

**Productivity and Improvement of Operations at Simitri  
Speciality Chemicals**

by

**KATIE MCCREADIE**

**24057542**

Submitted in the partial fulfilment of the requirements for  
the degree of

**BACHOLERS OF INDUSTRIAL ENGINEERING**

in the

**FACULTY OF ENGINEERING, BUILT ENVIRONMENT  
AND INFORMATION TECHNOLOGY  
UNIVERSITY OF PRETORIA**



University of Pretoria

**October 2009**

## **Executive Summary**

Simitri Specialty Chemicals (Pty) Ltd was established as a dedicated supplier of specialty chemicals for leather industry. Simitri's manufacturing plant, Chloorkop, is situated in Kempton Park, Gauteng and has 33 people currently employed within the company. They have experienced problems with the productivity in their plant, as well as quality control in the laboratories and the warehouse.

This project was aimed at increasing Simitri's current levels of productivity and improvement of operations by making use of industrial engineering methods as well as productivity measures and techniques with minimum to no costs incurred. These have been applied in all areas of the manufacturing process such as the laboratory, the plant (or factory floor) as well as the warehouse

This document describes the situation at Simitri Speciality Chemicals before making use of the techniques of systematic layout planning, facility layout for the warehouse and statistical quality control in the laboratory. All these techniques have been directed at improving the operations in the factory in order to decrease production time and increase the level of quality and as a result customers will receive their high quality products within a more acceptable time limit thus increasing customer satisfaction.

The future state of Simitri Speciality Chemicals has a more efficient flow of materials on the plant and within the warehouse and has a more productive quality control laboratory in place. This has resulted in an increase in the production levels on the plant, due to a more efficient flow of operations on the plant as well as in the laboratory, more control in the. The improvements of quality control in the laboratory has also led to management having more of an understanding of what is happening on the plant and what quality of materials they are purchasing for use in operations as well as the quality of the products that are being sold to customers. Management and the quality control team with the input from the workers on the factory floor are now able to identify unacceptable quality materials and products and why they are unacceptable and where improvements can be made.

This document provides a description of the current state of Simitri's plant, warehouse and laboratory, the solutions implemented in these areas and finally an explanation of Simitri's future state.

# Table of Contents

<b>1 Introduction and Problem Background</b>	<b>1</b>
1.1 Background.....	1
1.2 Problem Statement .....	2
1.3 Project Aim.....	2
1.4 Project Scope.....	2
1.5 Deliverables .....	3
<b>2 Literature Study</b>	<b>5</b>
2.1 Facility Layout .....	7
2.2 Warehouse operations .....	12
2.3 Quality Management System .....	17
<b>3 Proposed Investigation Methods</b>	<b>21</b>
3.1 Facility Layout .....	21
3.2 Warehouse Operations .....	22
3.3 Quality Management System .....	24
<b>4 Conclusion of Literature Study</b>	<b>26</b>
<b>5 Data and Information Gathering</b>	<b>27</b>
5.1 Warehouse Operations .....	27
5.1.1 Current Layout.....	28
5.1.2 Available Space.....	28
5.1.3 Receiving and Shipping operations .....	30
5.1.4 Order Picking Operations .....	30
5.1.5 Material Handling Equipment.....	31

5.2 Facility Layout .....	32
5.2.1 Current Plant Layout.....	33
5.2.2 Plant Process Operations and Activities .....	34
5.2.3 Space Requirements .....	36
5.3 Quality Management System .....	37
5.3.1 Current Quality Control Procedure.....	38
5.3.2 Current Structure of the Control Charts .....	39
5.3.3 Analysis and Use of the Control Charts .....	41
<b>6 Solution Design and Evaluation</b>	<b>43</b>
6.1 Warehouse Operations .....	43
6.2 Facility Layout .....	51
6.3 Quality Management system .....	59
<b>7 Conclusion</b>	<b>76</b>
<b>8 References</b>	<b>78</b>

## List of Tables

Table 2-1: SLP Relationship Ratings .....	10
Table 5-1: Forklift specifications .....	31
Table 5-2: Space Requirements for Plant Areas.....	37
Table 6-1: Recommended aisle widths for various types of flow.....	44
Table 6-2: Results of the weighted factor comparison .....	50
Table 6-3: Space Requirements for Plant Areas.....	54
Table 6-4: Weighted factor comparison between alternative layouts .....	58
Table 6-5: Weighted Factor comparison Table for Evaluating the Alternative Layouts.....	58
Table 6-6: Table showing weekly non-conforming product .....	62
Table 6-7: Table showing percentage content of 20 consecutive batches .....	66
Table 6-8: Table showing $R_{\min}$ and $R_{\max}$ values .....	68
Table 6-9: Table showing the x calculations .....	71

## List of Figures

Figure 1-1: Interim phase in the tanning process, “wet blue”, that Simitri provides chemicals for.	1
Figure 2-1: Ishiwata Process Improvement Steps.....	6
Figure 2-2: Example of a Relationship Chart .....	10
Figure 2-3: Activity relationship diagram .....	11
Figure 2-4: Scheme to classify warehouse design and operation planning problems .....	13
Figure 2-5: Utilisation of a warehouse’s cubic capacity.....	15
Figure 2-6: General objectives of materials handling.....	17
Figure 2-7: Generic production process.....	18
Figure 3-1: Chien's modified SLP Procedure.....	22
Figure 3-2: Warehouse space requirements.....	24
Figure 3-3: Cycle of continuous improvement.....	25
Figure 5-1: Typical warehouse functions and flows: .....	27
Figure 5-2: Current warehouse layout .....	28
Figure 5-3: Pallet racks used at Simitri warehouse. a.) 3mX2.5mX1m. b.) 3mX4mX1m. ....	29
Figure 5-4: Forklift .....	29
Figure 5-5: Simitri warehouse layout showing shipping/receiving area .....	30
Figure 5-6: Order picking colour chart .....	31
Figure 5-7: Stock that has been colour coded .....	31
Figure 5-8: Modified SLP procedure to be used .....	33
Figure 5-9: Current plant layout at Simitri Speciality Chemicals.....	34
Figure 5-10: Flow process chart for generic production process.....	35
Figure 5-11: Flow of operations on the plant.....	36
Figure 5-12: Current Quality Control Procedure .....	39
Figure 5-13: Raw Materials Control Chart .....	40
Figure 5-14: Final Product Control Chart .....	41
Figure 6-1: Obstructed doors.....	45
Figure 6-2: Possible shipping and receiving arrangements.....	45
Figure 6-3: Proposed picking slip .....	47
Figure 6-4: Alternative warehouse design A .....	48
Figure 6-5: Alternative warehouse design B .....	48

Figure 6-6: Alternative warehouse design C .....	49
Figure 6-7: Alternative warehouse design D .....	49
Figure 6-8: Systematic Layout Planning Procedure .....	51
Figure 6-9: Relationship chart of Simitri's manufacturing plant .....	52
Figure 6-10: Activity Relationship Diagram .....	53
Figure 6-11: Space relationship layout for Simitri manufacturing plant.....	55
Figure 6-12: Alternative block layouts a, b and c .....	56
Figure 6-13: p-chart for fraction of non-conforming product .....	63
Figure 6-14: Process for sampling content .....	65
Figure 6-15: Range chart for sampling of product.....	69
Figure 6-16: $\bar{x}$ chart of sampling of product .....	72
Figure 6-17: Stabilised $R$ and $\bar{X}$ charts .....	73
Figure 6-18: Cycle of Continuous improvement.....	74

## 1 Introduction and Problem Background

### 1.1 Background

Simitri Specialty Chemicals (Pty) Ltd was established as a dedicated supplier of specialty chemicals for leather industry. Simitri has served the leather industry since 1980. Formerly an operating division, Simitri is now a wholly owned subsidiary of AECI and a member of the Chemical Services group, the largest specialty chemical supplier in southern Africa. Simitri's manufacturing plant, Chloorkop, is situated in Kempton Park, Gauteng and has 33 people currently employed within the company. The average turnover per year is approximately 1000 tons.

**Figure 1-1: Interim phase in the tanning process, "wet blue", that Simitri provides chemicals for.**



Simitri are currently experiencing problems with their manufacturing process times, they feel that their processes are not efficient enough and believe that they can improve this with by utilising industrial engineering methods. Productivity principles will be applied to improve the product flow within the warehouse and plant as well as the control of factory operations to improve the processing time on the products.

Profits are essential for an organisation to prosper. It is, therefore, important that an organisation must be efficient and competitive. To ensure that an organisation is efficient and competitive it is essential that all non-productive processes, manual work procedures etc. are

eliminated. The use of work study techniques highlights all non-productive processes and procedures.

According to *Benjamin Niebal* and *Adris Frievalds* in their book *Methods, Standards and Work Design* the only way a business or enterprise can grow and increase its profitability is by increasing its productivity. Productivity improvement refers to the increase in output per work hour or time expended.

## 1.2 **Problem Statement**

Simitri has identified that the current production output on its products is below capacity. The problems that have been identified are:

- The processes time of the products through factory operations
- The laboratory testing times
- The warehouse operations.

Improvements need to be focused around the efficiency of quality control, the laboratory, and production times in the factory, the warehouse operations as well as the control of factory operations.

## 1.3 **Project Aim**

The aim of this project will therefore be to improve on the above mentioned areas with the use of productivity techniques in order to progress to a more acceptable productivity limit. The net result will be an improvement in the delivery of products to the clients as well as enhance customer satisfaction.

The main aim of the project is to improve the manufacturing time of the products being made at Simitri Speciality Chemicals. This improvement will be brought about by making use of productivity techniques that are applicable to the company operations.

## 1.4 **Project Scope**

The project scope is as follows:

- Improve operations in the factory in order to improve the manufacturing time on the products using methods engineering and work design

- Upgrade the quality control laboratory to shorten the time it takes for the laboratory assistants to process and deliver the information to the plant, by the introduction of a new technology interface such as Microsoft Access.
- Improve warehouse operations to shorten the time it takes for raw materials to be delivered to the manufacturing plant with the use of appropriate mechanical equipment
- Improve the warehouse operations to make sure the right products are being delivered to the right customers at the right time and in the right condition using logistics techniques.

As with any company the main objective is to maximise profit. The use of industrial engineering techniques with the main focus on productivity will maximise the profits made by Simitri Speciality Chemicals.

### 1.5 Deliverables

The deliverables of this project are industrial engineering techniques as well as productivity methods that are used to improve the efficiency of the production process, the laboratory times and the warehouse operations. To achieve this improvement in efficiency we will investigate the use of the following techniques listed as the deliverables of the project:

- Pareto analysis to identify current and potential problem areas
- Flow process chart
- More efficient departmental flow due to productive workers
- Work measurement to determine efficiency
- Use of control charts for statistical quality control work
- Line balancing to determine the number of workers to be assigned to each production area
- Recommendation of an improved quality control system
- Microsoft Access
- Simulation
- Warehouse design
- Principles of work design
- Methods engineering
- Establish time standards to perform given tasks
- Quality management

- Operation process chart
- Usage of mechanical equipment in warehouse operations
- Facility planning

## **2 Literature Study**

The literature review is essential for the gathering of information and consists of analysis of existing literature that will assist in solving the problems that have been highlighted in the previous chapters. The focal point of this dissertation is the efficiency of the total manufacturing process.

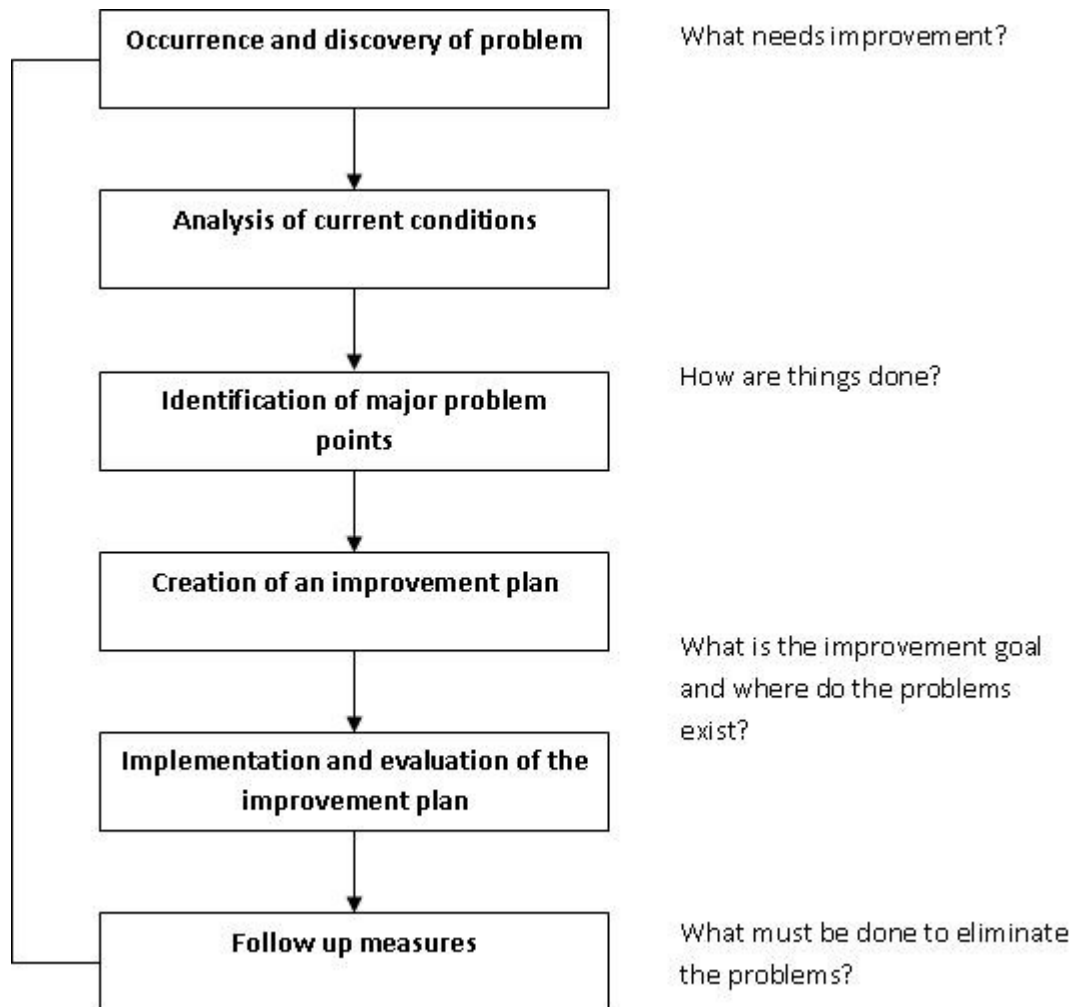
The following are tools that have been used in the information gathering process:

- Internet
- Library resources
- Previous studies
- Discussions
- Journals
- Observations

According to Junichi Ishiwata (1997), "... in manufacturing companies, process analysis is perhaps the most fundamental method in carrying out the endless and limitless process of making improvements" and that "you also need to consider not only the improvements that will make your own workplace better but also those that will produce positive effects downstream". This implies that improvement of factory operations will not only create an improvement on the process times on products, but will also cause positive changes in other areas of the company.

Figure 2-1 outlines what Ishiwata believes are the steps that need to be followed in order to improve the process.

**Figure 2-1: Ishiwata Process Improvement Steps**



By making use of Ishiwata's steps to achieve an improved process, a literature study has been compiled of existing information on improving total manufacturing operations.

The following industrial engineering techniques are a good way to start a project orderly and end the project with implementation:

- Pareto Analysis
- Cause and effect diagrams
- Process flow charts
- Root cause analysis (RCA)

- Critical analysis technique
- Bar charts
- Line balancing

The literature study will look at the three areas' that have been identified as contributing to this inefficiency, they are:

- The processes time on the products due to inefficient factory operations (facility layout)
- The warehouse operations
- The capability of the quality management system and

## 2.1 **Facility Layout**

In this section the problem that is being focused on is the long process times on the products, and it is believed that the factory operations are the vital aspects that are creating these inefficient process times.

Simitri is classified as a small to medium enterprise (SME), in the case study, Improving Operations in a Small Company (Gunasekaran, Forker and Kobu 2000), it is noted that SME's play a significant role in the national economy, therefore there is a need to help them improve their competitiveness and this can be achieved by maintaining high production standards and efficient production process and control systems.

The facilities planning process is usually divided into two key components: the facility location and the facility design/layout. Facility location is not relevant to this project, as the site for the facility cannot be changed.

Tomkins et al (2003) states that the generation of layout alternatives is a critical step in the facilities planning process, since the layout selected will serve to establish the physical relationships between activities.

The facility's efficiency is dependent of many factors such as the machinery layout as well as the department layout. The arrangement of machines and departments is determined by the plant layout procedure. This layout procedure should aim to determine the arrangements in

order to minimise production time, maximise turnover of work in process, as well as to maximise the factory output.

According to Tompkins (Tompkins et al. 2003) 'one of the most effective methods for increasing plant productivity and reducing costs is to reduce or eliminate all activities that are unnecessary or wasteful. A facilities design should accomplish this goal in terms of material handling, personnel and equipment utilisations, reduced inventories, and increased quality'.

Although a new factory layout will prove to be costly to the company, in the long run it may prove to be the more economical solution. As mentioned before the efficiency of a manufacturing facility can depend on the layout of machinery, therefore by making use of plant layout procedures to determine how to arrange the various machines could achieve minimisation of the overall production time and maximise the plants output therefore increasing customer satisfaction and, possibly, profits and, consequently, justifying the costs for a new plant layout.

Facilities' planning has a significant impact upon manufacturing cost and an important effect on the performance and efficiency of a manufacturing system. Good placement of facilities contributes to the overall efficiency of operations and can reduce up to 50% of the total operating expenses (Tompkins et al. 1996).

One of the most important steps in facility planning is the determination of relationships between relevant departments and all areas concerned. A relationship diagram also suggested by Te-King (2004) and Tompkins et al. (2003) seeks to determine which working areas should be in close relationship, at some distance, or for which it is an absolute necessity to not be close. Richard Muther (1962) developed a technique to measure the qualitative factors called a closeness rating chart, named systematic layout planning (SLP). Muther's systematic Layout planning will be the main focus of this part of the literature study.

According to Chien in his "empirical study of facility layout using a modified SLP procedure" (2004) an effective layout design upon a manufacturing system is significant. New technologies such as fuzzy logic, dynamic programming, genetic algorithms, computer simulation, computerised-aided layout etc have been developed with the goal of assisting enterprises seeking an effective procedural and algorithmic approach. However these algorithmic

approaches use only quantitative input data offering solutions that need further corrections that satisfy the requirements for facilities design.

In procedural approaches, Muther's (1973) view and method regarding systematic layout planning (SLP), is not only a proven tool in providing layout design guidelines but is still widely used among enterprises and the academic world (Yang et al., 2000), (Chien, 2004, Journal of Manufacturing Technology Management).

Muther's systematic layout planning (SLP) was developed by Muther in 1973 and is a systematic approach to plant layout. "the goal of SLP is to locate two areas with high frequency and logical relationships close to one another using a straightforward six step procedure" (Niebel et al. 2003, p. 111).

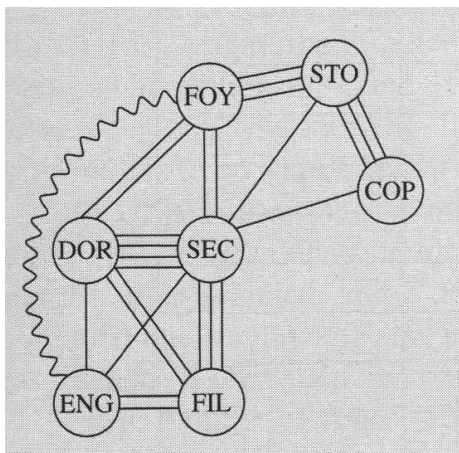
Niebal et al defines the six step procedure as follows:

1. Chart Relationships. The relationships between different areas are established and the charted on a special form called the relationship chart (Figure 2-2 below). The relationship chart shows the relative degree of closeness, desired or required, among different activities or areas. The relationship ratings range in value from 4 to -1 and are based on the vowels that semantically define the relationship, these are shown in table 2-1 below.



2. Space Requirements. Space requirements are established in terms of square footage. These values can be based on production requirements, extrapolated from existing areas etc. In addition to square footage, the kind and shape of the area being laid out, or the location with respect to required utilities, may also be very important.
3. Activity Relationships Diagram. A visual representation of the different activities is drawn. Starting with the absolutely important relationships (A's), using for short parallel lines to join the two areas. The analyst will then proceed to the E's, using three parallel lines approximately double the length of the A lines. This procedure is continued with the I's, then the O's etc., progressively increasing the length of the lines and trying to avoid crossing or tangling the lines. An example of such an activity diagram is shown below in figure 2-3.

**Figure 2-3: Activity relationship diagram**



4. Space Relationship Layout. A spatial representation is created by scaling the areas in terms of their relative size. Once an analyst is satisfied with the layout, the areas are then compressed into a floor plan. Here, modifications may be made based on the requirements for materials handling, storage facilities, personnel requirements, building features and utilities.
5. Alternative Arrangements Evaluation. In most cases when alternatives are generated, it is possible to have several that appear to be likely candidates. Evaluation is therefore needed to determine the best solution. First the analyst must determine the factors that are deemed most important, then the relative importance of these factors need to be

established through a system of weights. Each alternative is then rated for satisfying each factor. Each rating is then multiplied by the weight and summed up; the highest value will indicate the best solution.

6. Selected Layout and Installation. Finally the new method is implemented.

The techniques of systematic layout planning present a well organised and detailed view of the qualitative and quantitative factors for facility layout. Vollman and Buffa concluded in their article, "The facilities layout problem in perspective" (1996), that the traditional techniques of using Muther's SLP utilises graphic and schematic analysis to determine the qualitative factors. "These factors are incorporated into a methodology for the determination of which sub-groups or departments most require adjacent placement as well as for the evaluation of several proposed layout solutions."

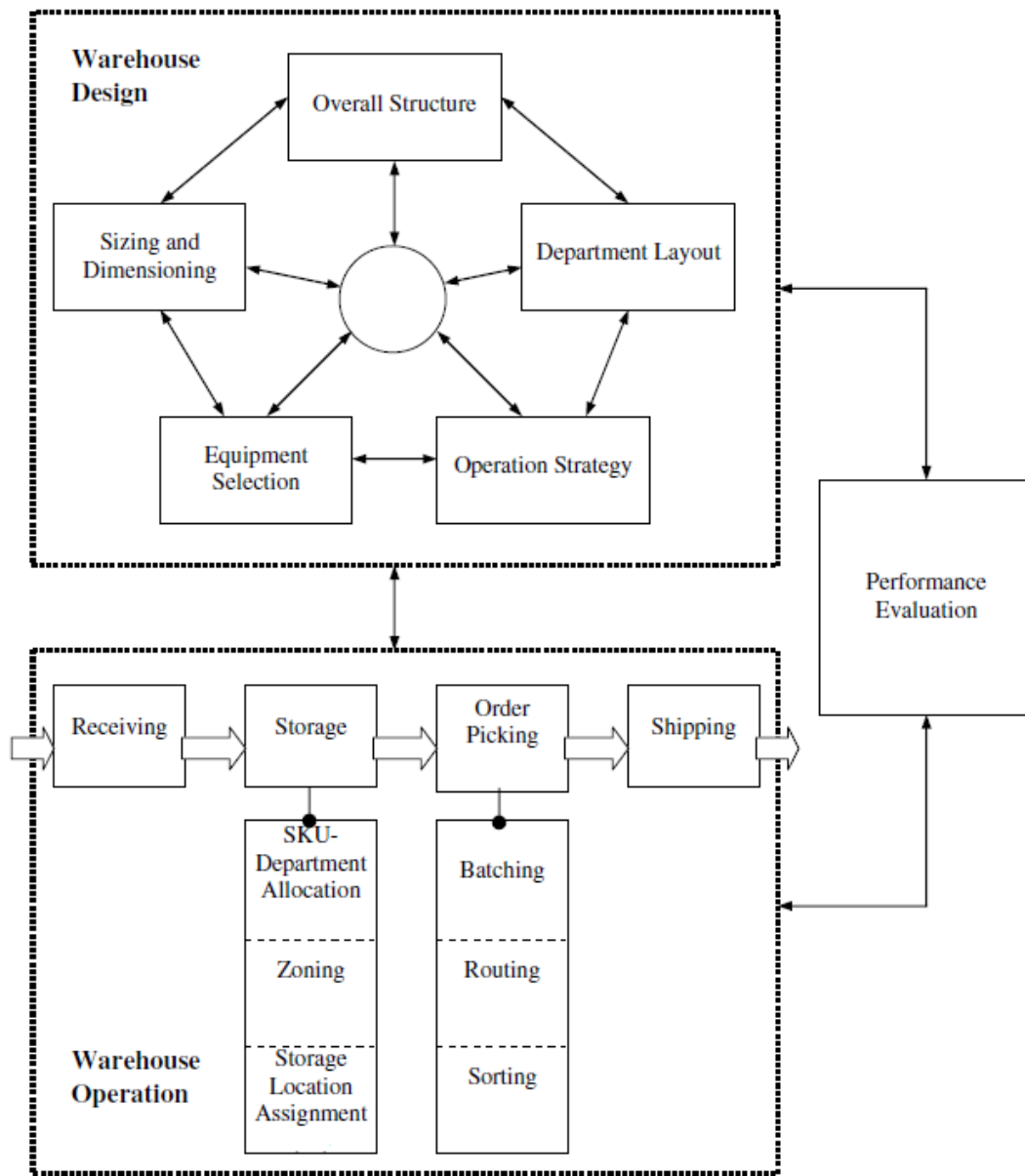
## 2.2 **Warehouse operations**

Warehouses are an essential component of any manufacturing operation. Their roles consist of: buffering the material flow to accommodate variability; consolidation of products for delivery to suppliers; and value-added-processing.

The acceptance of new management values such as Just-In-Time (JIT) brings new challenges for warehouse systems, including tighter inventory control, shorter response time, and a larger product variety. On the other hand, the widespread operations of information technology (IT), such as bar coding and warehouse management systems (WMS), offer new chances to improve warehouse operations.

The basic requirements in warehouse operations are to receive stock from suppliers, store the stock, receive orders from customers, retrieve stock and assemble them for shipment, and then ship the finished orders to customers. There are many concerns involved in designing a warehouse to meet these requirements. Space, labour, and equipment are resources that need to be allocated among the warehouse functions, and each function needs to be cautiously implemented, operated, and coordinated in order to realize the system requirements in terms of capacity, throughput and service. Figure 2-4, below, shows a scheme to classify warehouse design and operation planning problems.

**Figure 2-4: Scheme to classify warehouse design and operation planning problems**



Planning issues in warehouses typically involve inventory management and storage location assignment. Intelligent inventory management may result in a reduction of the warehousing costs. By introducing a sophisticated production planning and ordering policy we may reduce the total inventory, while guaranteeing a satisfactory service level. Reduced inventory levels not

only reduce inventory costs, but also improve the efficiency of the order-picking operation within the warehouse. This however is beyond the scope of this project, layout of the warehouse facility and the basic operations within it are only to be considered as part of this dissertation.

### **Receiving and Shipping**

The receiving and shipping areas are the interface of a warehouse for incoming and outgoing flow. The receiving area of the warehouse is where incoming shipments are in, unloaded, and placed in storage. From the storage area the orders are picked, prepared, and from there the orders are shipped to customers or the plant through the shipping area/s.

The basic decisions involved in the receiving and/or shipping operations are:

For those responsible for receiving/shipping:

- Information about incoming shipments (arrival time and contents).
- Information about customers demands (orders and their expected shipping time).
- Information about warehouse dock layout and material handling resources.

To be determined:

- The assignment of inbound and outbound carriers to docks, this determines the material flows.
- The schedule of the service of carriers at each dock.
- The allocation of labour and material handling equipment.

Subject to performance criteria and constraints such as:

- Resources required for the completion of all shipping/receiving operations.
- Level of service (cycle time and the load/unload time).
- Layout of docks and storage departments.
- Throughput requirements for all docks.

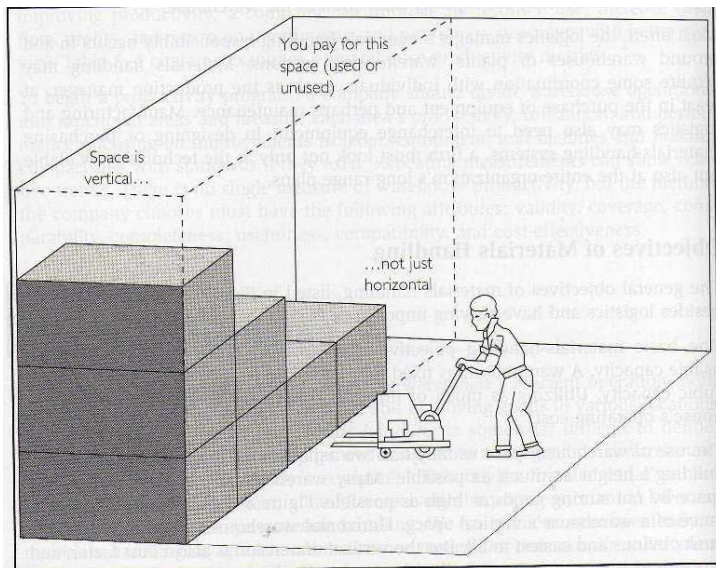
### **Storage**

Storage is the organization of the goods held in the warehouse. Storage must be optimal as this will achieve good space utilization and assist in capable material handling. The goods in the

warehouse should be organized into different departments, these departments can be determined upon the physical characteristics of how the goods are stored (e.g. whether in pallets, bags, cases etc), management considerations, or material handling considerations.

Storage operations should also make use of the full cubic capacity, as shown in figure 2-5 below.

**Figure 2-5: Utilisation of a warehouse's cubic capacity.**



### **Order Picking**

Order picking is recognized as the most expensive warehouse operation, as it is either labour intensive or capital intensive. Managing the order picking process involves the organization of the orders to be picked and of the material handling operations of the picking.

Order picking methods can vary and the selection of an order picking method is a strategic decision because it may have a wide impact on other decisions in the warehouse design and the warehouse operations. Following is a list of different order picking methods:

- Single order picking (the order-picker is responsible for the picking of a complete order)
- Batching (multiple orders are picked simultaneously by one order-picker, who is typically restricted to a certain zone in the warehouse)
- Zone picking

## **Material Handling**

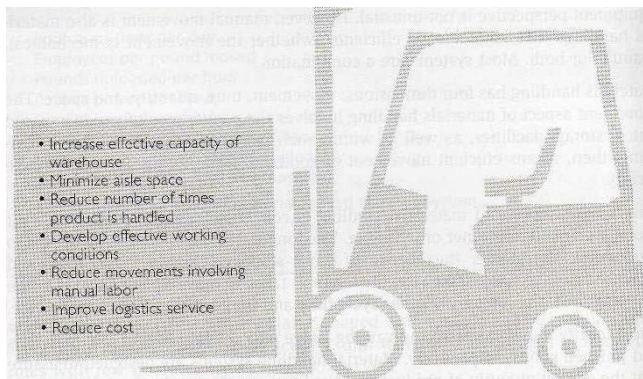
There are many types of warehouse systems that can be considered and are classified according to their material handling procedures.

The manual warehouse system (also known as picker-to-product system) is the most basic warehouse system concept. In this system the order picker makes use of material handling vehicles and rides the vehicle to the pick location. These vehicles, to mention a few, are pick carts (for horizontal item picking) or man aboard storage retrieval machines (for both horizontal and vertical picking), forklift trucks (the most popular form of vehicle used) and reach trucks. In manual order picking there are two fundamental approaches that are used, they are batch picking or single order picking, both of which are defined above). Batch picking reduces the travel time per pick. Though, it requires that orders must be sorted after the picking process. The order-picker may either sort the orders while traversing the warehouse (*sort-while-pick*) or the items may be lumped together and sorted afterwards (*pick-and-sort*). The sort-while-pick strategy can be applied, but the vehicle must be fitted with separate containers for separate orders.

Automated warehousing systems can also be described as 'product-to-picker systems'. Carousels are examples of product-to-picker systems as it automatically rotates while the picker maintains a fixed position at the front of the carousel. This example is used in cases of small to medium sized products. A rotary rack is similar to a carousel; however it is a more expensive version but proves more effective as every storage level can rotate independently, saving order picking time significantly.

The figure below, figure 2-6, shows the general objectives of materials handling.

**Figure 2-6: General objectives of materials handling.**



### 2.3 Quality Management System

Quality, as defined in the Oxford English dictionary, is the standard of something as measured against other things of a similar kind; the degree of excellence of something. Quality can also be defined as "... a predictable degree of uniformity, and dependability, at low cost and suited to the market"; this is the definition provided by Gitlow et al. (2005) this definition is more relevant to this study.

Increasingly, organizations are recognizing the strategic importance of quality and quality management. Many organizations have arrived at the conclusion that effective quality management can enhance their competitive abilities and provide strategic advantages in the marketplace (Academy of management Review, 1994).

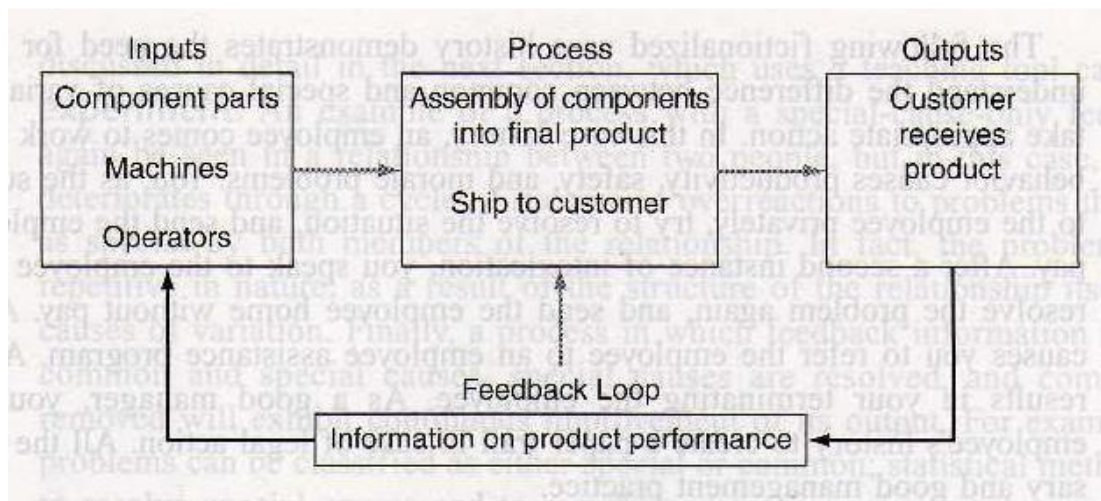
Total quality management (TQM) is a strategy that is aimed at creating awareness of quality in all processes of an organisation. TQM is used widely in many areas, such as manufacturing, hospitals, government etc. The key working of TQM are:

- Leadership
- Management of people
- Customer focus
- Use of information and analysis
- Process improvement
- Strategic and quality planning

We have focused on process improvement in the previous sections of this chapter with regards to the facility. In this section the focus will be on strategic and quality planning, customer focus, the use of information and analysis and process improvement focusing on the quality. The points that have not been mentioned from the list above are considered not relevant to this study.

A generic production process is shown below in figure 2-7. Inputs are transformed by the process to produce an output. Between the inputs and the outputs a feedback loop is integrated. This feedback loop is usually in the form of a quality control process, and can be used to respond to below standard quality.

**Figure 2-7: Generic production process**



### **Customer Focus**

The element of customer focus addresses how and how well an organisation determines current and emerging customer requirements and expectations, provides effective customer relationship management, and determines customer satisfaction. Customer focus is the keystone principle in the TQM philosophy.

Customer satisfaction starts at the source. If the raw materials are below standard, the final product will be unsatisfactory. A quality management system should therefore be established at

the beginning of the process by testing the raw materials and determine whether they are within the quality specifications that have been standardised for production.

### **Use of information and Analysis**

This element is concerned with the “scope, management, and use of data and information to maintain a customer focus, to drive quality excellence, and to improve . . . performance” (Malcolm Baldrige National Award Criteria, 1995). Organisations that consistently collect and analyse information will be more successful than those who do not (Journal of operations management, 1999).

The purpose of collecting data, in terms of a quality management system, is for the reason that more comprehensible decision making can be made if there is information available to make the decision. Collection of data for quality management will allow an organisation to make use of statistical process control (SPC). SPC, introduced by Walter Shewhart in 1924, provides a method for controlling quality in the production environment.

### **Strategic and Quality Planning**

Already mentioned is the method of statistical process control, SPC requires constant information and data gathering for its use. This gathering of information is not in vain, as it provides a useful tool for determining the quality of the output of the process, and a process that has been defined and documented can be stabilised and then improved. Without valid measurements, process [and quality] improvements are difficult if not impossible, and perhaps the best means of measuring process performance is a statistical control chart (Gitlow et al. (2005)).

Depending on the type of data that is gathered, two categories of statistical control charts can be used. They are:

- Attribute control charts – based on the number of times a particular event is observed.
- Variable control charts – consists of numerical measurements such as weight, length, width, height, etc. the process output is classified as either conforming or non-conforming.

Quality consciousness must increase in order for a firm to continue or reduce the difference between customer needs and process performance.

### **Process Improvement**

Process capability studies will be used to determine whether a process is unstable, investigate the source of the instability, determine their causes, and take action to eliminate such sources of instability (Gitlow et al., 2005). Once the sources of instability have been eliminated from the process, the natural behaviour of the process is called its process capability.

Process capability evaluates the output of the process (called “voice of the process”) with the specifications that have been determined by the customer (“voice of the customer”). The process capability must be determined before it can be improved.

Process improvement studies follow the Deming cycle of Plan, Do, Study, Act (Gitlow et al., 2005). Firstly, a **plan** must be constructed to decrease the difference between customer needs and process performance. The next step, **Do**, is to test the plan's validity by performing a planned experiment. Then collect data from the results of the planned experiment and **study** these results to determine whether the aforementioned plan will decrease the difference between the customer needs and the process performance. Finally if the data collected shows that the plan will achieve its objectives, the revised plan is standardized and put into practice, **Act**.

### **3 Proposed Investigation Methods**

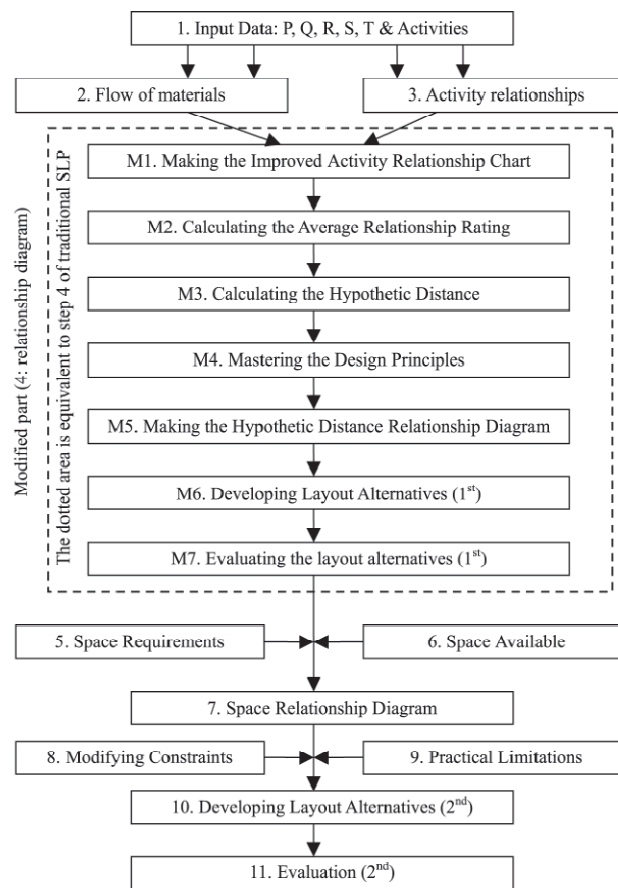
Information has been gathered and analysed in order to formulate a solution methodology for the three areas that have been identified as contributing to Simitri's inefficiency in its current operations. Following are the conclusions to the study.

#### **3.1 Facility Layout**

The facility planning technique of Muther's systematic layout planning has been investigated as a possible solution to improving factory operations as it has shown to be a very useful technique in factory layout plotting. However, as Chien points out in his study, "an empirical study of facility layout", there are complications that arise from increasing activity and the unavailability of effective plotting in practical operations.

In Te-King Chien identifies a modified SLP procedure; this modified procedure is shown in figure 3-1. In this "improved" SLP procedure the 6 steps that are identified by Muther in his systematic layout planning procedure have been modified into "improved" seven concepts and methods. These concepts and methods can help the "designer to manipulate the reasonable and accurate corresponding position between each activity group before designing procedure steps into 'space relationship diagram. More importantly, they help to attain the goal to design a workable proposal by using the concepts and methods without a highly professional designer' (Chien, 2004).

**Figure 3-1: Chien's modified SLP Procedure**



It has been decided that Chien's modified SLP procedure is too complex to be used on a small plant such as Simitri's. Simitri's manufacturing plant is not complex and is not too large, therefore the Muther's classic SLP procedure will be used. Chien's modified SLP procedure, although well thought out, simple and effective, will complicate the redesign of Simitri's plant.

### 3.2 Warehouse Operations

Warehouse operations have been shown to improve purely through the use of facility layout. Simitri currently has a warehouse in operation; however it has not been designed to make use of its full capacity. In order to improve the warehouse operations the following will be used:

- Improvement of order picking operations. This is, traditionally where a company spends most of its time and money to improve productivity. A successful order picking system is crucial to a warehouse's success.

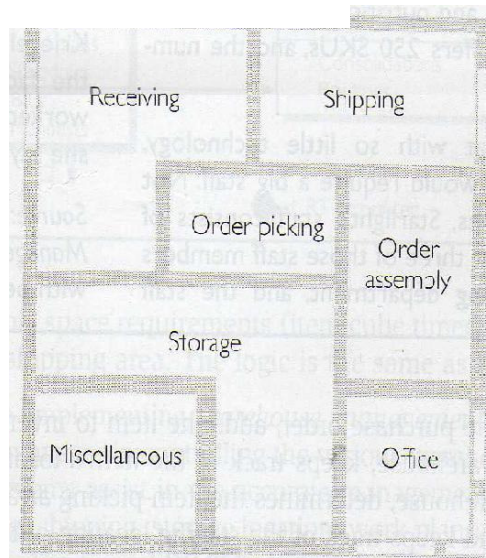
- Increasing productivity. The old principle of productivity - “do it faster with fewer people” - still applies to the mission of a warehouse. However more aspects other than labour must be included, such as the effective use of space and equipment. The combination of all these factors contributes to increased productivity.
- Utilisation of space. The old rule of thumb is that when a warehouse is more than 80% full, more space is needed (Tompkins et al., 2003). This rule is still applicable to this day and is based on the fact that when a warehouse reaches its capacity, it takes longer to put something away. This has the knock on effect that as time to find the storage location increases, the proper slotting of products starts to disappear with the end result of declined productivity and increased damages and accidents.

The functions of the warehouse that will be focused on are:

- Receiving
- Inspection and quality control
- Put away
- Storage
- Order picking
- Sorting
- Packing and shipping
- Replenishing.

Figure 3-2 is a depiction of basic warehouse space requirements. Space requirements have been allocated for the various warehouse activities such as order picking, storage, and assembly, shipping and receiving.

**Figure 3-2: Warehouse space requirements**



### 3.3 Quality Management System

A quality management solution will be put in place by making use of statistical process control and process stabilisation and improvement studies. Customer focus should be an important matter in all firms. Simitri, being established as a dedicated supplier of speciality chemicals to the leather industry must focus on quality improvement policies in order to maintain its international and local customer base. The strategic importance of better quality and better quality management are increasingly becoming more aware to organisations, this is because the awareness of effective quality management can enhance an organisations competitive ability and provide strategic advantages in the market place. Once customers become aware of the improved quality of products, the organisation stands a better chance of gaining a more competitive base in the market.

The use of information and analysis tools can help an organisation to determine where their process is lacking. Once this has been identified quality improvement and be put into place. As stated before, organisations that consistently collect and analyse information will be more successful than those who do not (Journal of operations management, 1999). When there is more data available to use, decision making with regards to quality management can become easier and more useful. Data collection will be collected by means of statistical process control.

SPC provides a method for controlling quality in the production environment and it proves to be a useful tool in determining the quality of the output of the process. If a process has been

defined and documented it can be stabilised and improved. The improvement studies follow the Deming cycle of Plan, Do, Study, Act (Gitlow et al., 2005). This has been described in detail in an earlier section. The Deming cycle of Plan, Do, Study, Act will be used in determining statistical process control.

From the two categories of statistical control charts mentioned, both the variable control chart and the attribute control chart can be used effectively in the environment being studied. This is due to type of information that can be gathered from the different processes. Quality consciousness must increase in order for a firm to continue or reduce the difference between customer needs and process performance.

Part of the quality management is continuous improvement. Figure 3-3 below shows the steps in the cycle of continuous improvement. This is similar to Deming's plan, do, study, act cycle it just includes the important aspect of staff training.

**Figure 3-3: Cycle of continuous improvement**



#### **4 Conclusion of Literature Study**

The areas in which industrial engineering techniques will be used to improve Simitri's efficiency are:

- Muther's systematic layout planning
- Warehouse design and
- Quality management.

Utilising these techniques as well as other industrial engineering techniques, such as work study, we can improve the overall production of the facility.

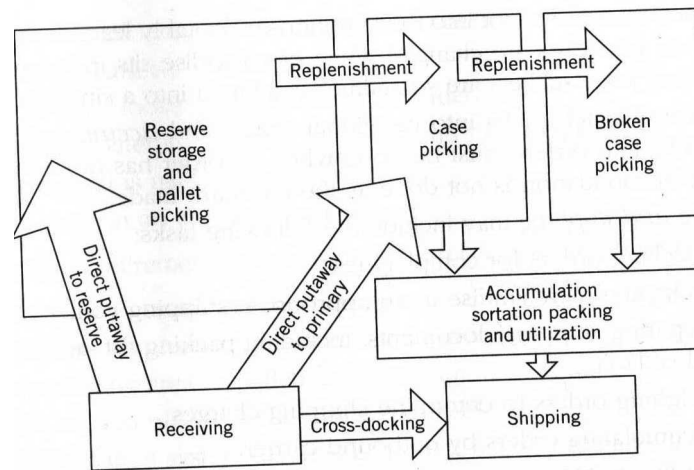
Throughput can be improved by at least 10% just by using layout techniques in the plant, setting up a useful and productive warehouse management system and quality management techniques. This 10% may seem like a small factor; however a 10% improvement means a lot. Cost savings, client satisfaction, employee satisfaction and increased efficiency are just some of the benefits that the company will experience if these proposed recommendations are put in place.

## 5 Data and Information Gathering

### 5.1 Warehouse Operations

The data and information gathering phase started with the warehouse operations as this step is the first in the series of improvements to be made at Simitri Speciality Chemicals. The activities that are performed within the facility can be categorized as either supporting or hindering, this phase is to identify the hindering activities and improve them to become supporting as well as to identify the supporting activities that will help with the warehouse operations; for the overall purpose of providing a suitable and efficiently run working environment. Figure 5-1 below depicts the typical warehouse functions and flows which should be in place. It is easy to just consider a warehouse as a storage area, however if the operations within the warehouse are performed optimally and efficiently then the warehouse can become an integral part of the entire plant being efficient.

**Figure 5-1: Typical warehouse functions and flows:**



In order for improvements to be made to the warehouse the following information is required:

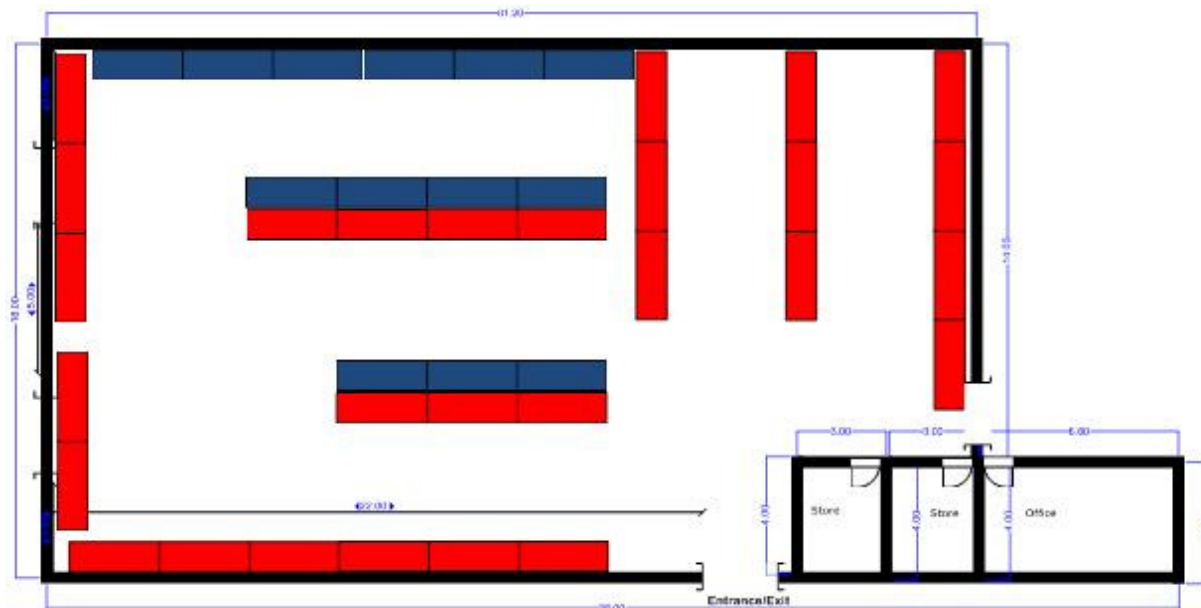
- Current layout
- Available space
- Receiving and shipping operations
- Order picking operations

- Material Handling equipment

### 5.1.1 Current Layout

The design of any facility is extremely important as it affects the ability of the facility to carry out its purpose. A current layout is required in order to see how the warehouse operations are being performed as well as to indicate the available space, storage equipment, material handling equipment and to see what parts of the warehouse are not being utilized effectively. The figure below is a basic diagram of the warehouse facility at Simitri.

**Figure 5-2: Current warehouse layout**



### 5.1.2 Available Space

Space planning includes the determination of space requirements for the storage of materials. While considering popularity, similarity, size and material characteristics, a layout must be developed that will maximize space utilisation as well as the level of service provided (Tompkins et al. 2003). Simitri's warehouse has the approximate area of 580m<sup>2</sup> and is rectangular in shape. Pallet racks are the means by which loads are stored and provide immediate availability of the loads. Currently there are 2 sizes of pallet racks; they are 3mX2.5mX1m and 3mX4mX1m as can be seen in the photographs below (figure 5-3).

**Figure 5-3: Pallet racks used at Simitri warehouse. a.) 3mX2.5mX1m. b.) 3mX4mX1m.**



Material handling equipment also requires certain spatial requirements, Simitri uses a forklift. Its load capacity is 1 ton and has a reach height of 4.7 meters, and can be seen below in figure 5-4.

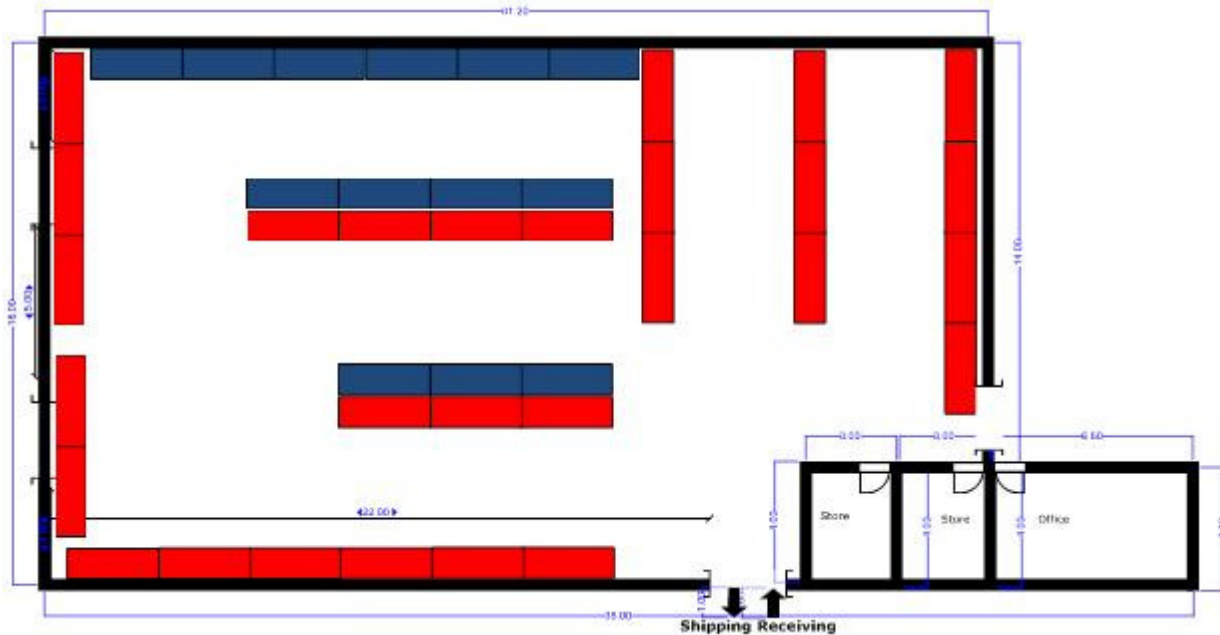
**Figure 5-4: Forklift**



### 5.1.3 Receiving and Shipping operations

The receiving and shipping principles at Simitri are shown on the figure below. The shipping and receiving functions operate from the same area. As can be seen in the photograph of the shipping/receiving area (figure 5-5) this area is not large enough to accommodate a shipment to or from a truck therefore coordination is difficult.

**Figure 5-5: Simitri warehouse layout showing shipping/receiving area**



### 5.1.4 Order Picking Operations

Order picking operations do not exist. The only principle that is in use is the first in first out principle (FIFO). Below is how FIFO is being implemented. Each load of raw materials that comes in on a monthly basis is marked with a specific colour depicting in which month it was received. The operators are then required to use the material in order of the month that it was received. For example if we are in August and there is still raw material available from January, but not any material from December or previous to this month, then that is the raw material that must be used. The colour chart is shown in figure 5-6 and examples of the marked stock in figure 5-7.

**Figure 5-6: Order picking colour chart**



**Figure 5-7: Stock that has been colour coded**



**5.1.5 Material Handling Equipment**

As explained above in available space, the material handling equipment being used is a single forklift. Its specifications are listed in the table below (table 5-1).

**Table 5-1: Forklift specifications**

<u>Description</u>	<u>Information</u>
Maximum load capacity	1 ton
Maximum lift reach	4.7 m
Maximum number of pallets lift truck can handle	1
Speed	67m/min

## 5.2 Facility Layout

According to Niebal et al. (2003) “the principal of effective plant layout is to develop a production system that permits the manufacture of the desired number of products with the desired quality at the least cost.” The physical layout of the plant incorporates:

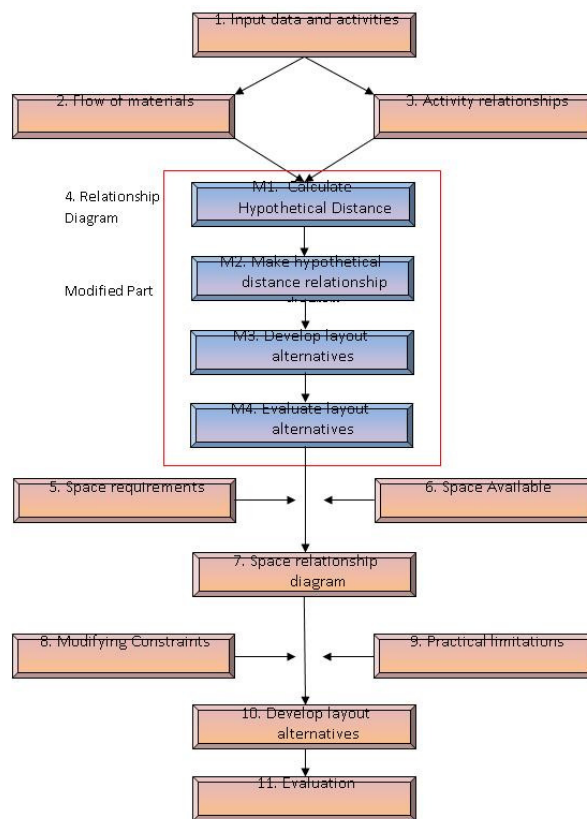
- Inventory control
- Material handling
- Scheduling
- Routing and
- Dispatching

In order to fulfil an effective plant layout all of the above elements must be carefully integrated. It will be an expensive operation to make changes to the current plant layout; however this has been weighed by management against the costs in lost sales due to stock outs and poor quality.

The new layout of Simitri’s plant will be determined using systematic layout planning. Niebal et al. (2003) points out that there is never one layout that tends to be the best. Many different plant layouts will have disadvantages as well as advantages, Simitri’s current layout, however, has more disadvantages than advantages. The aim is to fix this problem and make sure that the solution design that will be implemented has advantages that outweigh the disadvantages.

Systematic Layout Planning (SLP) is an effective and general plant layout design methodology this popular approach to facility planning was developed by Muther in 1973. In conjunction with Chien’s modified SLP procedure (Chien, T., 2004) the facility layout planning method that will be used is shown in figure 5-8 below. This SLP procedure developed by Muther has received considerable publicity in determining an appropriate “best” layout plan (Tompkins et al., 2003).

**Figure 5-8: Modified SLP procedure to be used**



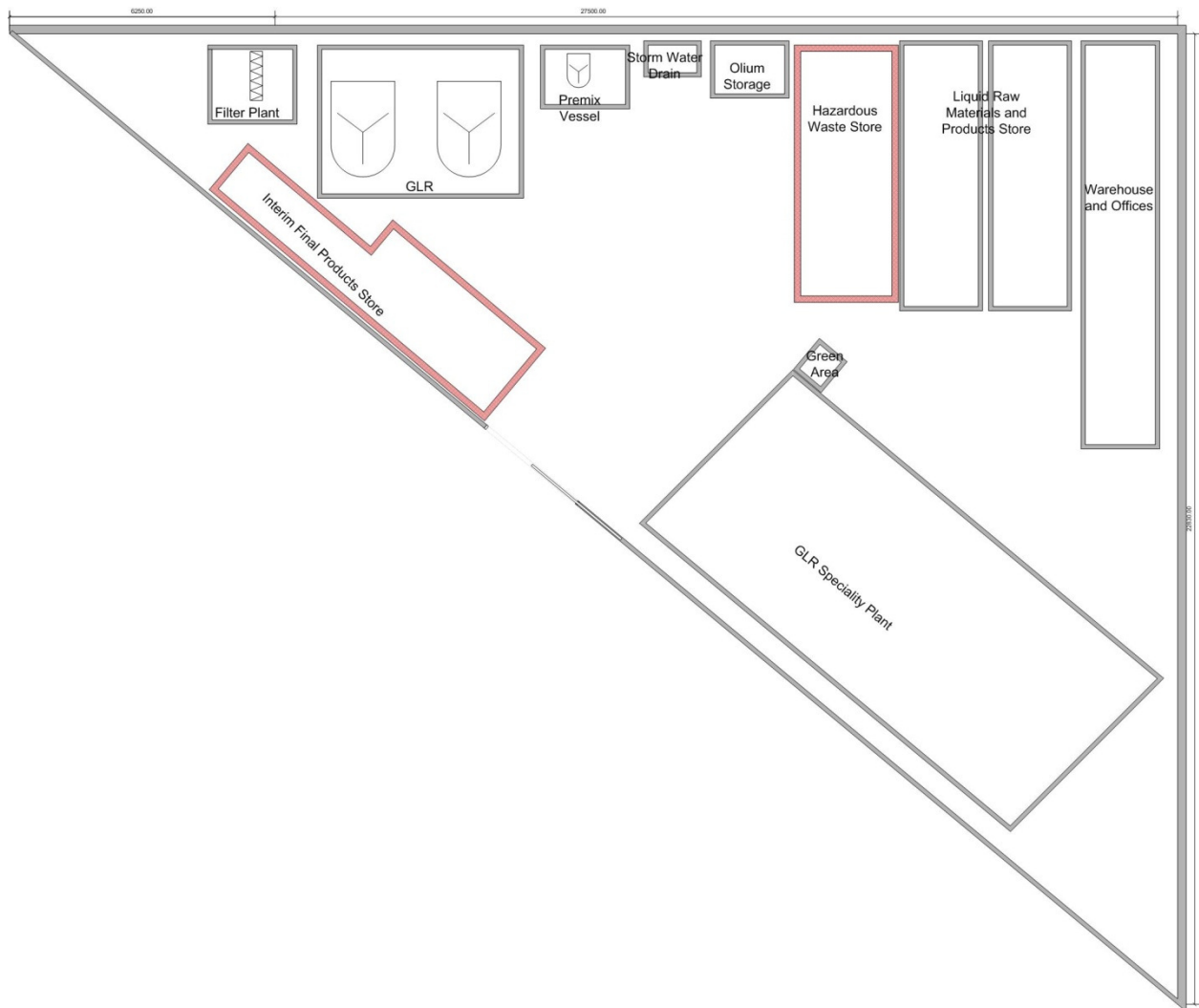
In order to carry out this modified SLP procedure, necessary information is needed. This information is:

- Current plant layout
- Plant process operations and activities
- Space requirements

### 5.2.1 Current Plant Layout

The current plant layout is used to determine how the plant operations are being performed as well as to indicate the relationships between different areas, the space relationships, the activity relationships and the flow of the materials through the plant. Figure 5-9 shows the current plant layout.

**Figure 5-9: Current plant layout at Simitri Speciality Chemicals**



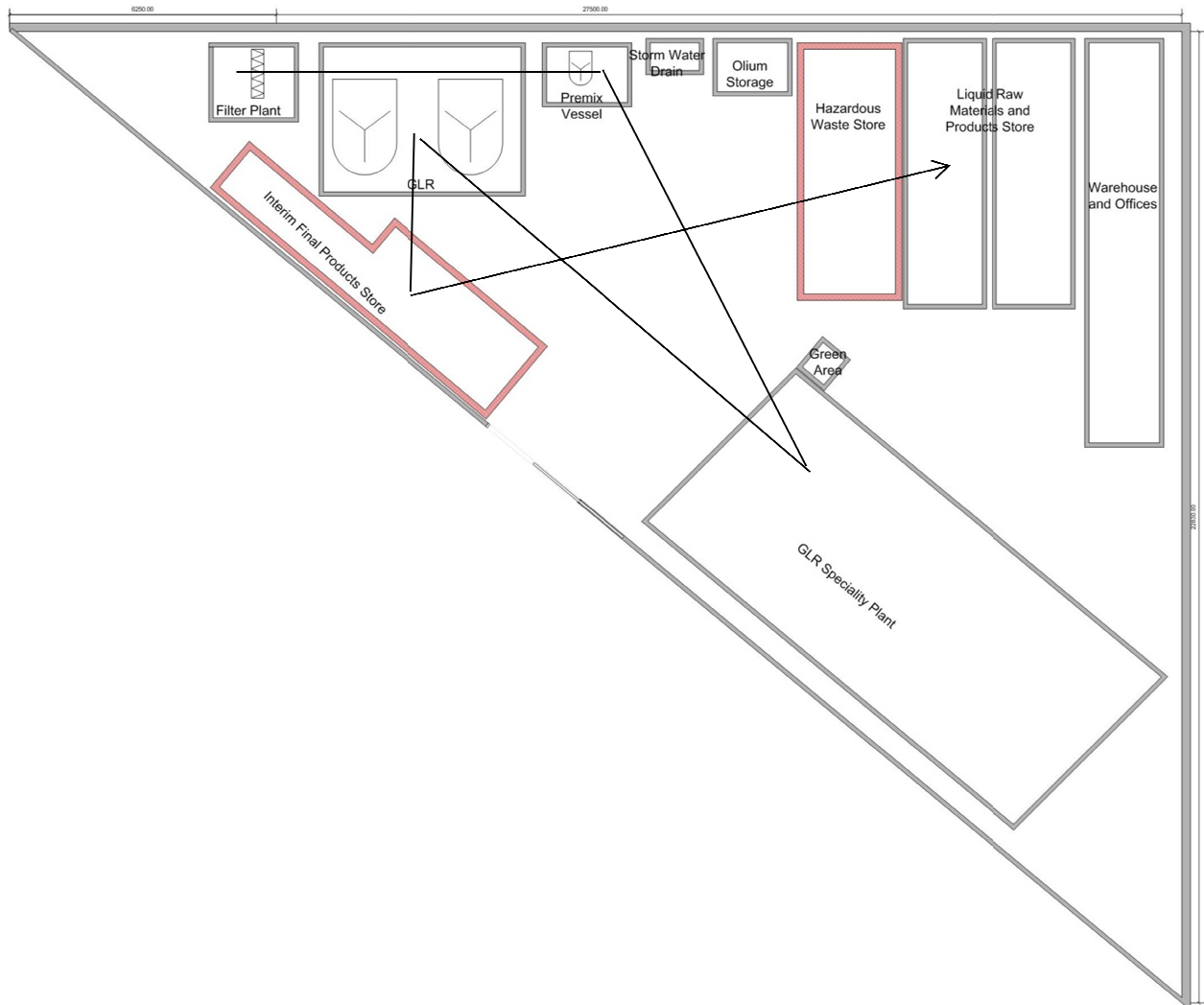
### 5.2.2 Plant Process Operations and Activities

For the modified systematic layout planning procedure to be carried out effectively, the processes and the activities that happen on the plant needs to be understood. A generic process of Simitri's production procedure is outlined below in figure 5-10.

**Figure 5-10: Flow process chart for generic production process**

Location: Simitri, Chloorkop		Summary		○	Operation
Activity: Manufacture of product X		Event	Present	⇨	Transportation
Date: 01/09/09		Operation	20	D	Delay
Operator: Mr Mohlope		Transport	4	□	Inspection
Analyst: KA McCreddie		Delay	4	▽	Storage
Method: Present		Inspection	2		
Type: Worker		Storage	1		
Remarks:		Time (min)	2159		
		Distance (m)	869		
Event Description	Symbol	Time (min)	Distance (m)		
wash filter plant	○ ⇨ ● □	30	0		
add item A	● ⇨ D □	50	0		
connect flexible hose to packout valve on filter plant to premix	○ ⇨ ● □	2	24		
Shut packout valve	● ⇨ D □	1	24		
transfer item A to premix vessel	○ ⇨ ● D □	60	0		
Premix items A, B, C	● ⇨ D □	75	0		
load item D	● ⇨ D □	45	0		
load water	● ⇨ D □	30	0		
load item E	● ⇨ D □	25	0		
mix with compressed air	● ⇨ D □	30	0		
Wash GLR	● ⇨ D □	30	14		
Wash GLR Speciality plant	○ ⇨ ● □	30	44		
connect flexible hose to packout valve on premix vessel	○ ⇨ ● □	2	34		
packout premix vessel to GLR Speciality plant	○ ⇨ ● D □	85	34		
Charge with item F	● ⇨ D □	25	0		
check premix vessel to make sure no solid remains	○ ⇨ ● □	12	34		
rinse premix with water	● ⇨ D □	20	0		
transfer that water to GLR speciality to flush line	● ⇨ D □	25	34		
add item G	● ⇨ D □	90	0		
Start Stirrer	● ⇨ D □	2	0		
charge with item H	● ⇨ D □	20	0		
stop stirrer at 90 degress celcius (time is average time stirred)	● ⇨ D □	480	0		
pack out product into drums	● ⇨ D □	40	0		
transfer product from drums into GLR	○ ⇨ ● D □	5	44		
Packout product into GLR	● ⇨ D □	20	0		
Charge item I into GLR	● ⇨ D □	20	0		
stir	● ⇨ D □	30	0		
send sample to lab	○ ⇨ ● D □	120	500		
packout GLR into bins	● ⇨ D □	30	0		
store in interim storage	○ ⇨ D □	720	16		
move to final products store	○ ⇨ D □	5	67		

**Figure 5-11: Flow of operations on the plant**



The flow process chart has helped to indicate on the current layout figure how the flow happens on the plant, shown in figure 5-11.

### 5.2.3 Space Requirements

The entire plant has an area of 4960 m<sup>2</sup>; the areas that do not fall under the production process are included in the table as they are still required for storage and other process that may happen on the plant. Each area on the plant has been measured in square meters and the space that is required is shown in table 5-2.

**Table 5-2: Space Requirements for Plant Areas**

<b>Area</b>	<b>Space Required (m<sup>2</sup>)</b>
<b>Filter Plant</b>	56
<b>Premix Plant</b>	56
<b>GLR</b>	126
<b>GLR Speciality Plant</b>	3276
<b>Interim Storage</b>	184
<b>Storm Water Drain</b>	4
<b>Olium Storage</b>	4
<b>Hazardous Waste store</b>	100
<b>Liquid Raw materials and Final Products Store</b>	300
<b>Warehouse and Offices</b>	259
<b>Green Area</b>	4

### 5.3 Quality Management System

Simitri relies on its quality control process throughout the manufacturing process; interim products need to be tested continuously in order to identify whether the process is finished or not. The quality management system, therefore, needs to be efficient and accurate in order to send the correct information to the plant as well as to produce the results in a timely manner.

For any improvements to be made to the quality management system information has to be gathered to see where the system is lacking and what could be implemented to achieve this more efficient procedure. The information that will be gathered is:

- The current quality control procedure
- The current structure of the control charts used
- Analysis of the control charts used and
- The uses of the current control charts

### **5.3.1 Current Quality Control Procedure**

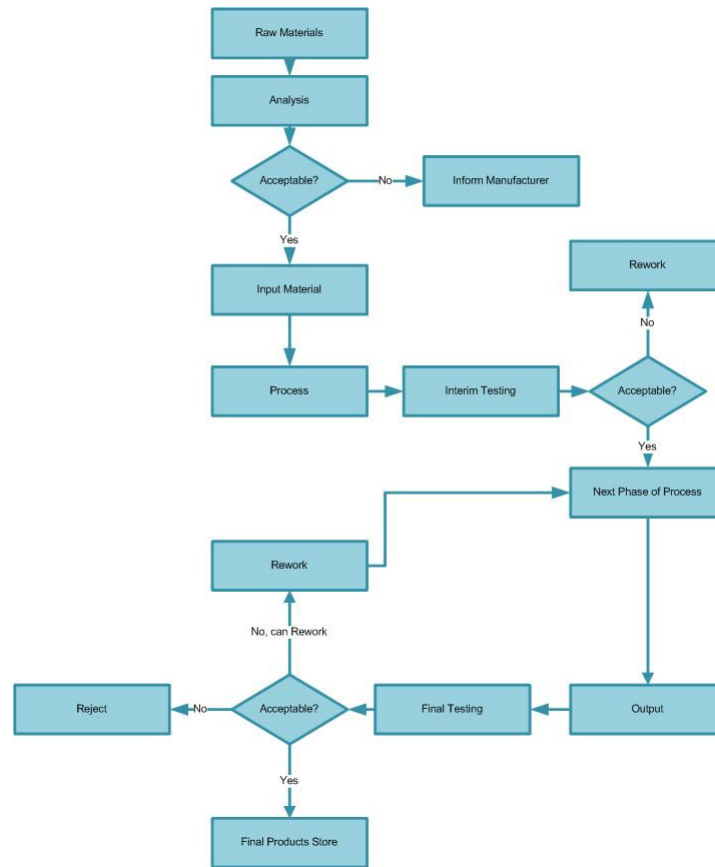
Raw materials are, as with most manufacturing companies, ordered in bulk. The raw materials that are received from the suppliers are then batch tested to see whether they conform to the standard that is needed for manufacture. Once tested, the quality analyst will record this data onto a raw materials control chart and either sends the raw materials to the raw materials store or back to the manufacture depending on if it is the right standard.

The manufacturing process then commences and once certain interim phases are reached, samples are collected and sent to the lab for testing. These tests indicate whether the process has reached the level that it needs to be or whether more products must be added (or reworked). Currently there is no record of this interim product data.

The manufacturing process then recommences and once the final product is reached, more samples are collected from the batch and sent for analysis at the lab. The analysts will then accept the product, reject the product, or inform the manufacturing department of any rework that should be done. The only information that is recorded is that of the accepted final products. Once any product has been reworked, the lab will retest and see whether it conforms to the acceptable standards.

This process is shown in the diagram below.

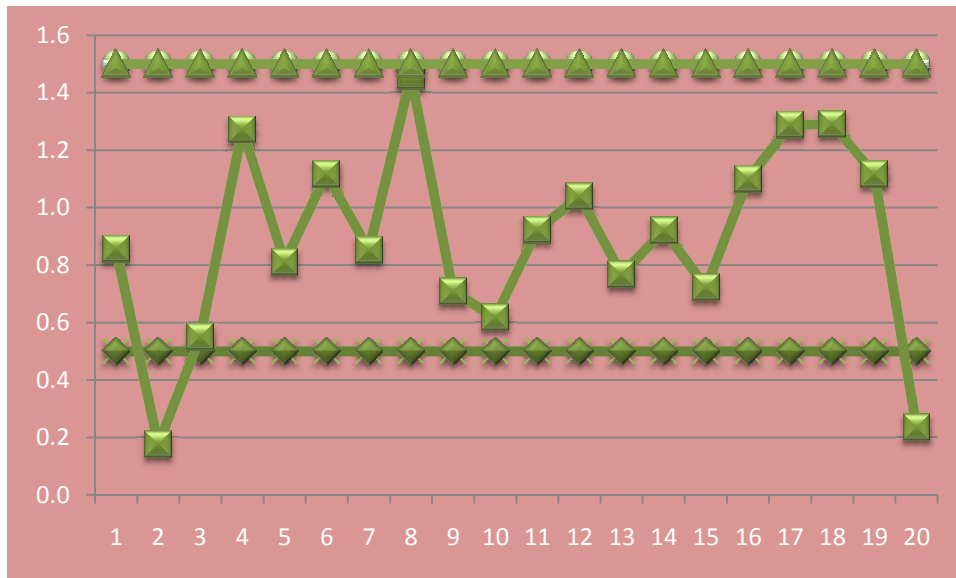
**Figure 5-12: Current Quality Control Procedure**



### 5.3.2 Current Structure of the Control Charts

For the quality control of the raw materials that are used for manufacturing, one sample from every batch is randomly tested to see whether the quality standard is met. At the moment Simitri will test this raw material and convert the results into a number which falls between 0 and 2. The limits that must be satisfied are between 0.5 and 1.5. If the tested batch does not fall within these confines, then the batch is considered rejected and sent back to the supplier. An example of the raw materials control chart is shown in figure 5-13 below.

**Figure 5-13: Raw Materials Control Chart**

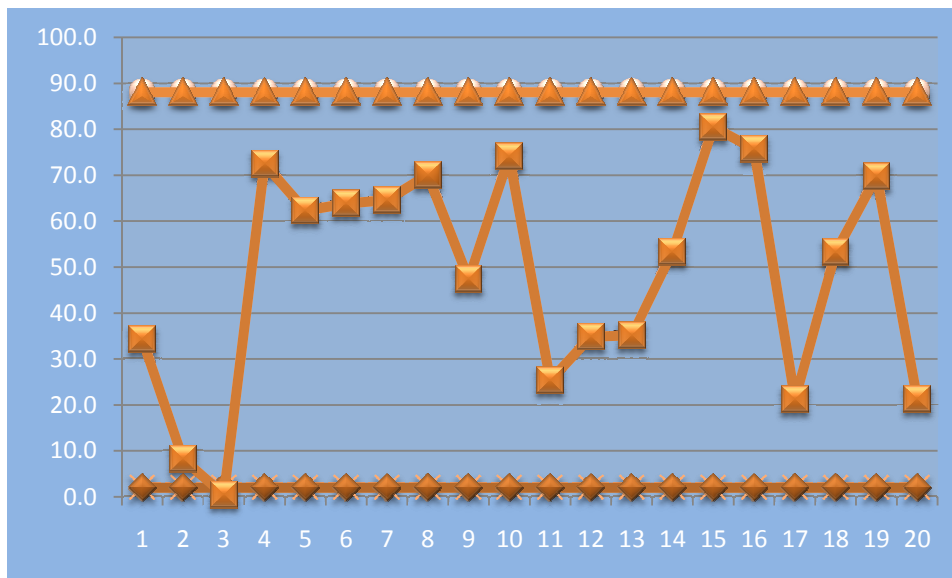


As can be seen from the above chart, 2 batches failed the quality test and were sent back to the supplier.

The recording of the final products follows a very similar procedure. The tested product result is a number which falls between 0 and 100, the acceptable range of the products falls between 2 and 88 any product that falls above or below this range is marked as reject, however if it can be reworked, the results will not be recorded and the plant is informed of the batch that can be reworked.

An example of the final products control chart is shown in figure 5-14 below.

**Figure 5-14: Final Product Control Chart**



All batches passed the quality test except for one; this one was rejected for an unknown reason.

### 5.3.3 Analysis and Use of the Control Charts

For the quality control department at Simitri, these charts would seem effective. They are easy to analyse, as either a batch has failed the quality control process or it has passed. However they do not make sense to many people outside of the quality control department. How each test is converted to a factor between 0 and 2 for the raw materials test was quite a complicated process and why it is converted could not be explained other than because that is how it is done. The exact same comments relate to the final products control chart. For the quality control analyst these charts make sense, however they are not the only department that needs to understand the quality control results.

Management needs to view these results in order to see how the process fairs and how and why a batch has failed the quality control process. If the reason behind the failure is not identified, the manufacturing process could reach the point of chaos and more products will begin to fail the quality control test.

Although the quality control department at Simitri is supposed to be one of the most important functions of the company, they are not very well organised and they do not have a lot of information to provide. This is positive for the reason of any improvement that can be made will

probably make a big difference to the running of this department; however in another respect the information that is provided is not entirely sufficient to determine what improvements should be made.

## **6 Solution Design and Evaluation**

### **6.1 Warehouse Operations**

The physical system of any warehouse is the most necessary system to put in place as this makes certain that any constraining, misapplied or outdated activities are eliminated and ensures more effective and efficient warehouse operations. In order to improve the overall operations within the warehouse facility, the industrial engineering method of facility layout will be applied. According to Tomkins et al. (Facilities Planning, 3<sup>rd</sup> edition) before layout planning can commence, the objectives of a warehouse layout must be determined. In general the objectives of a layout are:

- To use space efficiently
- To allow for the most efficient material handling
- To provide the most economical storage in relation to costs of equipment, use of space, damage to material, handling labour and operational safety
- To provide maximum flexibility in order to meet changing storage handling requirements
- To make the warehouse a model of good housekeeping

As was mentioned in the data and information gathering phase in the previous chapter and the objectives outlined above, the layout will be improved by looking at the following area's:

- Available space and Layout
- Receiving and shipping operations.
- Order picking operations
- Material handling equipment

Space requirements for a warehouse is the most difficult to determine. For the purposes of this project, however, the space requirements do not need to be determined. The warehouse is a fixed facility on the Simitri site and therefore what needs to be determined is how to use this space effectively. The most important considerations will be to determine how to arrange the

pallet racks in order to use the space effectively, as well as the aisle space for personnel and material handling equipment.

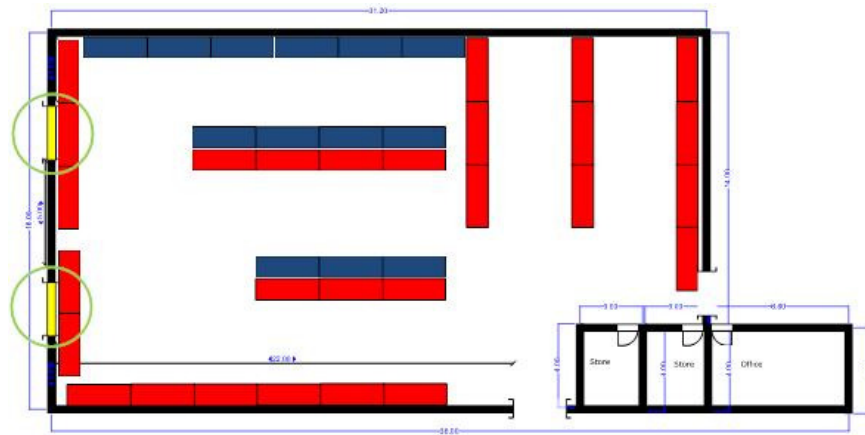
The table below, adapted from Facilities Planning (Tomkins et al, 2003), shows the various types of aisles widths that are recommended for the various types of flow. With the material handling equipment being used currently at Simitri the aisle widths should be no more than 2.7 meters; they are, however, up to and over 4 meters in width. This is diminishing the amount of space that is available for material storage use. The aisle width should however not be too narrow as well, although this will save space it may slow down the store and retrieve operations and result in greater damage. Cross aisles are also an option as they reduce travel times, they do also take up a lot of available space therefore a balance is required.

**Table 6-1: Recommended aisle widths for various types of flow**

<b><u>TYPE OF FLOW</u></b>	<b><u>AISLE WIDTH (m)</u></b>
<b>Tractors</b>	3.7
<b>3-ton Forklift</b>	3.4
<b>2-ton Forklift</b>	3
<b>1-ton Forklift</b>	2.7
<b>Narrow aisle truck</b>	1.8
<b>Manual platform truck</b>	1.5
<b>Personnel</b>	1

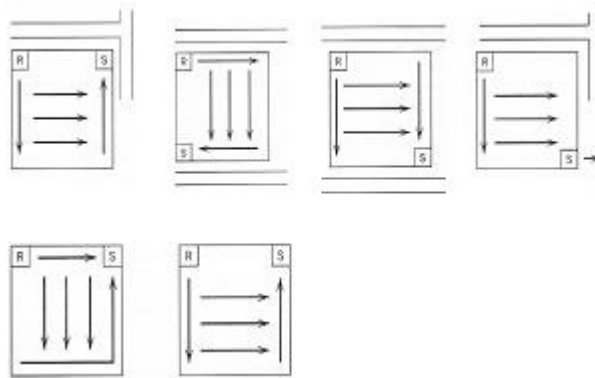
Receiving and shipping operations, as has been shown in figure 5-5, happen within the same area. This is a major space a time consideration. Figure 6-2 shows that there are two doors that are currently obstructed by pallet racks, which could be used as shipping and receiving areas. Access by trucks and personnel is not an issue. These are two separate operations and need to be kept separate in order to maintain control of the functions.

**Figure 6-1: Obstructed doors**



Possible arrangement of shipping and receiving areas depend on access to transportation facilities. Below are various arrangements of receiving and shipping areas that Simitri could use if their pallet racks are rearranged to make use of the obstructed doorways.

**Figure 6-2: Possible shipping and receiving arrangements**



Order picking is the most critical function in distribution operations. Warehouse professionals identify order picking as the highest-priority activity in the warehouse for productivity improvements (Tompkins et al.) which is the main aim of this project. The current order picking procedure has been discussed in the information and data gathering phase. The basis of the current procedure is good, however this can be built upon to make it more user friendly for the operators as well as to obtain better control. The idea of colour coding in order of the month that it is received in is basic, however it is a good idea. A solution to the problem of having colours that are difficult to differentiate is easily solved by allocating certain racks to the stock in order of

month as well as colour coding them so that any person performing the order picking task will also be able to distinguish if all the stock is in the right place this will ensure an effective stock location system. A cost analysis should be done to see whether the current practice of using spray paint to colour code, or using stickers will be the best option.

An order picking document is crucial; it should be a clear and easy to read document that provides specific instructions to the order picker making the job easier than it currently is. Figure 6-4 below is an example of such type of picking form. The main purpose to include these in the order picking procedure is, again, to maintain control over the movement of stock when it is being picked for use in the plant. This will also help in combining order picking tasks when applicable, as all materials that are needed for manufacture on the day are picked together. The combination of order picking tasks help to reduce the times:

- Travelling to, from and between pick locations
- Extracting items from storage locations
- Documenting picking transactions
- Sorting items into orders
- Packing items, and
- Searching for pick locations.

**Figure 6-3: Proposed picking slip**



**SIMITRI**  
SPECIALTY CHEMICALS  
PO Box 1235  
Chloorkop  
1624  
Phone: +27 11 9723235  
Fax: +27 11 9273234  
www.Simitri.co.za

# Pick Slip

Pick Slip	
Page	
Date	
Order Number	
Branch/Plant	

Order Date	Shipping Instructions

Description	Item Number	Quantity	Shipped	Backorder

There need not be any reason for change of the material handling equipment being used currently in the warehouse. As mentioned previously Simitri uses a one-ton forklift for all movements being performed in the warehouse. Although there was sufficient space for movement in the warehouse, the aisle space being used was far too much for what was required. This was taken into account in the warehouse redesign.

Four different solutions have been proposed. They follow in figures 6-5 to 6-8.

Figure 6-4: Alternative warehouse design A

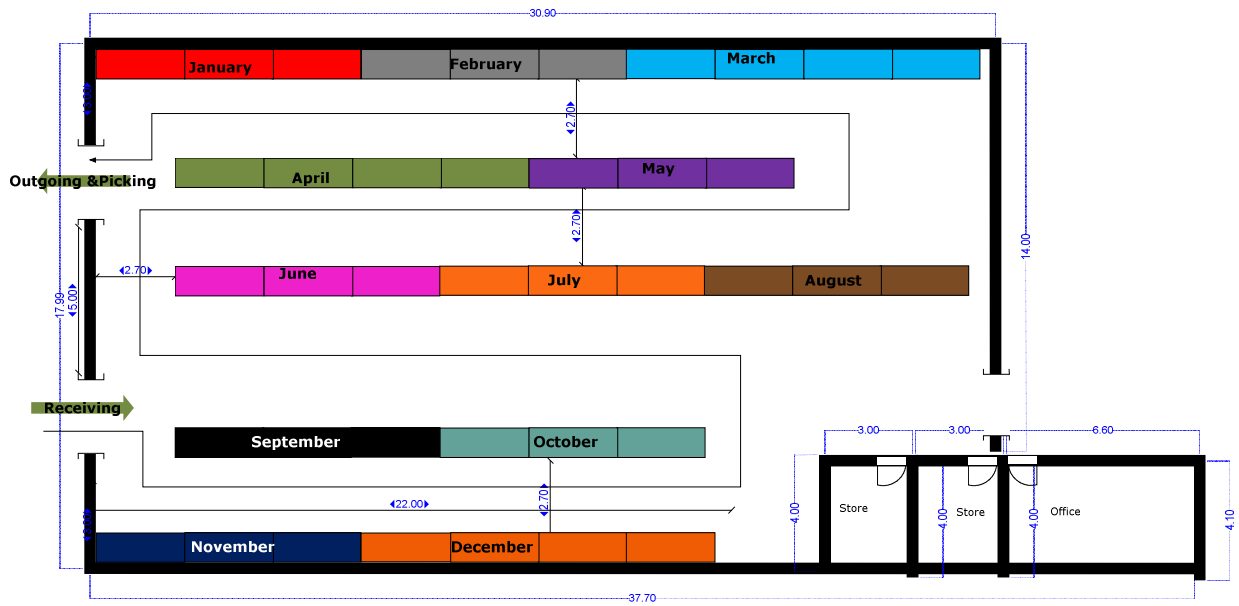
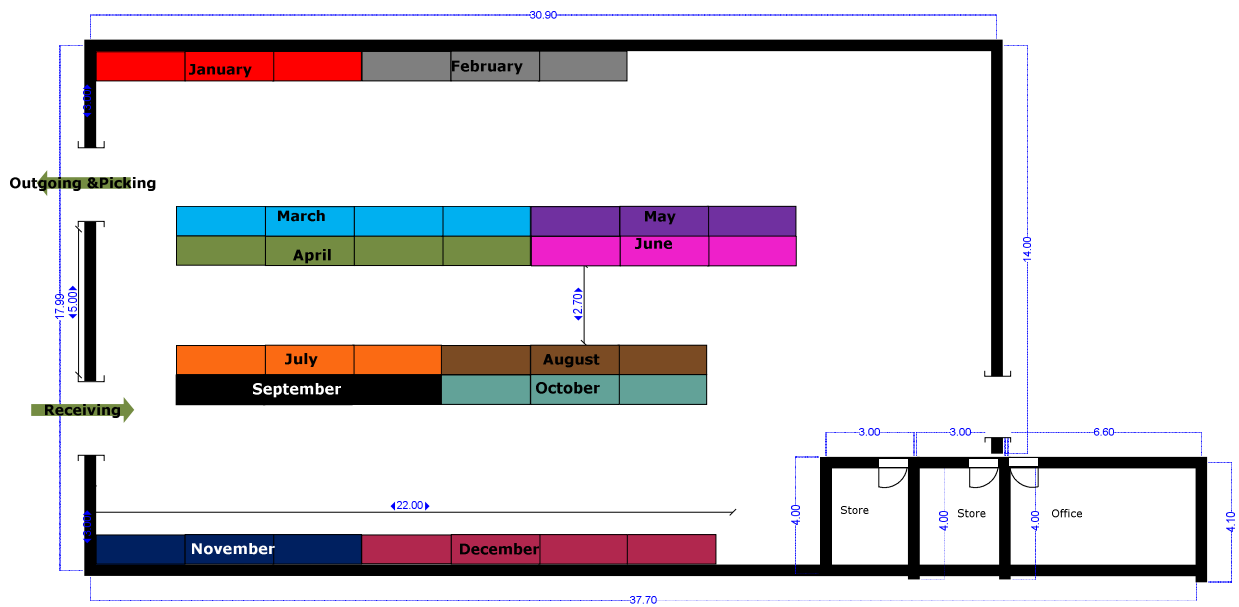


Figure 6-5: Alternative warehouse design B





The weighted factor comparison method has been used in order to compare the alternative solutions against a common set of factors. These factors are:

- Floor Space, amount of space available for personnel and material handling equipment as well as space for future expansion
- Forklift movement, the space available for the forklift to move
- Flexibility, for the workspace to be rearranged if necessary
- Ability to serve process operations, all operations that are required can be fulfilled successfully

Quantifying these factors was done in a way as to see which layout best suite the requirements listed. The ability to serve process operations was listed as the highest priority, this is because the focus of the project is to increase the productivity in the plant and warehouse, the ability to serve process operations will help increase the productivity and therefore is quantified as the highest weight in the layout comparison. Floor space is the next highest, this is due to the fact that there is a lot of movement within the warehouse from personnel as well as material handling equipment, and therefore floor space is a high ranking factor. Forklift movement and flexibility are ranked as equal. Material handling equipment, though expensive, can be changed. If the forklift proves to be too large for the warehouse more alternatives need to be considered. Flexibility must be included as a factor, because as with any warehouse the ability to expand must be considered. Table 6-2 below shows the results of the weighted factor comparison.

**Table 6-2: Results of the weighted factor comparison**

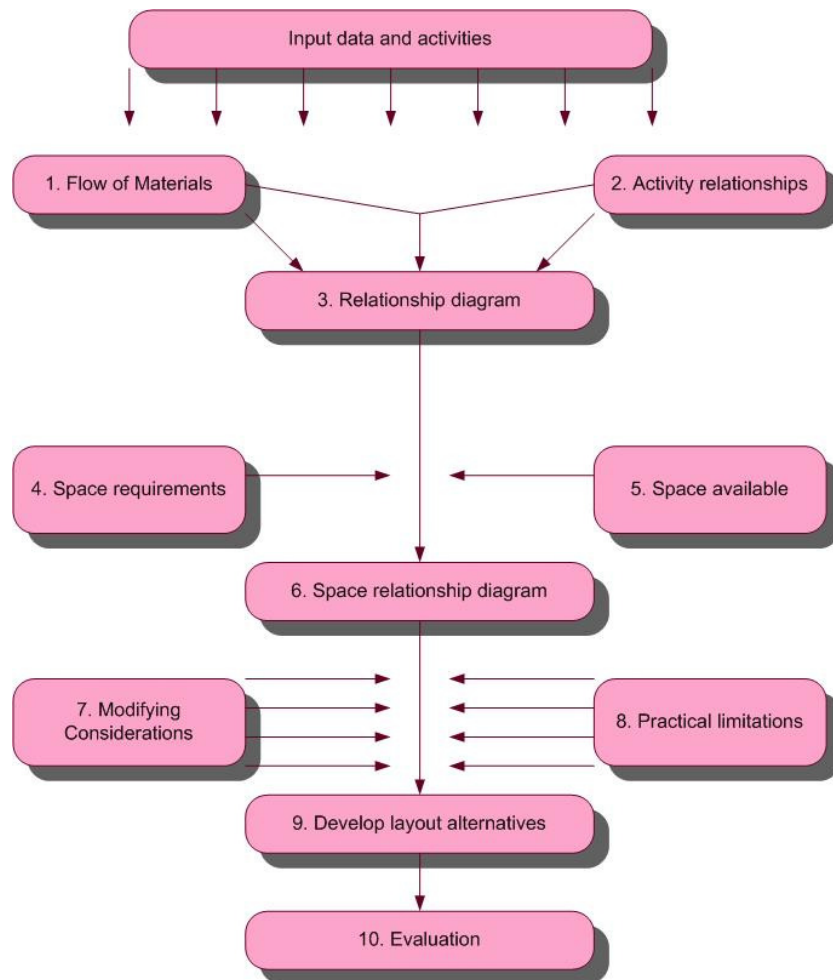
		A		B		C		D		
Factor	Weight	Rate	Score	Rate	Score	Rate	Score	Rate	Score	
<b>1</b>	Floor Space	25	15	375	20	500	10	250	15	375
<b>2</b>	Forklift Movement	20	10	200	15	300	20	400	15	300
<b>3</b>	Flexibility	20	15	300	15	300	20	400	15	300
<b>4</b>	Ability to serve process operations	35	20	700	15	525	25	875	25	875
		100		1575		1625		1925		1850

Layout C ranked the highest in the weighted factor comparison and will be suggested to management. Layout C has sufficient floor space available for the movement of personnel and material handling equipment, there is enough flexibility available for future expansion projects and has the best ability to serve the process operations efficiently and effectively. These improvements will be made with absolutely no cost to the company.

## 6.2 Facility Layout

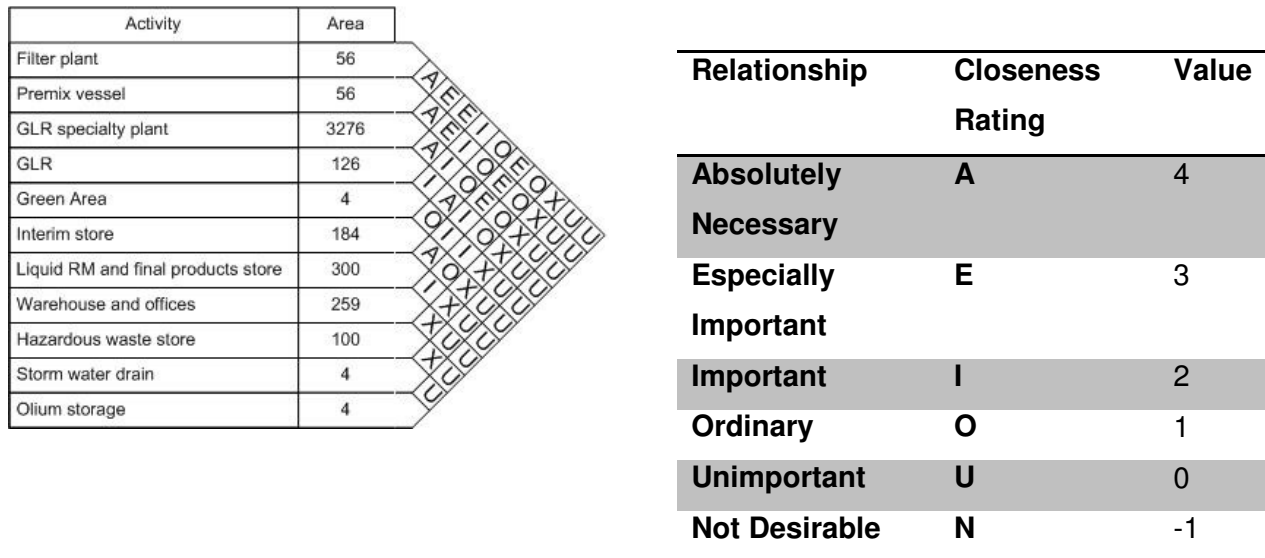
All the required information has been gathered to start with the modified SLP procedure. The solution design of the facility will follow the following order as laid out in Tompkins et al. (Facilities Planning, 2003):

**Figure 6-8: Systematic Layout Planning Procedure**



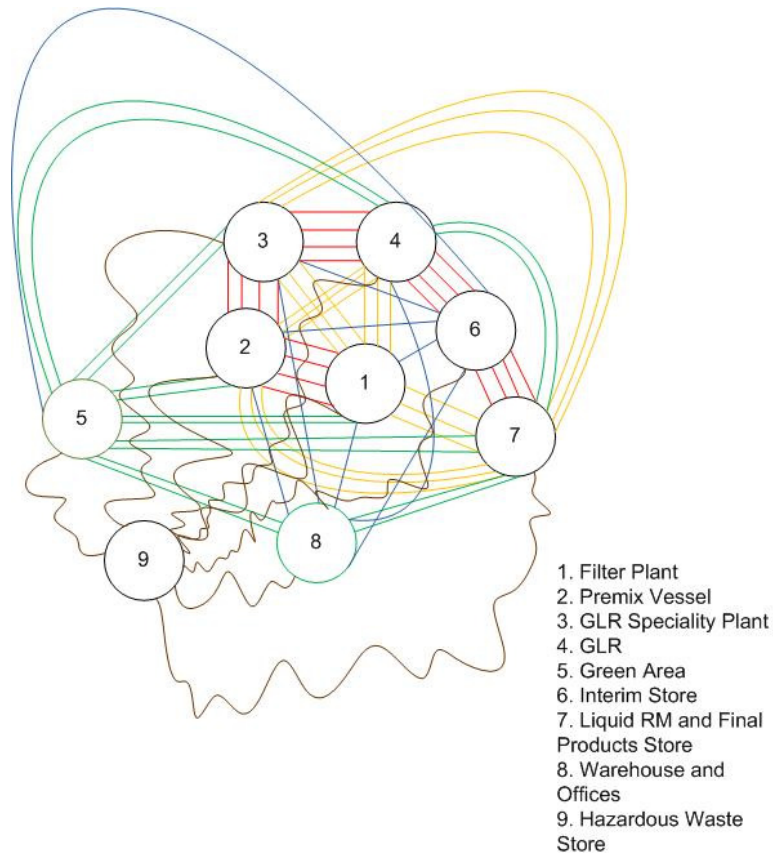
The relationship chart defines how the departments within the manufacturing plant interact. The chart has been drawn up to take into account all the areas of Simitri's manufacturing plant, although some of the areas, such as the storm water drain, are not part of the actual processes performed on the plant they need to be taken into account for space relationships and requirements. The relationships are defined in terms of the necessity of closeness that is required between two departments; this will help in the development of alternative layouts.

**Figure 6-9: Relationship chart of Simitri's manufacturing plant**



The requirements of all activities that take place on the plant need to be taken into account in order for the facility to perform optimally and more efficiently. The activities that do not form part of the production operations on the plant have not been included while determining the activity requirements as this will over complicate the problem as well as veer from the objective. The figure below is a visual representation of the different activities that happen on the manufacturing plant. The activity relationship diagram is based on the roles and relationships of the activities as described in the relationship chart as well as the flow process data (see figure 5-10).

**Figure 6-10: Activity Relationship Diagram**



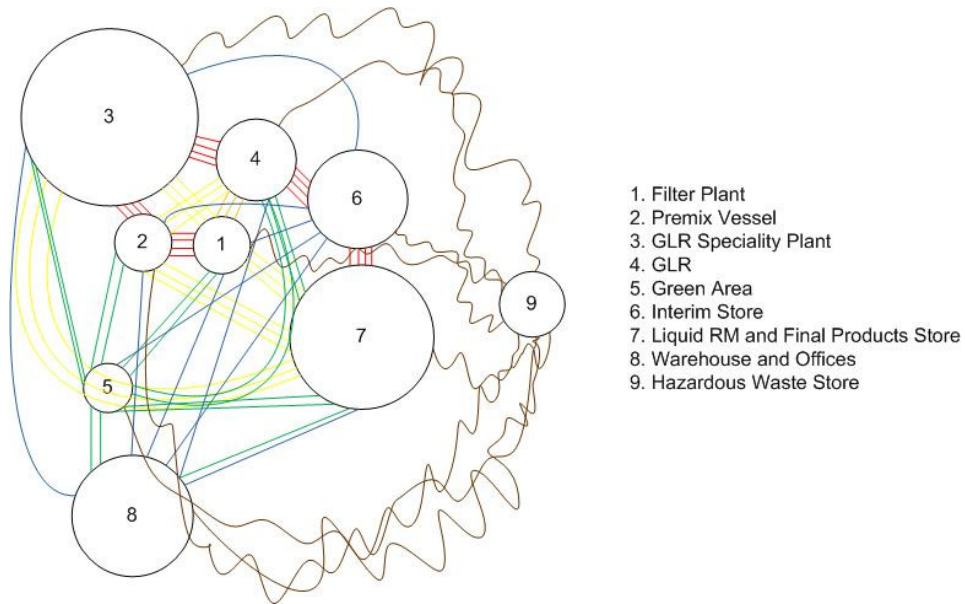
It is imperative that the space requirements are correctly defined in this phase of the procedure. Facility relocation is not an option; therefore the redesign of the facility must take into account the space that is available on the plant as well as the space that each area of the manufacturing process will occupy. The space requirements for each area on the Simitri plant were determined in the data and information gathering phase. The table showing the space requirements is repeated below:

**Table 6-3: Space Requirements for Plant Areas**

<b>Area</b>	<b>Space Required (m<sup>2</sup>)</b>
<b>Filter Plant</b>	56
<b>Premix Plant</b>	56
<b>GLR</b>	126
<b>GLR Speciality Plant</b>	3276
<b>Interim Storage</b>	184
<b>Storm Water Drain</b>	4
<b>Olum Storage</b>	4
<b>Hazardous Waste store</b>	100
<b>Liquid Raw materials and Final Products Store</b>	300
<b>Warehouse and Offices</b>	259
<b>Green Area</b>	4

Every activity is important and cannot be removed from the production process, and every facility on the plant must be accounted for. From the information in the table above as well as the activity relationship diagram a spatial representation can be created through the scaling of the different areas into their relative sizes. From the space relationship diagram it can be seen what the relative size of area is required for each department. The space relationship layout is depicted in the figure below.

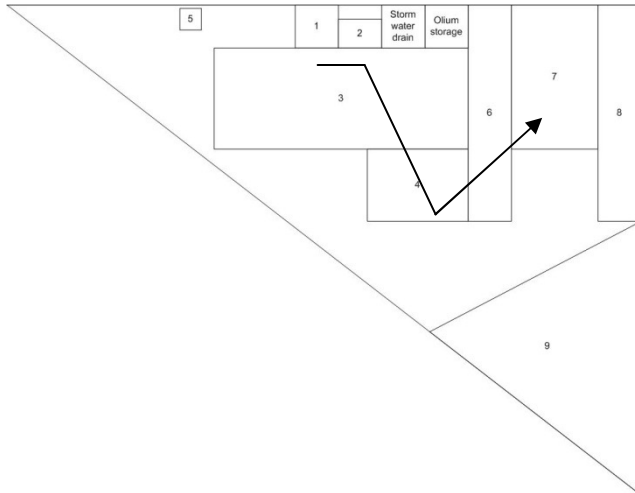
**Figure 6-11: Space relationship layout for Simitri manufacturing plant**



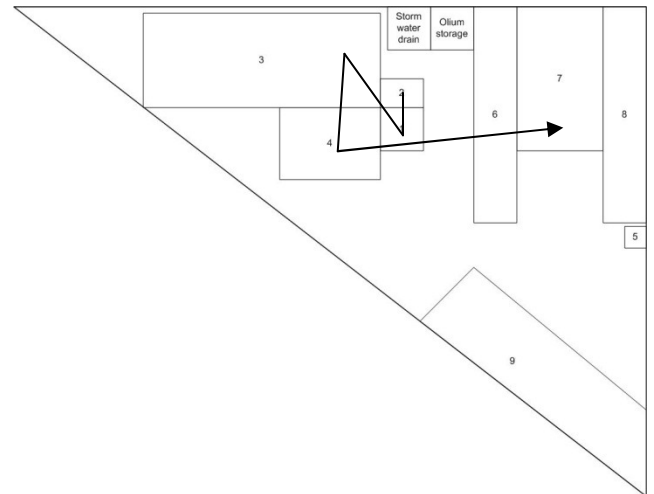
This space relationship diagram is then converted into block layouts. For a suitable solution to be developed it is vital that a number of layout alternatives are developed. All the information that has been gathered through all phases of the project must now come together to determine suitable and realistic alternatives for the facility redesign. Many alternatives can be acknowledged, however three of the identified possible solutions have been selected for evaluation. These alternatives are a conversion of all the previous phases of the SLP procedure into a floor plan or block layout. The three alternatives are shown below.

**Figure 6-12: Alternative block layouts a, b and c**

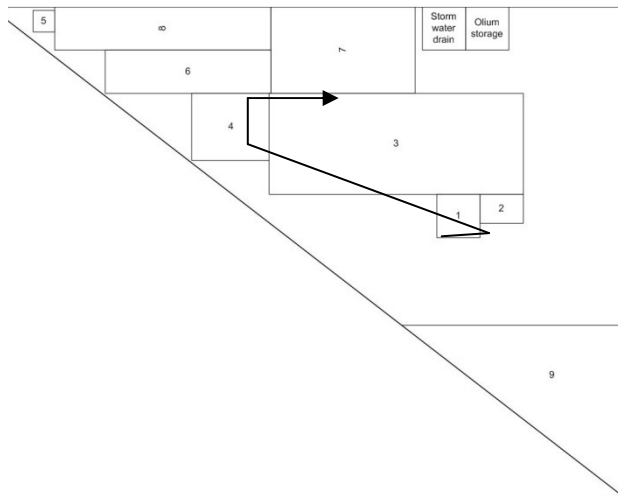
**a.**



**b.**



**c.**



Tompkins et al. defines four general flow patterns, with regards to flow between departments. It is not always possible to get the exact shape of flow that is required, especially since the shape of Simitri's manufacturing area is not square. The identified general flow patterns are straight-line, u-shaped, s-shaped and w-shaped. The arrangement of the facilities in alternative layout **a** is in a u-shape, alternative layout **b** is a combination of s-shaped and straight-line and alternative layout **c** is in a general s-shape. These layouts have been fashioned so that the flow is in one of these general shapes because they generally create effective flow between the different facilities.

The SLP process, once alternative layouts have been identified, generally uses the weighted average comparison technique to perform the evaluation of the alternatives. This is because the weighted average comparison technique generally delivers objective and unbiased results and is relatively simple to perform.

The criteria, and their respective weights, that have been selected to compare the alternative layouts are:

1. Ability to serve process operations	20
2. Space utilisation	15
3. Quality of product	12
4. Ease of rearrangement	10
5. Working conditions and employee satisfaction	8
6. Ease of control	7
7. Safety	10
8. Material handling costs	5
9. Ease of maintenance	5
10. Ease of future expansion	8

The sum of the weights is 100, and the layout alternative ranking against each factor is shown in the table below.

**Table 6-4: Weighted factor comparison between alternative layouts**

	Layout Alternatives		
	a	b	c
<b>Factor</b>			
<b>1</b>	15	10	15
<b>2</b>	8	7	12
<b>3</b>	10	10	10
<b>4</b>	4	4	4
<b>5</b>	5	6	5
<b>6</b>	5	5	5
<b>7</b>	7	7	6
<b>8</b>	4	3	2
<b>9</b>	4	4	4
<b>10</b>	3	5	6

**Table 6-5: Weighted Factor comparison Table for Evaluating the Alternative Layouts**

Factor	Weight	Ratings and Weighted Ratings					
		a		b		C	
<b>1</b>	20	15	300	10	200	15	300
<b>2</b>	15	8	160	7	140	12	240
<b>3</b>	12	10	200	10	200	10	200
<b>4</b>	10	4	80	4	80	4	80
<b>5</b>	8	5	100	6	120	5	100
<b>6</b>	7	5	100	5	100	5	100
<b>7</b>	10	7	140	7	140	6	120
<b>8</b>	5	4	80	3	60	2	40
<b>9</b>	5	4	80	4	80	4	80
<b>10</b>	8	3	60	5	100	6	120
	<b>100</b>		<b>1300</b>		<b>1220</b>		<b>1380</b>

By evaluating the alternative layouts using the weighted factor comparison method the following results were obtained:

- Layout a: 1300
- Layout b: 1220
- Layout c: 1380

On the basis of the results obtained by this method, the preferred solution would be alternative layout c with 1380 points, compared to 1300 points for alternative a and 1220 points for alternative b.

### 6.3 **Quality Management system**

The quality management system at Simitri is based on a very good quality control procedure. The procedure is concerned with continuous testing of the products, from the raw material products through the interim products and lastly the final products to be distributed to the customer. This procedure shows that Simitri is concerned with customer focus; however the recording procedure is not consistent with continuous improvement methods.

Continuous improvement incorporates six aspects in its cycle of continuous improvement. These six aspects are:

- Written policies, standards and procedures
- Staff training
- Supervision
- Internal and external audit
- Corrective action and
- Learning and improving services.

Simitri does have written policies, standards and procedures in which they conduct their quality control processes, this was discussed in the data and information gathering phase. A very basic explanation of their policies would be the testing procedure (raw materials, interim and final product testing), their standards would be the limits that the different products must fall within predetermined control limits, and the procedure would be the way that the lab analysts perform the testing. This is the only aspect that could be regarded as falling into the continuous improvement life cycle.

This section will cover only the corrective action step in the cycle as the other steps will need more of a management influence. For corrective action to be put into operation the following procedures will be established:

- Statistical process control
  - Use of the correct control charts
- Stabilising the process
- Improving the process

The interim products testing will not be dealt with here; rather the raw materials and the final products control charts will be designed.

There are many types of control charts that are used in quality management, and they fall under two categories, namely attribute control charts and variables control charts. Attribute control charts are based on counts or the number of times an event is observed. For attribute control charts, there are two basic types: the classification charts and the count charts. Variables control charts are based on numeric data (width, height, length etc.).

Currently, from inspection of the control charts in the data and information gathering phase (see figures 5-13 and 5-14), Simitri's quality control department are using a form of attribute control charts, the product is measured as either conforming or non-conforming. These, however, are not providing any department with enough information.

Variables control charts would be more useful for Simitri's final products as they "contain more information than attribute data. Furthermore, because variables control charts deal with measurements themselves, they do not mask valuable information and therefore are more powerful than attribute charts," (Gitlow et al.).

### **Raw Materials**

It has been decided that Simitri will use an attribute control chart for the charting of the information recovered from their raw materials quality inspection; in particularly the **p** classification chart. The conditions for use of a p chart (adapted from "Quality Management", Gitlow et al.) are as follows:

- The sample must be classifiable as either possessing or not possessing the characteristic
- The probability that the sample possess the characteristic is assumed to be stable
- The probability that a sample possesses the characteristic of interest is assumed to be independent of whether any other sample possesses the characteristic.

For simplicity sake as well as for demonstration purposes, only one of the raw materials will be charted using the **p** chart; however the process will be the same for any other raw material that is used by the plant.

The raw material that is being tested must be tested in constant subgroup sizes. For this instance a subgroup size of 10 will be used. “Constant subgroup size implies that the same number of items is sampled and then classified for each subgroup on that chart” (Gitlow et al.). A sample size of ten has been chosen because 10 bags of the raw material are delivered each week according to the forecast. The raw material being tested will be classified as non-conforming or conforming product, the aspect of the raw material being tested is the correct content of element X (please note that under confidentiality agreement no material names can be mentioned). Below is a table showing three months of weekly tested raw material coming in from the supplier.

**Table 6-6: Table showing weekly non-conforming product**

<b>Day</b>	<b>Sample Size</b>	<b>Number of Non- Conforming Products in Batch</b>	<b>Fraction</b>
<b>July 6</b>	10	1	0.1
<b>13</b>	10	1	0.1
<b>20</b>	10	4	0.4
<b>27</b>	10	2	0.2
<b>August 9</b>	10	1	0.1
<b>10</b>	10	6	0.6
<b>17</b>	10	1	0.1
<b>24</b>	10	3	0.3
<b>31</b>	10	1	0.1
<b>September 7</b>	10	1	0.1
<b>14</b>	10	1	0.1
<b>21</b>	10	1	0.1
<b>28</b>	10	4	0.4
<b>Totals</b>	130	27	

The next step will be to calculate the centreline; this is the average fraction of non-conforming products and is calculated using equation 6-1.

$$\text{Centerline } (p) = \bar{p}$$

$$= \frac{\text{Total number of non - conforming products in all subgroups under investigation}}{\text{Total number of units examined in all subgroups under in vestigation}} = \frac{27}{130}$$

$$= 0.207692$$

**6-1**

The next step is to calculate the upper and lower control limits. The upper control limit (UCL) is calculated as  $\bar{p}$  plus three times the standard error and the lower control limit (LCL) is calculated

as  $\bar{p}$  minus three times the standard error. Control limits are also referred to as three-sigma limits, where sigma ( $\sigma$ ) is used to denote the process standard deviation. The calculation of the control limits are shown in equations 6-2 and 6-3.

$$UCL(p) = \bar{p} + 3 \sqrt{\frac{\bar{p}(1-\bar{p})}{n}} = 0.192308 + \sqrt{\frac{0.192308(1-0.192308)}{10}} = 0.592531$$

6-2

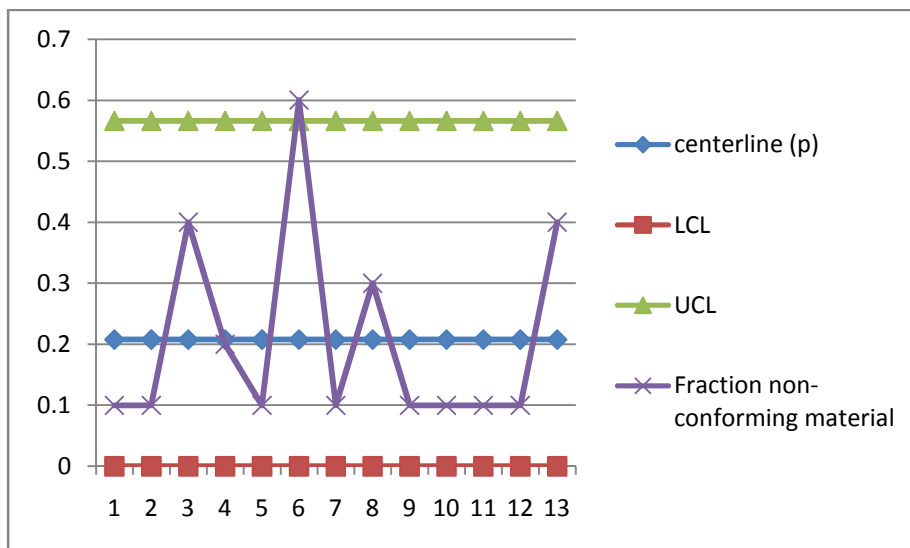
$$LCL(p) = \bar{p} - 3 \sqrt{\frac{\bar{p}(1-\bar{p})}{n}} = 0.192308 - \sqrt{\frac{0.192308(1-0.192308)}{10}} = -0.17715$$

6-3

The lower control limit is a value below zero; this is meaningless therefore a zero will be used as the LCL instead.

All this information is plotted on a line chart along with the fraction of non conforming products. This can be done in many available programs; however because Microsoft Excel is readily available and all the lab analysts are trained to use it, it will be used for recording of the data. Below is a graph showing the completed p-chart.

**Figure 6-13: p-chart for fraction of non-conforming product**



It can be seen that the process is not in control, this can be seen from the outlying point on 10 August, which has a fractional value of 0.6. Going back to the data, it can be seen that 6 of the bags of raw material were non-conforming.

This is where the usefulness of the control charts come into effect. The supplier was then contacted and informed about the out of specification raw material, when posed with the question of why 60% of the delivered product was out of spec, the purchasing department found out that there had been a problem on the suppliers manufacturing facility which led to many products being made out of specification.

If there are any outlying points on the control charts, the lab can find out why there was a problem and then eliminate the non-conforming products. This forms part of the process stability and improvement study.

According to Gitlow et al. the attribute process capability study will determine the process's capability in terms of fraction defective output for a unit of input. The process capability for a p chart is  $\bar{p}$ , therefore for the raw materials the process capability will be 0.207692. The problem with attribute capability studies is that it is not specific about why the product did not meet specification. This, however, is not important to Simitri as it is not their products that are failing to meet specifications and therefore the product can be replaced by the supplier company.

The attribute process capability studies requires that there is a lot of data, specifically, according to Gitlow et al., that there be twenty to twenty five samples per time period. Unless Simitri does the control charts once every two weeks rather than once a week, there is not enough data to perform the process capability study. This does not pose a problem; the process capability study does not have to be performed on the raw materials as they are considered uncontrollable by Simitri. However if the results of the control charts follow the trend of always having outlying points, then Simitri should reconsider their supplier and try find a supplier who can deliver a greater percentage of conforming products.

A process improvement study will also not be conducted here because the information will prove useless to the plant.

The  $\bar{p}$  charts recorded should be submitted to management on a monthly basis for review by management as well as the concerned departments, this is so that the relevant parties are

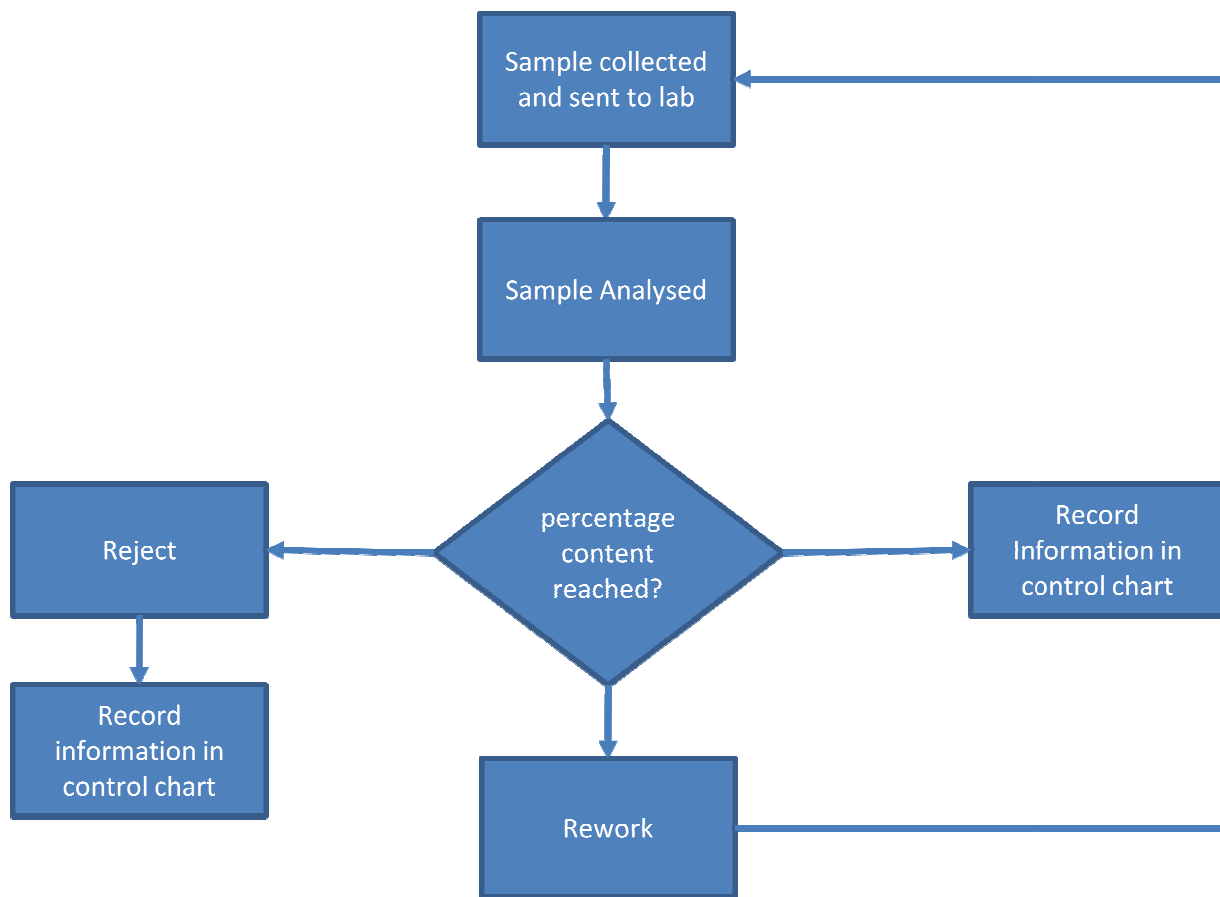
informed of what is happening in all aspects of the company and therefore make sure that corrective action is taken.

### Final Products

The  $\bar{x}$  and R chart will be used to record the process variability (R) and the subgroup average ( $\bar{x}$ ). The product is measured as a percentage of content, and the sold product could range from a 40% content to a 100% content. The focus here will be on the products with 80% content as this is the most popular product sold.

The process that is shown in the figure below is one that Simitri should use to test and record the content percentage of their product.

Figure 6-14: Process for sampling content



The process for producing this product is unpredictable; the timing of the operations is vital and if at any point something is done wrong the whole process could be jeopardy. This is one of the reasons why sampling is done so frequently.

The  $\bar{x}$  and R chart will be used in the analysis of one batch of the 80% product. Generally the acceptable percentage will range between 78 and 82% for the customer to be happy with the quality; anything that lies outside of these values will not be acceptable.

The information that was collected was done over a 3 month time frame in which 20 batches were produced. Each batch that was produced was sampled twice and sent immediately to the lab. The results of the testing of the content are shown in the table that follows:

**Table 6-7: Table showing percentage content of 20 consecutive batches**

Observation No.	batch number	Percentage Content	
		1.0	2.0
1.0	1.00	78.7	79.5
2.0	2.00	79.0	79.3
3.0	3.00	89.0	80.0
4.0	4.00	79.5	79.8
5.0	5.00	80.8	81.3
6.0	6.00	79.7	80.0
7.0	7.00	78.1	79.3
8.0	8.00	79.5	79.7
9.0	9.00	78.7	81.2
10.0	10.00	78.2	78.9
1.0	11.00	78.0	78.3
12.0	12.00	79.1	81.5
13.0	13.00	80.6	79.4
14.0	14.00	79.8	79.4
15.0	15.00	79.1	79.7
16.0	16.00	81.7	80.7
17.0	17.00	80.5	78.1
18.0	18.00	80.6	80.9
19.0	19.00	81.2	81.9
20.0	20.00	78.9	78.9

A sample size of two was chosen as the testing procedure is highly expensive, but there still needs to be more than one sample to make sure that the test results are consistent.

The  $\bar{x}$  and R variables control charts is a two step process. First the subgroup range (R) is calculated along with its control limits, these are then plotted in the R chart to determine the process variability. Then the subgroup average ( $\bar{\bar{x}}$ ) is calculated along with its control limits and plotted in the  $\bar{\bar{x}}$  chart to record the process location.

Range Chart:

The first step in producing the range chart is to calculate R; this is done using equation 6-4:

$$R = R_{max} - R_{min}$$

**6-4**

It will be easier to understand using the following table, the  $R_{max}$  values are highlighted in red and the  $R_{min}$  values are highlighted in yellow.

Table 6-8: Table showing R<sub>min</sub> and R<sub>max</sub> values

Batch Number	Percentage Content		Nominal	%:
	1.0	2.0	80%	
			R	
1.00	78.7	79.5		0.7
2.00	79.0	79.3		0.3
3.00	89.0	80.0		9.0
4.00	79.5	79.8		0.4
5.00	80.8	81.3		0.5
6.00	79.7	80.0		0.2
7.00	78.1	79.3		1.2
8.00	79.5	79.7		0.2
9.00	78.7	81.2		2.5
10.00	78.2	78.9		0.8
11.00	78.0	78.3		0.3
12.00	79.1	81.5		2.5
13.00	80.6	79.4		1.2
14.00	79.8	79.4		0.4
15.00	79.1	79.7		0.6
16.00	81.7	80.7		1.0
17.00	80.5	78.1		2.4
18.00	80.6	80.9		0.3
19.00	81.2	81.9		0.7
20.00	78.9	78.9		0.0
				25.0

The average R values ( $\bar{R}$ ) and is calculated using equation 6-5:

$$\bar{R} = \frac{\sum R}{k}, \text{ where } k \text{ is the number of subgroups.}$$

$$k = 20$$

$$\bar{R} = \frac{25}{20} = 1.3$$

6-5

The upper and lower control limits are then calculated using equation 6-6 and 6-7.:

$$UCL(R) = D_4 \bar{R}$$

$$UCL(R) = 3.267 * 1.3 = 4.1$$

6-6

$$LCL(R) = D_3 \bar{R}$$

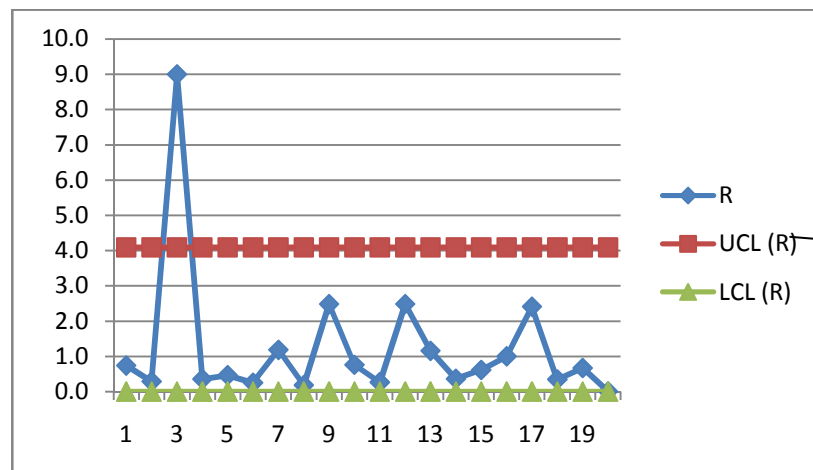
$$LCL(R) = 0 * 1.3 = 0$$

6-7

The values of  $D_4$  and  $D_3$  are determined from the book Quality Management (Gitlow et al.) in Appendix B table B.1.

Everything that is necessary to draw the R portion of the variable control chart has been calculated; below is the range chart for the sampling of the product.

**Figure 6-15: Range chart for sampling of product**



As can be seen there is one out of control point shown in the range chart; however this will be discussed in the process improvement and capability studies.

The next phase is to now produce the  $\bar{x}$  chart. The  $\bar{x}$  chart shows the variation in the averages for each of the subgroups. The equation that is used is shown in equation 6-8.

$$\bar{x}_j = \frac{\sum_{i=1}^z y_i}{z}, \text{ where } i \text{ is the sample number within the subgroup; } 1 \leq i \leq z$$

$k$  is the percentage content

$z$  is the number of observations in the subgroup;  $z = 2$

**6-8**

Therefore:  $\bar{x}_1 = \frac{78.7+79.5}{2} = 79.1$

The rest of the  $\bar{x}$  calculations are shown in the table below:

**Table 6-9: Table showing the x calculations**

Observation No.	Batch Number	Percentage Content		Nominal	R	%	$\bar{x}$
		1.0	2.0	80%			
1.0	1.00	78.7	79.5		0.7		79.1
2.0	2.00	79.0	79.3		0.3		79.2
3.0	3.00	89.0	80.0		9.0		84.5
4.0	4.00	79.5	79.8		0.4		79.6
5.0	5.00	80.8	81.3		0.5		81.1
6.0	6.00	79.7	80.0		0.2		79.9
7.0	7.00	78.1	79.3		1.2		78.7
8.0	8.00	79.5	79.7		0.2		79.6
9.0	9.00	78.7	81.2		2.5		79.9
10.0	10.00	78.2	78.9		0.8		78.5
11.0	11.00	78.0	78.3		0.3		78.2
12.0	12.00	79.1	81.5		2.5		80.3
13.0	13.00	80.6	79.4		1.2		80.0
14.0	14.00	79.8	79.4		0.4		79.6
15.0	15.00	79.1	79.7		0.6		79.4
16.0	16.00	81.7	80.7		1.0		81.2
17.0	17.00	80.5	78.1		2.4		79.3
18.0	18.00	80.6	80.9		0.3		80.7
19.0	19.00	81.2	81.9		0.7		81.6
20.0	20.00	78.9	78.9		0.0		78.9
					25.0		1599.2

The next step is to calculate  $\bar{x}$ , this is the centreline of the control chart:

$$\bar{x} = \frac{\sum x_i}{k}$$

**6-9**

Therefore:  $\bar{x} = \frac{\sum x_i}{k} = \frac{1559.2}{20} = 80$

The upper and lower control limits are calculated using equations 6-10 and 6-11 below:

$$UCL = \bar{\bar{x}} + A_2\bar{R}$$

6-10

$$LCL = \bar{\bar{x}} - A_2\bar{R}$$

6-11

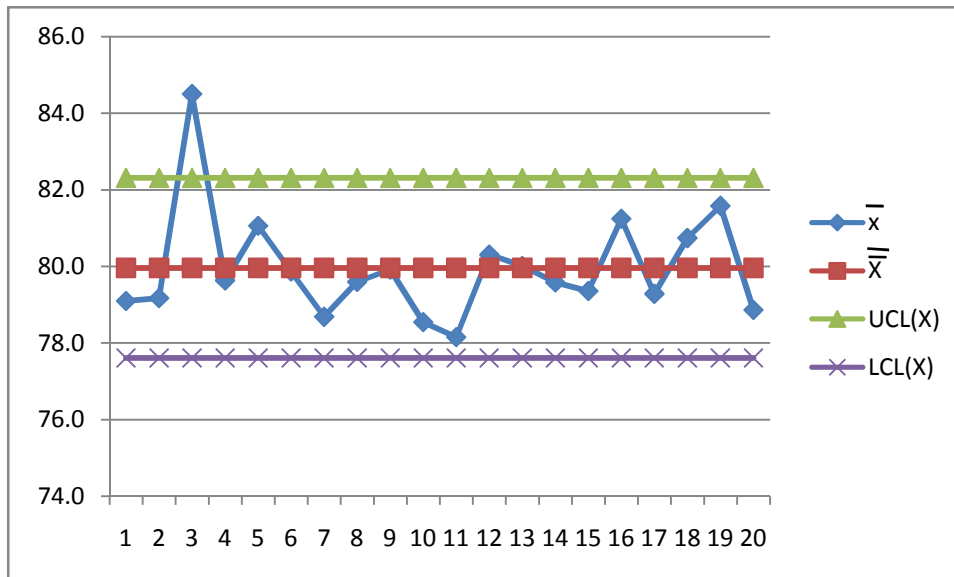
$A_2$  is found in table B<sub>1</sub> "Quality Management," Gitlow et al. Therefore:

$$UCL = \bar{\bar{x}} + A_2\bar{R} = 80 + 1.880 * 1.3 = 82.3$$

$$LCL = \bar{\bar{x}} - A_2\bar{R} = 80 - 1.880 * 1.3 = 77.6$$

The  $\bar{x}$  chart is shown in the figure below

**Figure 6-16:  $\bar{x}$  chart of sampling of product**



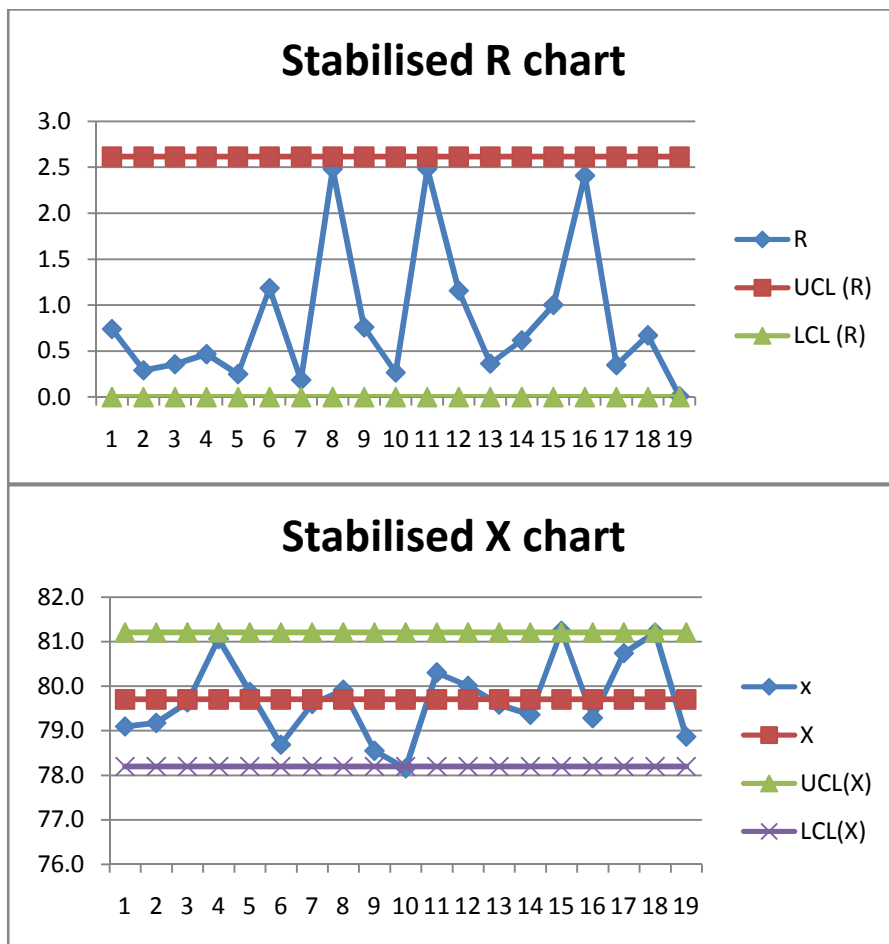
Notice that one of the points is outside the control limits; this indicates a lack of control. To determine the source of this special variation further investigation is needed. However the  $\bar{R}$  cannot be evaluated properly until the  $\bar{x}$  chart has been stabilised.

The process capability study requires that both charts be in statistical control. To stabilise the control charts the points that are out of control (outlying points) need to be eliminated, before this elimination can happen the source of the lack of control must be determined.

The lab analysts questioned the manufacturing plant as to why observation number 3, sample one had such a high percentage content. The manufacturing plant investigated this and came to no conclusion, upon further research by the lab analyst it was found that the sample tested had not been labelled properly and was actually a sample form one of the 90% content products. This conclusion to the outlying point can now be used to eliminate that observation number from the information gathered.

The following figure shows both the control charts in statistical control.

**Figure 6-17: Stabilised  $\bar{R}$  and  $\bar{X}$  charts**



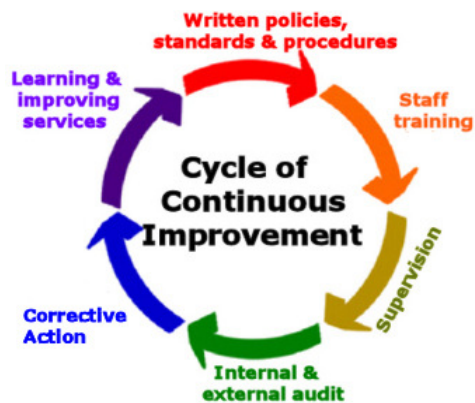
The process is now stable, the benefits of this now stable process is that it has a known capability. However, a stable process can still produce defective items and will continue to do so as long as the system stays the same. Management is considered the “owner” of the system and no process will change unless management takes the steps necessary to reduce common variation and also to reduce the difference between the customer needs and process performance.

The improvement study is focussed on two improvement areas, namely:

- Reducing the process average
- Reduce the level of common variation

Reducing the process average includes trying to reduce the number of defects or changes in process to increase the level of production. The level of common variation needs to be reduced in order to fall into the scope of continuous improvement and customer focus. This is where the cycle of continuous improvement falls in.

**Figure 6-18: Cycle of Continuous improvement**



Staff training is a strong element in reducing the level of common variation. All plant staff should be trained correctly and in the same way in order for the common variation to be reduced. The procedure that the workers follow should be consistent and should be standardised as much as possible for the workers to perform their jobs properly and so that an exact time frame can be allocated to the production of the products. The sampling procedure is a good aspect, especially since there needs to be improvement studies a lot of information is needed to ascertain where things might be going wrong on the plant and where new or improved procedures need to be

implemented in order for the workers to do their part in minimising the variation. Reducing the process average and reducing the process variation should go hand-in-hand and should be done coincidentally. Once the area's that need improvement are found, corrective action can then take place and therefore improvement of service will follow.

## 7 Conclusion

The current state of Simitri Speciality chemicals is that of an inefficient manufacturing facility, warehouse and quality control laboratory. This projects main aim was to centre on the customer focus by improvement of three main areas in the company:

- The manufacturing facility
- The warehouse and
- The quality control laboratory

The manufacturing facility has a facility layout that was not designed for Simitri's current manufacturing operation, with the result of excessive material handling and transportation of materials. Operators are making the best use of what they have been handed, but this is not sufficient. Focusing in on the facility layout of the manufacturing plant, there has been an attempt to rectify this situation by the redesign of the facility and its resources. The selected layout was chosen for implementation as it has the ability to reduce the operation time. It has been suggested to management that this facility layout be implemented in order to help reduce manufacturing time as well as to make the operator's job easier and therefore better done.

The warehouse design also used facility design to help with the flow of materials through the warehouse. With the use of basic warehouse operations, such as the use of picking forms, improving the flow of operations by making use of the currently hidden entrance and exit area's and by a very basic first-in first-out procedure, the warehouse can be run effectively efficiently and at a lower cost to the company. Alternative layouts were designed, and the best layout was selected by making use of the weighted average method.

The quality control laboratory and the quality management system was the last to be focussed on. The laboratory had an inefficient way of recording data of the raw materials as well as for the final products. With the focus on this and by making use of quality management principles and control charts the efficiency and the usefulness of this lab and the data that it provides can be improved dramatically. Management needs to understand that taking a proactive role in this area can greatly increase the usefulness of its lab as well as increase customer awareness and satisfaction.

All that this project contains is suggestions to the future state of Simitri Speciality Chemicals and possible solutions to some of Simitri's problems. In solving these inefficiencies there could be a great cost saving and an increase in their customer support base.

## 8 References

Tompkins, J., White, J., Bozer, Y., Tanchoco, J. 2003. Facilities Planning: Third edition. Massachusetts: John Wiley and Sons.

Kelton, W., Sadowski, R., Sturrock, D. 2007. Simulation with Arena: Fourth edition. New York: McGraw-Hill.

Gitlow, H., Oppenheim, A., Oppenheim, R., Levine, D. 2005. Quality Management: Third edition. New York: McGraw-Hill.

Coyle, J., Bardi, E., Langley, C. 2003. The Management of Business Logistics: A Supply Chain Perspective. Ohio: Thomson Learning.

Pooley, J. Integrated Production and Distribution Facility Planning at Ault Foods. *Interfaces*, 4:113-121.

Acklesberg, R. Small Businesses do plan and it pays off. *Long Range Planning*, 5:61-67.

Ishiwata, J. (translated by Talbot, B.). 1997. IE for the shop floor 1: Productivity through process analysis. New York: Productivity Press.

Ghalayini, A., Noble, J., Crowe, T. Integrated Dynamic Performance Measurement System for Improving Manufacturing Competitiveness. *Production Economics*, 1996:207-225

Carillo, J., Gaimon, C. Improving Manufacturing Performance through Process Change and Knowledge Creation. *Management Science*, 2:265-288.

Van den Berg, J.M., Zijm, W.H.M. Models for Warehouse Management: Classification and Examples. *Production Economics*, 59:519-528.

Aleisa, E.E., Lin, L. (2005). For Effective Facilities Planning: Layout Optimisation then Simulation, or vice versa? In Proceedings of the 2005 Winter Simulation Conference.

Pearson, T. Measurements and the Knowledge Revolution. *Quality Press*, 1999.

Mengjie, Y., de Koster, B.M. The Impact of Order Batching and Picking Area Zoning on Order Picking System Performance. *European Journal of Operational Research*, 198:480-490.

Samson, D., Terviovski, M. The Relationship between Total Quality Management Practices and Operational Performance. *Journal of Operations Management*, 17:393-409.

Foulds, L. R. (1983). Techniques for Facilities Layout: Deciding Which Pairs of Activities Should be Adjacent. *Management Science*, 29:1414-1426

Chien, T. (2004). An empirical study of facility layout using a modified SLP procedure. *Journal of Manufacturing Technology Management*, 15:455-465

Vollman, T. E., Buffa, E. S., (1966). The facilities Layout Problem in Perspective. *Management Science*, 12:B450-B468

Berg, J.D., (1999). Models for Warehouse Management and Classification Examples. *European Journal of Production Economics*.

Gu, J., Goetschalckx, M., McGinnis, F., (2006). Research on Warehouse Operation: A Comprehensive Review. *European Journal of Operational Research*, 177:1:1-21

Dira, A., Pierreval, H., Hajri-Gabouj, S., (2007). Facility Layout Problems: A Survey. Institut National des Sciences Appliquées et de Technologie.