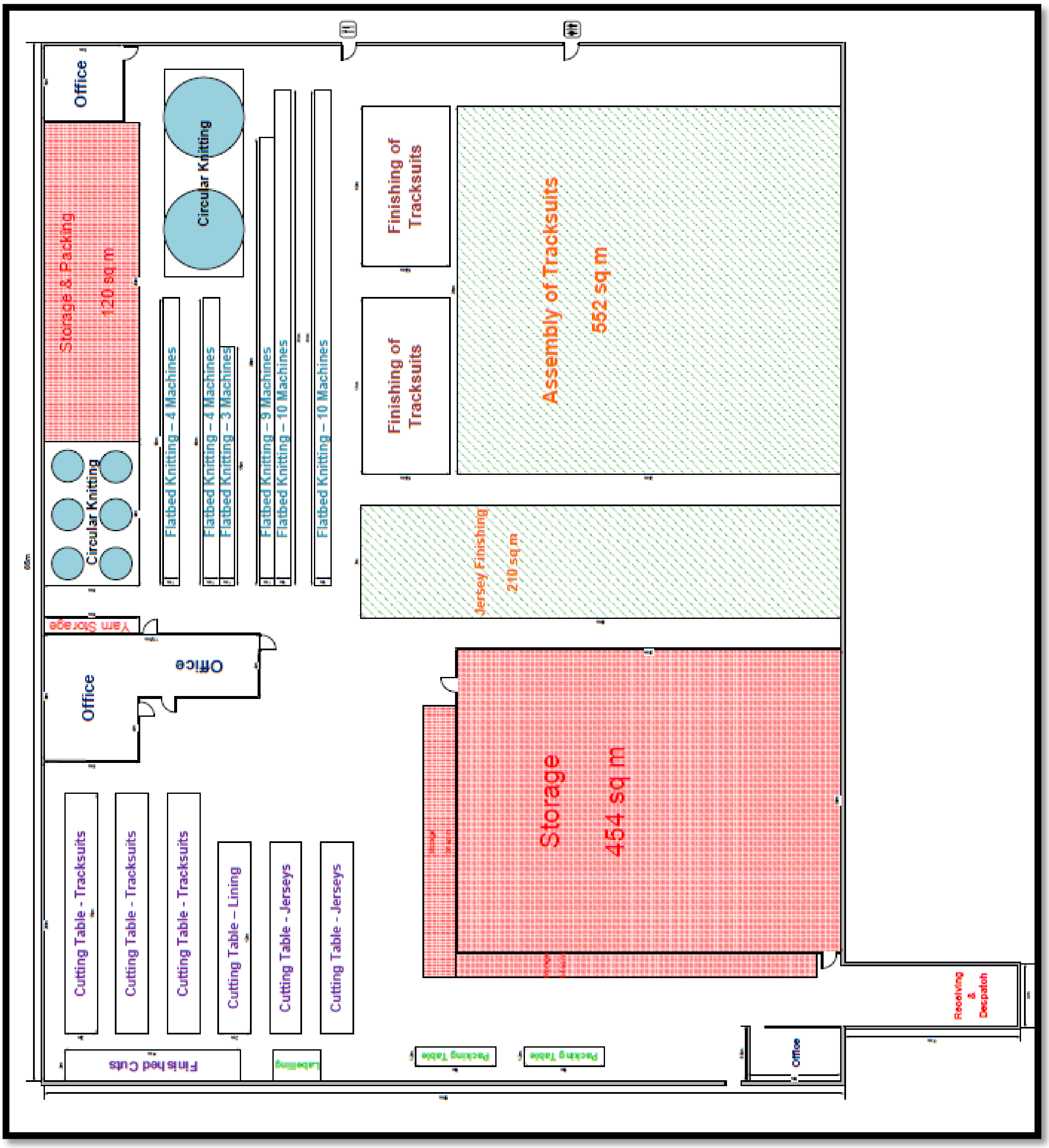

Figure 28: Floor Plan of Beetex with Dimensions

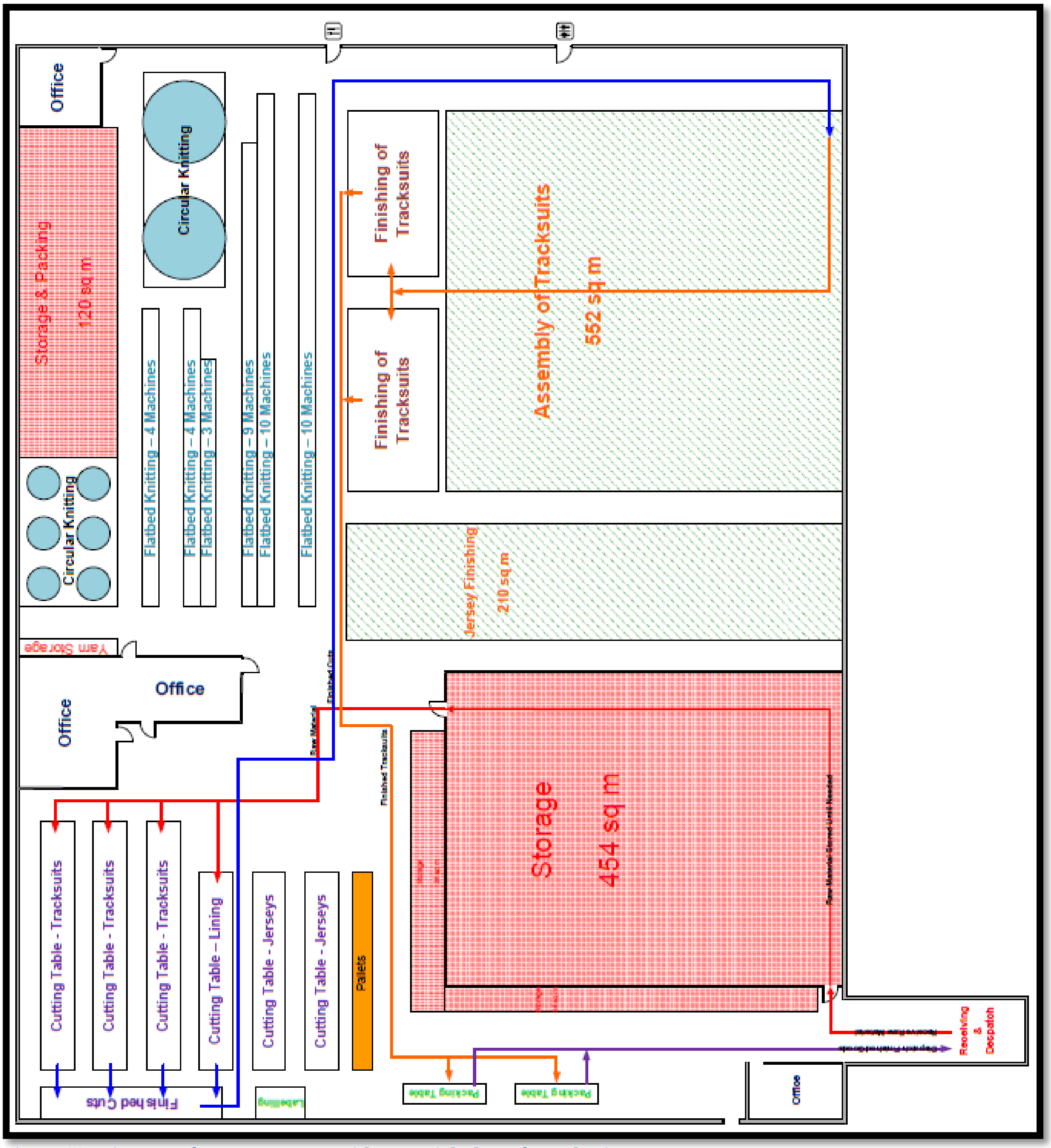

Figure 29: Diagram of Beetex Factory with Material Flow of Tracksuits

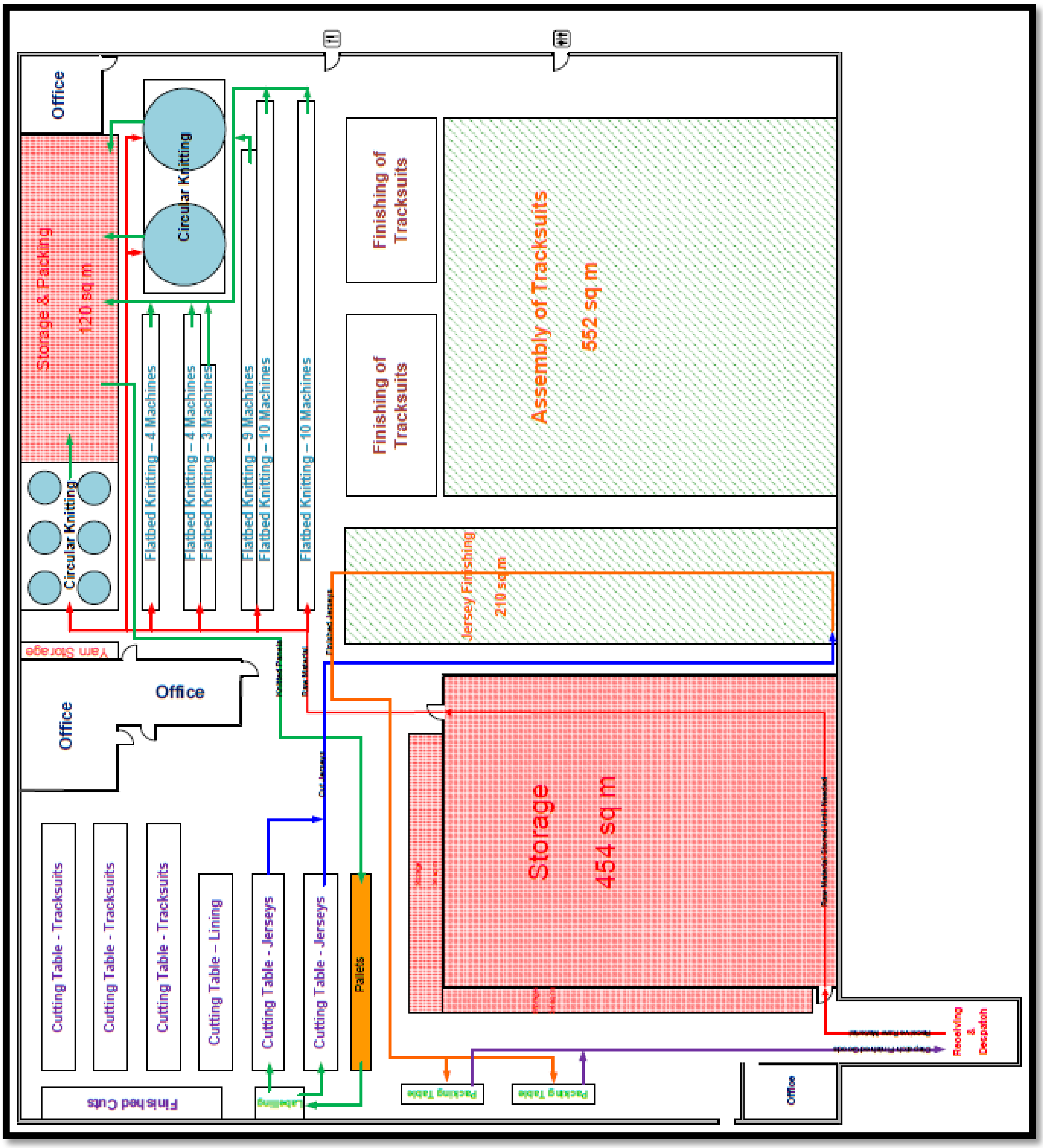

Figure 30: Diagram of Beetex Factory with Material Flow of Knitting

Figure 31: Main Factory- Main operations

Appendix C:

Standard Stock

Blazer Standard Stock	Standard Units Put in Stock 2010	
	Style 1	**Style 2**
Maroon	1150	771
Navy	1995	935
Black	3343	1085
Bottle	2819	1445
Dk Navy	2226	1463
Royal	2201	1840
Brown	1032	82
Total	**14766**	**7621**
Total Per Month	**1866**	

L/S Shirts Standard Stock Style:	Standard Units Put in Stock 2010
1	10566
2	2499
3	5869
4	17744
5	7237
6	2767
7	4856
8	489
Total	**52027**
Total Per Month	**4336**

S/S Shirts Standard Stock Style:	Standard Units Put in Stock 2010
1	5274
2	3105
3	2463
4	6399
5	20333
6	10514
7	7419
8	5191
9	2310
10	8536
Total	**71544**
Total Per Month	**5962**

Tunics Standard Stock Style:	Standard Units Put in Stock 2010
Black 1	3029
Black 2	13049
Total	**16078**
Total Per Month	**1340**

Girls Hipster Slacks Standard Stock	Standard Units Put in Stock 2010
1	4822
2	9804
3	12129
4	4329
Total	**31084**
Total Per Month	**2590**

Shorts Standard Stock	Standard Units Put in Stock 2010
Grey	22623
Khaki	16261
Maroon	1666
Bottle	2826
White	7149
Black	4199
Navy	5619
Total	**60343**
Total Per Month	**5029**

Longs Standard Stock	Standard Units Put in Stock 2010
Grey1	11530
Grey2	18127
Grey3	6075
Grey4	7443
Total	**43175**
Total Per Month	**3598**

Total Standard Stock Per Year	302135
Total Standard Stock Per Month	25178

Appendix D:

Rent and Water & Electricity Expenses for Beetex

Account Number/ Prd.	Source	Date	Description/ Reference	Posting Seq.	Batch-Entry	Debits
3545-62			WATER EN ELEKTRISITEIT			
01	CB-40	2011/01/31	WATER & LIGTE - BEETEX	2	2-1	20 849.39
			2449 15- 876			
01	GL-AJ	2011/01/31	REVERSAL DEC2010 PROVISIONS	2	2-1	
			J0493 8- 1			
01	GL-AJ	2011/01/31	PROVISIONS JAN2011	2	2-1	20 849.40
			J0500 22- 1			
01	GL-AJ	2011/01/31	REVERSAL DOUBLE ENTRIES DEC201	2	2-1	
			J0493 32- 1			
			Net Change and Ending Balance for Fiscal Period 01:			
02	CB-40	2011/02/28	WATER & LIGTE - BEETEX	3	3-1	30 091.14
			2546 59- 578			
02	GL-AJ	2011/02/28	REVERSAL JANUARY PROVISIONS	3	3-1	
			J0508 54- 1			
02	GL-AJ	2011/02/28	PROVISIONS FOR FEBRUARY 2011	3	3-1	30 091.14
			J0511 63- 1			
			Net Change and Ending Balance for Fiscal Period 02:			
03	CB-40	2011/03/31	W&L BEETEX	196	197-41	26 690.54
			2684			
03	GL-AJ	2011/03/31	REVERSAL FEB PROVISIONS	203	204-1	
			J0521			
03	GL-AJ	2011/04/04	PROVISIONS MARCH 2011	205	206-1	26 690.54
			J0522			
			Net Change and Ending Balance for Fiscal Period 03:			
04	CB-40	2011/04/30	W&L BEETEX	383	398-4	27 199.85
			2763			
04	GL-AJ	2011/04/30	REVERSAL MAR2011 PROVISIONS	376	390-1	
			J0534			
04	GL-AJ	2011/04/30	PROVISIONS APRIL 2011	415	429-1	27 199.85
			J0537			
			Net Change and Ending Balance for Fiscal Period 04:			
05	CB-40	2011/05/31	WATER&LIGTE BEETEX	600	614-17	23 718.84
			2848			
05	GL-AJ	2011/05/31	REVERSAL APRIL PROVISIONS	618	632-1	
			J0547			
05	GL-AJ	2011/05/31	REVERSAL APRIL PROVISIONS	618	632-1	
			J0547			
05	GL-AJ	2011/05/31	PROVISIONS FOR MAY 2011	625	639-1	23 718.84
			J0549			
05	GL-AJ	2011/05/31	REVERSAL DOUBLE ENTRY	639	653-1	27 199.85
			J0547			
05	GL-AJ	2011/05/31	PROVISION PER C KIRTOM	698	714-1	11 000.00
			J0555			
			Net Change and Ending Balance for Fiscal Period 05:			
			Totals: WATER EN ELEKTRISITEIT			295 299.38
			Report Totals:			295 299.38

Table 9: Water and Electricity Account for Jan-Jun 2011

Account Number/ Prd.	Source	Date	Description/ Reference	Posting Seq.	Batch-Entry	Debits
3130-62			HUUR BETAAL GEBOUE			
01	CB-40	2011/01/26	EAGLE CREEK - HUUR BEETEX	2	2-1	3 000.00
			2431 15- 547			
01	CB-40	2011/01/26	EAGLE CREEK - HUUR BEETEX	2	2-1	22 000.00
			2431 15- 547			
			Net Change and Ending Balance for Fiscal Period 01:			
02	CB-40	2011/02/28	EAGLE CREEK - HUUR BEETEX	3	3-1	22 000.00
			2533 59- 469			
			Net Change and Ending Balance for Fiscal Period 02:			
03	CB-40	2011/03/28	HUUR BEETEX	99	100-31	22 000.00
			2631			
			Net Change and Ending Balance for Fiscal Period 03:			
04	CB-40	2011/04/28	HUUR BEETEX	332	346-37	22 000.00
			2755			
			Net Change and Ending Balance for Fiscal Period 04:			
05	CB-40	2011/05/30	HUUR BEETEX	555	569-33	22 000.00
			2835			
			Net Change and Ending Balance for Fiscal Period 05:			
06	CB-40	2011/06/24	HUUR BEETEX	797	802-91	22 000.00
			2926			
			Net Change and Ending Balance for Fiscal Period 06:			
			Totals: HUUR BETAAL GEBOUE			135 000.00
			Report Totals:			135 000.00

Table 10: Rent Account for Beetex