An analysis of the information handling system at TFM Industries

by

J. du Plessis
28254148

Final Project Document

Submitted in partial fulfilment of the requirements for the degree of

BACHELORS OF INDUSTRIAL ENGINEERING

in the

FACULTY OF ENGINEERING, BUILT ENVIRONMENT AND INFORMATION TECHNOLOGY

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

UNIVERSITY OF PRETORIA

October 2012

Executive Summary

TFM specialises in the import, manufacturing, supply and support of specialist truck bodies for the transport, construction, forestry, cargo body, waste and environmental transport industries. The company consists of six separate facilities in the Olifantsfontein area. The project will focus specifically on the Main Plant facility. TFM recently realized that the company's current production and planning systems were outdated and ineffective, and that steps needed to be taken to improve this. The company decided that reassessing the current enterprise resource planning (ERP) system and bringing in new technologies would be the best course of action. Newer technologies and more modern views of production planning have all contributed globally to better product and process management techniques. The aim of this project is to investigate the methods and technologies that will enable TFM industries to have in time, in sequence, and accurate manufacturing progress information readily available. In the first stages of the project the main goal was to define the project problem statement, aim and scope. The next step was to identify what technologies would be best suited to the project and research each option extensively. The chosen technology was then researched further to determine the technical specifications. The next stage was to identify the available methods, tools, and techniques required to analyse the problem feasibility and requirements. Material and information flow diagrams, feasibility studies and requirements analysis techniques were identified as the most appropriate tools and were used to define and evaluate the current and proposed information handling system. The material and information flow diagram shed some light on the complexity of the system and aided in identifying the key areas that require improvement. The requirements analysis aided in discovering TFM's needs and will be used to explain these needs to the system developers. The feasibility study was formulated in a feasibility matrix that proved that the proposed system would be a viable solution. The final step was to determine how the system should be implemented and to develop clear instructions and procedures for employees to follow once the system is operational.

Table of Contents

List of Figures

List of Tables

List of Acronyms

Acronym	Description
AHP	Analytic Hierarchy Process
Assy. MO	Assembly Manufacturing Order
BOM	Bill of Materials
CCD	Charged Coupled Device
EAN	European Article Number
ERP	Enterprise Resource Planning
GA	General Assembly
LED	Light Emitting Diode
MO	Manufacturing Order
NATO	North American Treaty Organization
PDF	Portable Data File
PO	Purchase Order
QR Code	Quick Response Code
RF	Radio Frequency
RFID	Radio-frequency Identification
RM	Raw Material
RO	Read Only
RTP	Request to Purchase
RW	Read Write
UGPIC	Universal Grocery Products Identification Code
UID	Unique Identification
UPC	Universal Product Code
USB	Universal Serial Bus
WIP	Work In Process
WORM	Write Once, Read Many

Chapter 1 - Introduction and Purpose of Study

1.1 Company Background

TFM Industries was originally established in 1966 to specialise in truck customisation, maintenance and repair. In the late 1970's the company decided to expand its production into the armoured vehicle industry. It is well known for its products such as the Casper, Nyala, Scout and RG31 military and riot control vehicles, which were used by the United Nations and the North Atlantic Treaty Organization (NATO) as well as the SA Security Forces.

Today however TFM specialises in the import, manufacturing, supply and support of specialist truck bodies for the transport, construction, forestry, cargo body, waste and environmental transport industries. Some of the products include: ambulances, cash-in-transit vehicles, tippers, trash compactors, mixers, fuel tanks, trailers of all sizes, various components for the automotive and engineering industries, specialized conversions and even motorcycle and side-car ambulance combinations for use in rural areas where access is limited.

TFM has also created some valuable relationships with various international companies such as HEIL (USA), Faun (Germany), Meiller (Germany), Doppstadt (Germany), Schwing Stetter (Germany), Theam (France), Marrel (France), PZB (Italy), Cargo Van (Germany), Marathon (USA) and Southfields (England).

Figure 1 - TFM MK4 Mixer

1.2 Facility Background

The company consists of six separate facilities in the Olifantsfontein area in Ekurhuleni, Gauteng. Figure 2 shows the five facilities in the Clayville Industrial area in Olifantsfontein. They can be categorised as follows:

- Main Plant – Construction Equipment and Specialised parts
- West Plant – Environmental Equipment, Defence, Medical and Custom projects
- North Plant – Cargo bodies
- East Plant – Product Support
- Logfin – Logistics, Finances and Industrial components
- Wynberg – Trailers, Beverage- and Dry bulk feed transport solutions, Rigid Bodies.

The main focus of this project will be on the Main plant, and could at a later stage be expanded to include the other facilities as well. The Main plant facility acts as a supplier to the West plant as the Main plant facility has specialist equipment such as a plasma cutter and automated press brake.

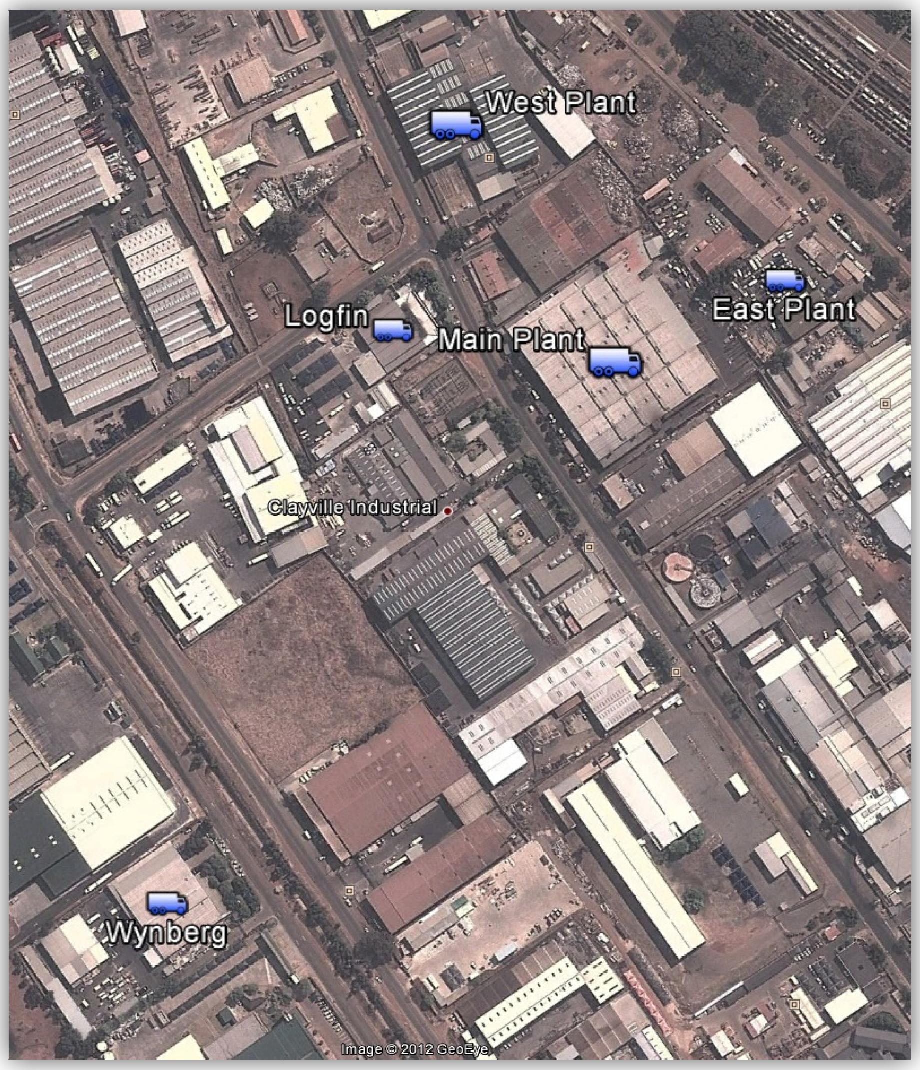

Figure 2 - Locations of Olifantsfontein Facilities

1.3 Project Background

TFM recently realized that the company's current production and planning systems were outdated and ineffective, and that steps needed to be taken to improve this. At present the company is not able to accurately develop a master production schedule and plan the key production milestones related to each project. This information is extremely important when trying to predict when a specific job will be completed and delivered to the client. Accurately managing inventory levels is also currently a major issue at TFM. The stock levels shown on the system cannot always be trusted as the information in the system is not always very accurate and up to date. In order to utilise the current enterprise resource planning (ERP) system to its full potential the company must have an information system that is extremely accurate and can provide information that is up to date.

Newer technologies and more modern views of production planning have all contributed globally to better product and process management techniques. The company decided that reassessing the current ERP system and investigating new technologies such as bar-coding could help to bring TFM into a new age of manufacturing excellence.

These steps would help to increase the reliability and accuracy of information in the system, decrease the time lags between data capturing points and help the company to increase scheduling and the availability of production progress information. Improving the visibility of this information is also of great importance to the company, as this would help to keep all persons involved in these processes up to date. This information could also be used to give customers more accurate estimations of when a specific job would be completed.

The company currently uses two software packages as an ERP system. The first program is Sage Accpac which is an ERP system that can be used for financial management, inventory management, purchasing, project management, sales and receivables. The second program is MISys Manufacturing which is a companion program to Accpac that adds improved manufacturing capabilities. The basic manufacturing package of MISys can be used to: "Control inventory levels of raw material and work in process (WIP), use multi-level bills of material (BOM), revise BOMs, conduct physical inventory cycle counting, and process production work orders"(MISys inc.). Additional modules can also be purchased including advanced purchasing, advanced production, material requirements planning and bar-coding.

The scope of this project is fairly large as there are quite a large amount of changes that need to be made to the existing system in order to achieve the final goal of manufacturing progress visibility. For this reason the project will be broken down into several phases. Phase 1 will be completed during the course of this thesis and will mainly focus on improving the flow of information throughout the company by implementing a system that can track parts and update inventory levels by using an applicable technology such as bar-coding or radio-frequency identification(RFID). The new system will help to increase the accuracy and reliability of information, while reducing time lags between data capturing points.

Phase 2 of the project will involve an investigation into the available visual management techniques and how other industries have applied these techniques. This phase of the project will be completed with the help of an outside consultancy firm. Additional phases will be identified as the project progresses.

1.4 Problem Statement

In any organization the accuracy and reliability of the day to day information flows are extremely important. For each different industry and type of organization the contents and type of information varies. In a manufacturing environment such as TFM there is a huge amount of information that flows through the company every day. The information can usually be related to specific sections of the company. Some examples include sales information, customer requirements, design requirements, material requirements, purchasing information, stock levels, manufacturing progress, assembly specifications and finally quality control standards.

All of this information is tracked through specific documents related to each step of the process. These documents are Job cards, Bills of Materials (BOMs), Manufacturing Orders (MOs), Purchasing Orders, Assembly MOs, Production Route cards and Pink Slips. Information flow throughout TFM can be seen in Figure 3 below. Tracking all of these documents through a manual system can be extremely labour intensive and time consuming. Another issue that will always arise with manual data capturing is basic human errors and a lack of in time data capturing.

Additional problems occur when these documents are not processed in the correct order. Documents have been known to end up out of sequence at the data capturer's station. This causes errors and lags in the system, as the ERP program requires information to be entered into the system in the same logical sequence as the manufacturing process. This means that an MO for a certain part required in a specific assembly needs to be closed on the system before the assembly MO can be closed.

Another issue is the fact that parts are not always captured into the inventory system after completion but are rather fast tracked to the assembly line to ensure that projects are finished according to schedule. This causes major issues in the system, as parts are then seen as negative inventory once the assembly manufacturing order is started, this will be explained in more detail in later sections of the report.

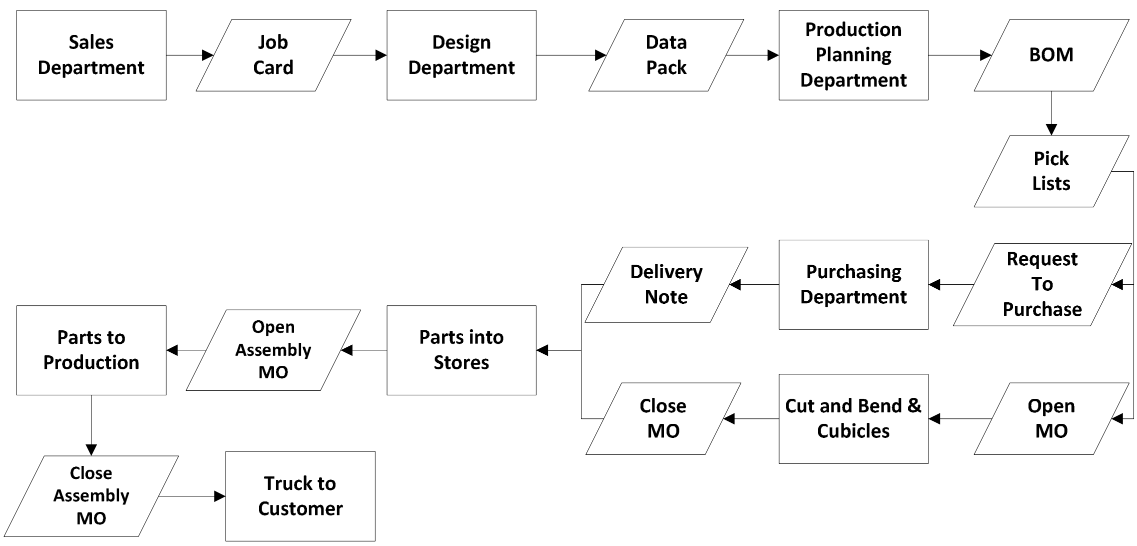

Figure 3 - Flow of Information

1.5 Project Aim

1.5.1 Aim

The aim of this project is to investigate methods and technologies that will enable TFM industries to have in time, in sequence and accurate manufacturing progress information readily available. Once the accuracy and quality of the company's operating information is satisfactory more effort can be put towards using this information to implement visible management techniques.

1.5.2 Objectives

In order to successfully reach the aim of this project certain objectives is identified:

- Improved management of important process documents
- Increased priorities with regard to process documents
- Improved communication throughout the manufacturing process
- Increased data capturing points in the system
- Increased convenience during the data capturing process
- Increased quality and accuracy of the necessary manufacturing information
- Improved visible management on all levels.

1.5.3 Action

In order to meet these objectives the following steps need to be followed:

- Evaluation of current data capturing practices
- Investigation and evaluation of available technologies and techniques
- Evaluation of system requirements
- Comparison of alternative solutions' feasibility
- Full implementation of the chosen technology
- Integration of the chosen system into the existing ERP system
- Training sessions with factory supervisors
- Training sessions with data capturers

1.6 Project Scope

Phase one of the project is a smaller but essential part of the main goal of creating increased visibility of manufacturing progress on the factory floor. The subsequent phases will not be covered in this project and will be completed after phase one with the end goal being a fully functional information system that delivers visual, accurate and in time data to all sections of the business as required.

TFM has invested quite a lot of time and money into the company's ERP system and feel that deviating from this system would be unnecessary. For this reason it is essential that the new system and technology is integrated successfully into the existing system.

As with any project it is preferable to minimise the amount of time spent on the project as well as the financial expenses related to the project. The main costs associated with this project will be the costs of the barcode equipment, the cost of training and any additional costs required to implement the changes in the company.

The project involves an in-depth literature review of bar-coding systems, RFID alternatives, and what can be achieved with such a system, implementation of the bar-coding system and training to increase employee awareness on the importance of accurate, timely information.

The project is also subject to fixed time constraints which are dependent on various external factors. When making drastic changes in a manufacturing environment it is always important to remember that a human element must be taken into account. Changes need to be implemented gradually to ensure that employees are comfortable with the new processes and procedures. Sudden changes in any working environment will always run the risk of creating unhappy employees and could lead to actions such as strikes.

1.7 Document Structure

Chapter 1 - Introduction and Purpose of study

Chapter 1 outlines the background of the project and defines the problem statement and project scope. This chapter aims to give the reader a broad overview of what the project is about and how it was identified. It also defines the objectives of the project and the necessary actions required to reach these objectives.

Chapter 2 - Literature Review and Selection of Appropriate Technologies

Chapter 2 contains an extensive literature review about the available technologies and how they have been applied in the industry. The two main technologies were identified as bar-coding and RFID. These two options were researched and compared in this chapter. Case studies were also researched to illustrate how bar-coding systems have been successfully implemented by various industries.

Chapter 3 - Methods, Tools and Techniques

Chapter 3 contains research and explanations of the methods, tools and techniques that would be the most appropriate aids in solving the identified problem. The methods can be broken down into four basic questions: What is the current situation and where would TFM like to go? What does TFM need to do to get there? Will the chosen solution be the best solution? Will the new system interact with the current systems and will employees use the new technology effectively?

Chapter 4 - Application of Methods, Tools and Techniques

Chapter 4 contains the relevant data and results obtained from the application of the methods, tools and techniques identified in Chapter 3. Development of the material and information flow diagram, requirements study and feasibility analysis is presented in this chapter.

Chapter 5 - Implementation Plan and Operating Procedures

Chapter 5 contains details about the successful implementation of the new system as well as an in depth description of the operating procedures that are to be followed by the workers once the system has been implemented. This chapter also contains preliminary training plans to ensure that all employees are comfortable with the new technology.

Chapter 6 - Conclusions and Recommendations

Chapter 6 consists of the conclusions and recommendations developed during Chapter 4 and 5. This chapter serves as a summary of the project and provides recommendations for the future of the project.

Chapter 2 - Literature Review

In order to understand the described problem at TFM better, and attempt to identify, evaluate and select the best solution a literature study was conducted. In this study existing and new emerging technologies that may aid TFM in improving the accuracy and quality of manufacturing information was investigated.

2.1 Bar-coding

The first alternative that will be investigated is bar-coding. Barcodes are used in a wide variety of industries to capture and convey large amounts of product or even personal information in a simpler, quicker and more accurate manner. As the needs of the industries around the world have changed, various different types of barcodes and barcode scanners have been developed.

2.1.1 History

Barcodes first made an appearance in 1966 and by 1970 the first Universal Grocery Products Identification Code (UGPIC) was developed by a company called Logicon Inc. The American company Monarch Marking and the British company Plessey Telecommunications were the first companies to produce bar-coding equipment for industrial use. As the technology progressed, the UGPIC evolved into the Universal Product Code (UPC) symbol set, by 1973. The first UPC scanner was installed in 1974 at a supermarket in Ohio, USA, and the first product that included a bar code in their packaging was Wrigley's Gum (Bellis, 2000).

2.1.2 Definitions

A few basic definitions are listed below:

- A barcode is a machine-readable representation of information that is formed by combinations of high and low reflectance regions of the surface of an object, which are converted to '1's and '0's (Kato, Tan, & Douglas, 2010).
- A barcode is a printable machine language (Burke, 1984).
- A barcode is a method of automatic identification and data collection (Bellis, 2000).
- A barcode is a printed machine-readable symbol that consists of a series of bars and spaces of varying widths (Terblanche, 1998).

Barcodes enable companies to store large amounts of product and process information in a compact digital format. By using the appropriate scanners this digital code can be interpreted and decoded to provide useful information and update this information in the enterprise resource planning (ERP) system. Bar-coding provides an excellent alternative to manual data capturing. It is faster to use and eliminates the human-element from the equation, thus providing increased accuracy. When investing in mobile bar-coding stations a company can also improve the timeliness of their information handling, as these stations can be placed in strategic locations throughout a facility.

2.2 Radio-frequency Identification (RFID)

Even though the basic principles of RFID have been around for many years, this technology is yet to see significant usage levels in industry. Most industries still rely on basic barcodes as opposed to RFID tracking. RFID can however prove extremely useful if implemented correctly. As technological processes have improved over the years, developers have managed to shrink RFID tags down to the size of a rice grain. A key advantage of RFID technology is the fact that these tags can be scanned indirectly through packaging materials, meaning that multiple items can be scanned at once just by pushing a pallet or cart of the items through a scanner.

2.2.1 History

A general consensus exists that the origins of RFID technologies lie as far back as World War II, where all the countries involved were using radar to track ships and aeroplanes. Throughout the 1950s and 1960s the technology was continuously developed leading to the implementation of systems that would alert companies to stolen items by placing RFID tags and scanners on their products and in their stores. If an item had not been paid for an alarm would sound alerting the staff. Companies continued to experiment with various different signal strengths and bandwidths which eventually led to the implementation of RFID systems to track company assets and containers. Today 13.56 MHz tags are used in a number of different applications. These include smart cards, anti-theft devices, product and even pet tracking and tracing. The manufacturing, pharmaceutical and defence industries are starting to implement RFID technology as a way to keep track of manufacturing progress (Roberti, 2012).

2.2.2 Definitions

A few basic definitions are listed below:

- RFID is any system of identification wherein an electronic device that uses radio frequency or magnetic field variations to communicate is attached to an item (Glover & Bhatt, 2006).
- RFID technology uses radio waves to automatically identify physical objects (either living beings or inanimate items) (Lahiri, 2005).
- RFID is any method of identifying unique items using radio waves using a reader and a transponder (RFID Journal, 2011).
- RFID is a technology that provides automatic identification of an object, animal or person with an RFID tag (Thomas, 2008).

RFID systems are systems that enable organisations to scan multiple items simultaneously using a single scanner. A small RFID tag is placed inside product packaging. This tag sends out a frequency that communicates any information stored on the tag to the scanner. RFID technology is also widely used in so-called "smart cards" that contain information that can be used to for example unlock doors or enable a person to start their car. The main parts of an RFID system is the RFID tags, RFID scanners or readers, reader antenna and the controller.

2.3 Bar-coding versus RFID

At first glance it might seem that RFID is a much better option. **Table 1** contains some of the advantages that RFID systems posses when compared to bar-coding (White, 2007).

Barcode	RFID
1. Require line of sight to be read	1. Can be read without line of sight
2. Can only be read individually	2. Multiple tags can be read simultaneously
3. Cannot be read if damaged or dirty	3. Can cope with harsh or dirty environments
4. Can only identify the type of item	4. Can identify a specific item
5. Cannot be updated	5. New information can be over-written
6. Require manual tracking and are susceptible to human error	6. Can be automatically tracked removing human error

Table 1- Advantages of RFID over Bar-coding

Despite the advantages of RFID, it became clear upon further investigation that a bar-coding solution would be much more appropriate in the case of TFM. The first major factor in favour of bar-coding is that of cost. Barcodes themselves cost between 7 and 8 cents to print, while RFID tags can cost anywhere from R1 up to about R10 each. These amounts might not sound like much but when multiplied by the hundreds and even thousands of tags and barcodes that would be required each year it add ups to a substantial amount that could be saved by opting for the more cost effective option. Another cost associated with the implementation of these systems is the cost of the reader or scanner themselves. A barcode scanner can cost anywhere from about R600 up to about R10000 while RFID scanners range between R5000 and R25000 (BarcodesInc, 2012).

The second factor that needs to be considered is the fact that bar-coding is a universal technology that has been applied successfully by various industries around the world. Most products around the world already have barcodes printed on them. Bar-coding has been around for many years and there is a very good infrastructure already in place for dealing with barcodes. RFID is a technology that is still growing and has not found a common place in industries around the world.

Two major disadvantages of RFID technology is security and physical restrictions. While barcodes require direct line of sight to be scanned RFID tags can be scanned remotely. This means that the signals emitted by RFID tags can be intercepted and the information stored on them can be stolen. RFID tags can also not be read through most metals and liquids as they interfere with the radio waves that a tag emits. As most of the items that will be scanned at TFM are made of metal this could prove to be very problematic.

In order to link part information to specific jobs TFM also want to use bar-coding directly on the relevant documents required by each job. With bar-coding it is a simple matter of printing the barcodes from the system onto the documents. With RFID however this is not possible.

In the end it is evident that a bar-coding solution would be best suited to address TFM's needs. RFID systems might prove to be more advantageous in general, but when the specific needs of the company are taken into consideration bar-coding does prove to be the better option. Barcodes are easier to implement, cost effective and can be placed on any item or document without any issues.

2.4 Technical Specifications of Chosen Technology

2.4.1 Barcode Types

Barcodes come in a range of different types that have been developed over the years. Each different type has its own unique characteristics and field of application. Figure 4 shows some examples of barcode types (Toptroniq, 2007). The main barcode types are summarised in Table 2 below.

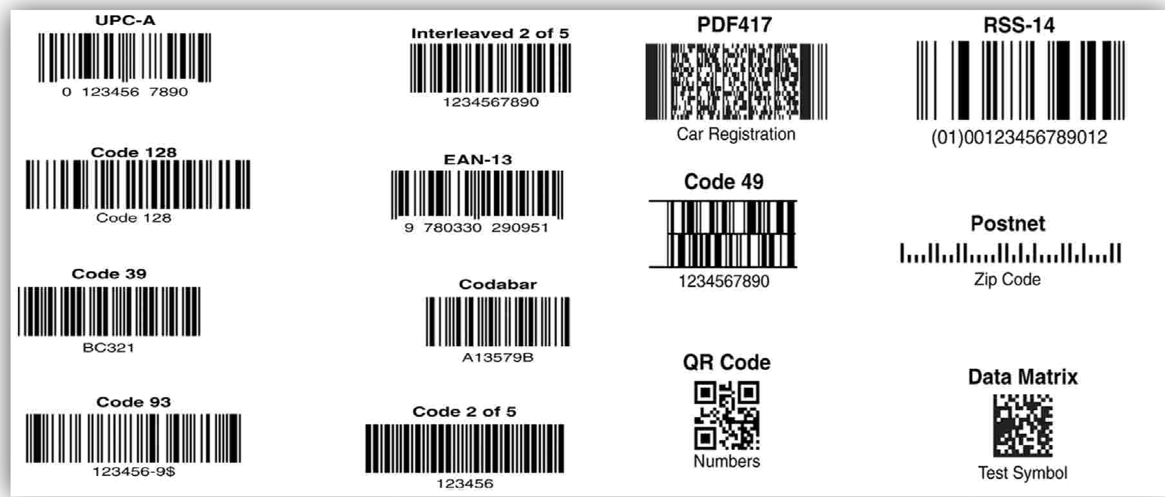

Figure 4 - Common Barcode Types

Barcode Type	Field of Application	Characteristics
UPC-A	Retail (USA)	Fixed Length of twelve digits and uses numbers only. Universal Product Code (UPC).
Code 128	Shipping and Packaging	Can contain 128 ASCII characters and can be used for numeric or alphanumeric barcodes.
Code 39	Manufacturing Industry (Inventory Tracking)	Alphanumeric codes up to 43 characters and can contain numeric values between 0 and 9, letters between A and Z and some special characters.
Code 93	Manufacturing Industry (Inventory Tracking)	Similar to Code 39 but more compact. Can include 47 characters with numeric values between 0 and 9, letter between A and Z, and a larger range of special characters.
Interleaved 2 of 5	Film Industry	Linear barcode used on film canisters to identify manufacturer information.
EAN 13	Retail(Rest of World)	Fixed Length of twelve digits and uses numbers only. European Article Number (EAN).
Codabar	Library Books	Encodes sixteen different characters with an additional four stop/start characters. Self-checking barcode.
PDF 417	Driver's Licence, Airline Tickets	Two dimensional barcode that is used for signatures, photographs and fingerprints. Portable Data File (PDF).
QR Code	Wide application area (Advertising, Mobile Tagging)	Two dimensional or "matrix barcode" that can contain massive amounts of both numeric and alphanumeric characters. Quick Response Code (QR Code).
Data Matrix	Smaller items	Used on smaller items where traditional barcodes are too large. Also a two dimensional barcode.

Table 2 - Comparison of Barcode Types

2.4.2 Barcode Scanner Types

There are three main types of one dimensional barcode readers or scanners:

1. Pen

   Pen type barcode readers consist of a light emitting diode (LED) and a photodiode and are sometimes also referred to as a wand type barcode reader. The photodiode measures the light intensity emitted from the bars when the LED illuminates the barcode. The information is then transmitted to a computer and decoded. Pen type readers are however more difficult to use as they require very little shaking and need to be held perfectly still.

2. Laser

   Laser scanners are slightly more advanced and utilise a laser that reflects against a mirror inside the unit. The reflected beam then reads the barcode and transmits the information to a photodiode, which results in more accurate readings making this scanner easier and quicker to use. They can either be fixed or wireless units. They are the most accurate of the three options and work at long range. They are however slightly more expensive than the other alternatives.

3. Charged Coupled Device (CCD)

   CCD scanners consist of hundreds of small LED's that illuminate the barcode. Instead of measuring the light intensity they measure the voltage of the light in front of each LED. These voltages are then translated into data by a computer. CCD scanner are more accurate than pen type scanners but should only be used at medium to short distances and are limited in terms of barcode lengths.

2.4.3 Barcode Reader Connection Types

Barcode readers can furthermore be classified according to the way that they connect to the organizations servers and ERP system. The three connection types available are:

1. Wired/USB Connection

   Wired barcode readers connect to the company's computers through a direct universal serial bus (USB) connection. This means that any object or document that needs to be scanned must be available at the data capturing terminal. The main advantage of wired barcode readers is cost as they are quite a bit cheaper than the wireless options. Another advantage is that as the reader is directly connected to a computer the company does not run the risk of having the reader stolen or misplaced. A wired reader also enables the data capturer to directly edit information on the system regarding the item that has been scanned. The main disadvantage is that items cannot be scanned directly on the factory floor as the reader cannot work independently from the computer.

2. Wireless/RF Connection

   There are two main types of wireless barcode scanners, the first works with a radio frequency (RF) connection. These barcode readers work in a similar fashion as cordless telephones. Each reader is paired with a base station which is connected to a computer. The base station is used to communicate wirelessly with the scanner; it is also used to charge the scanner when not in use. Other types of wireless barcode readers have their own built in keypad and operating system to enable the user to edit information wirelessly. The main advantage of these readers is increased mobility. They enable the user to scan a barcode away from the data capturing station which means items can be scanned directly on the storage racks. Some disadvantages are cost and decreased security. Wireless readers are easier to misplace or can be stolen as they are not physically attached to a computer. An easy solution to this is to implement strict daily checks and sign out and sign in sheets for all wireless devices.

3. Wireless/Bluetooth

   Bluetooth barcode readers posses many of the same characteristics as RF barcode readers with the added advantage that they can communicate with various other Bluetooth capable devices such as laptops, cell phones and personal digital assistants (PDAs). This means that the user can easily send scanned information to various different devices. Price wise they cost about the same as the RF type readers and are also subject to the same theft/misplacement issues. They do however have a shorter operating range as that of an RF reader.

2.4.4 Barcode Printer Types

In order to print the required barcode tags the company will also have to invest in a barcode printer. The five main types of barcode printers are compared in Table 3 below (Zebra Technologies, 2011).

Technology	Print Quality	Scanner Readability	Installation Cost	Maintenance Cost	Materials Waste
Dot Matrix	Fair	Low	Low/Moderate	Moderate/High	High
Ink Jet	Moderate	Low/Moderate	High	Moderate/High	High
Laser	Moderate	Moderate	High	Moderate/High	High
Direct Thermal	Moderate/Excellent	Moderate/Excellent	Moderate/High	Low	Low
Thermal Transfer	Excellent	Excellent	Moderate/High	Low	Low

Table 3 - Barcode Printer Comparisons (Zebra Technologies, 2011)

From this table it can be seen that the direct thermal and thermal transfer type printers are generally considered as the best option. They provide a high print quality and readability at low maintenance cost and with less material wastage than the other options. Between these two options the thermal transfer type printer would be the best candidate as it produces a much more robust image that cannot be rubbed off easily.

2.5 Analytic Decision Making

In order to choose the most appropriate technological solutions for this project three decisions had to be made:

- Which type of barcode should be used?
- Which type of barcode reader or scanner should be used?
- Which type of connection should be used?

To aid in making this decision the Analytic Hierarchy Process (AHP) was utilised. This process was developed by Thomas L. Saaty and uses mathematical calculations to determine the relationships between the various decision criteria and the most desirable alternatives. The Saaty rating scale contains a series of ratings that can be used to determine the relative importance of each criteria or alternative, as seen in Table 4 below (Saaty, 1980).

This scale is then used to develop pair-wise comparison matrices, intermediate matrices and finally a matrix containing the relative weight or rating of each criteria and alternative. When these weights are multiplied and added together an overall rating is developed for each alternative. The alternative with the highest rating can then be deemed the most likely or best solution to the problem. All the relevant matrices can be seen in Appendix A.

SAATY RATING SCALE TABLE	
Rating (R)	**Description of Relative Rating**
1	Equal
3	Weak preference
5	Essential or strong preference
7	Demonstrated preference
9	Absolute preference
2, 4, 6, 8	Intermediate values
Reciprocals of the above	If for criterion x, option A has a rating of one of the above when compared to option B (RXAB), then option B has the reciprocal rating when compared to option A (RXBA).

Table 4 - Saaty Rating Scale

For each decision a hierarchy diagram containing the appropriate criteria as well as the viable alternatives was developed, as seen in Figures 5 - 7. The desirability ratings obtained through the AHP process can be seen below each criteria and alternative. From these ratings we can see that the best combination of technology for this project would be a code 128 type barcode, a laser type scanner and a wireless radio-frequency connection type.

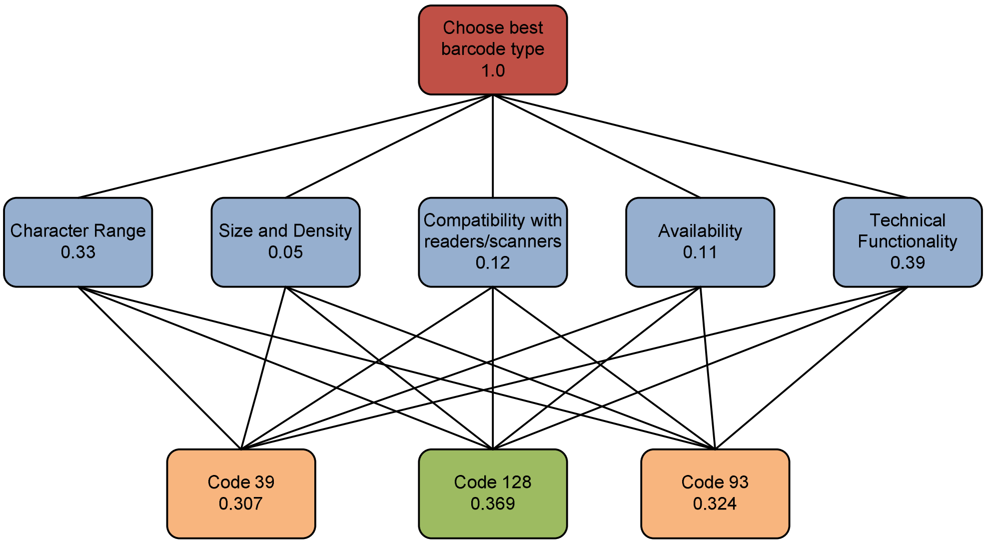

Figure 5 - Best Barcode Type Hierarchy

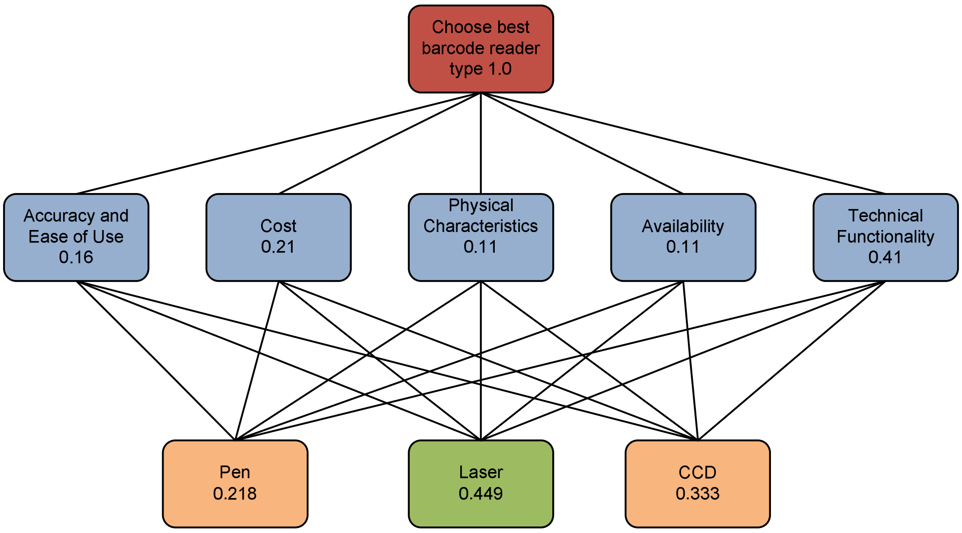

Figure 6- Best Barcode Reader Type Hierarchy

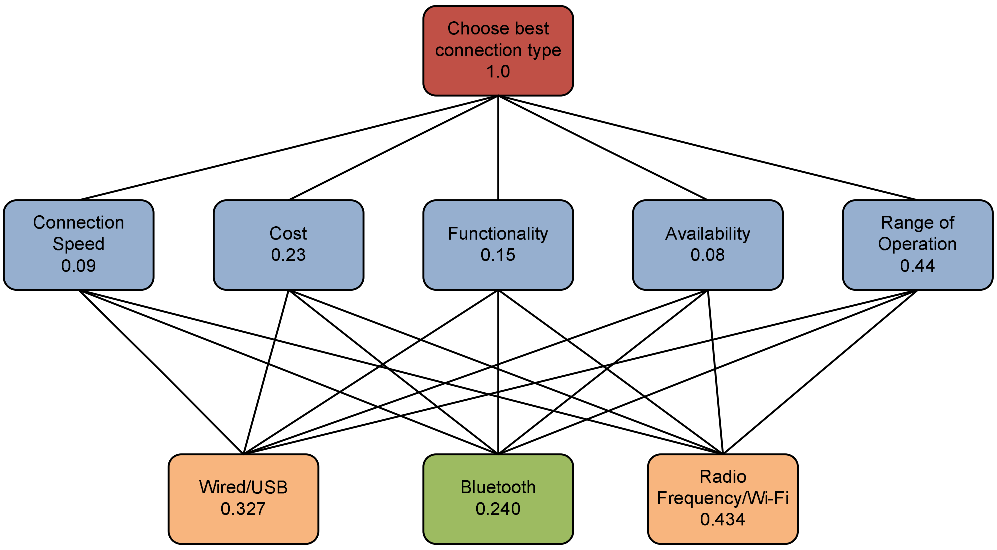

Figure 7 - Best Connection Type Hierarchy

2.6 Bar-coding in the industry

Successful bar-coding systems have been implemented in various industries around the world. Bar-coding has proved to be a simple, cost-effective solution, whether to improve inventory tracking or to eliminate excessive paperwork.

2.6.1 Case Study 1: Barrett Firearm Manufacturing Inc.

Barrett Firearms Manufacturing Inc (BFMI) is an American company that designs and manufactures various high calibre rifles such as the Barrett M107 .50 calibre sniper rifle. In 2006 the company was approached by the United States Department of Defence for a large contract of M107 rifles. The contract was awarded on one condition; BFMI had to incorporate a bar-coding system that would work with the Army's unique identification code (UID).

The first step the company took was to assign the task to their Director of Operations, Eddie Macon. Macon proceeded to investigate all the available options and information related to UID. The next step was to partner up with a bar-coding solution consultancy firmed called A2B Tracking. Together with A2B tracking, Macon established an implementation plan to facilitate in implementing the bar-coding system. The third step was to establish the type of barcode and the placement of the barcode on the firearm. Given the fact that the firearms would be used in harsh environments they had to ensure that the barcodes would be able to stand up to rigorous conditions faced by soldiers in the field. Each rifle was then fitted with a 2-D matrix polyester UID label similar to the tag pictured in Figure 8 (A2B Tracking Solutions, 2007).

Adding this barcode label to each rifle enabled BFMI to comply with Department of Defence's UID marking mandate, which requires all US Army firearms to have a unique identification mark. All items mark with this UID is uploaded into an Item Unique Identification (IUID) registry that is used by the US Army to store valuable information about each item on a database. This means that the information of each rifle produced by BFMI can be traced back to them in the event of a malfunction or investigation. The UID can also be used by BFMI to track the rifles throughout the manufacturing process and to gather valuable logistics and maintenance information for each rifle (A2B Tracking Solutions, 2007).

Figure 8 - Example of a polyester UID label

2.6.2 Case Study 2: Flexpipe Systems Inc.

Flexpipe Systems Inc. is a Canadian company that supplies oil and gas producers with non-metallic, corrosion-resistant pipes and crimped steel fittings. The products manufactured by the company are used in the gathering of oil and gas and should therefore be manufactured in a way that can ensure environmental safety. If for example a pipe that Flexpipe Systems has manufactured breaks or leaks it could be devastating to the environment. For this reason the company decided that it is extremely important that they are able to track specific lots and their locations in the event of a recall. The company also realized that they were doing large amounts of non value-adding work as all information was entered manually into the system.

In order to address all the identified issues the company decided to implement a bar-coding system with the help of an outside consultancy firm. The consultancy firm implemented a system by which handheld barcode readers are used to track serial, lot and batch data and enter it automatically into the company's ERP system. After implementation of the system the company has minimised the time it takes to track a problematic batch and recall it from days down to a quick ten minute search of the database. Colin Moyer, inventory control manager at Flexpipe Systems also noted that the company is now able to ship their products much quicker and that all the required details for each product can now be logged quicker and more accurately (Staff, 2010).

2.6.3 Case Study 3: Aesica Pharmaceuticals

Aesica Pharmaceuticals is a manufacturing and research company involved in the pharmaceutical industry. The company is based in the UK, with additional facilities in Europe. The company realised that their current warehouse management system had certain limitations. Employees had to walk back and forth between the offices and the warehouse with printed lists of items to be picked.

Logistics Manager at Aesica Pharmaceuticals, Chris Rand noted that: "It wasn’t time-efficient for staff to return to the office every time they completed their picks." and "during the period the operators were out with a list, there was no way to get a real-time view of stock levels or movements" (IBM, 2011)

The company then approached global computer giant IBM and one of their partner companies CSI to aid them in solving this issue. Aesica Pharmaceuticals uses SAP as their ERP system. "CSI and Aesica’s warehouse team worked together to map out the new business processes, implement barcode scanning in SAP, roll out the Psion Workabout Pro hand-held scanning devices and Zebra wireless label printers, and train the warehouse staff." (IBM, 2011). Barcodes and barcode scanners were used to replace the paper system and meant that employees could stay in the warehouse the whole day and scan products wirelessly to the office. This also ensured that picking information appeared on the system immediately, reducing unnecessary time lags in the system.

Chris Rand further states that: "We can ensure that our production lines have the right materials ready whenever they need them, so we can meet customers’ orders more quickly and deliver a better service.”(IBM, 2011). Aesica Pharmaceuticals are now considering expanding this bar-coding project to all the other departments of their business to ensure that all these sections operate with the same manufacturing visibility as the warehousing department.

2.6.4 Case Study 4: Industrial Electronic Appliance Manufacturer

A large industrial electronic appliance manufacturer decided that it was time to implement information driven production management system in their China-based facilities with the hope that it will improve their work-in-process (WIP) visibility. The manufacturer also hoped that a bar-coding system would improve the traceability of each manufactured item. The company spent a couple of years testing various barcode types and scanners until they found the best combination for their needs.

By placing various scanners in strategic locations throughout the production line the company was able to automate the data capturing process. Product would pass through certain stations equipped with barcode readers which would then, depending on the barcode information, divert the product to the appropriate location. As the products pass through these stations they are also given a time and date stamp on the company's production system, this means that at any moment the company has access to real time WIP information. All the information in the system is stored on a central database and can be accessed in real time by any department in the organization (BlueStar Nordic, 2012).

2.6.5 How does this relate to TFM?

It is clear that all of these case studies share a common goal. The implementation of some kind of system that can enable them to accurately track some kind of product, item or document in real time while also improving the overall manufacturing progress visibility. In all of the cases the companies approached bar-coding consultancy firms to help them achieve this goal. The first step was commonly to identify the barcode type followed by choosing a barcode reader type. After implementation of the systems all the companies noticed an improvement in manufacturing visibility and product traceability. Overall they were all satisfied that they had made the right decision in choosing a bar-coding solution.

The case of TFM is no different. The company wants to be able to use a system to keep inventory levels up to date and to accurately manage important process documents. By following the correct steps this system can be implemented successfully and provide a comprehensive solution to the company's problems.

From this literature study and by investigating the project requirements it was determined that the best barcode types for the company's purposes will be Code128. The best type of reader will be a Laser type reader that can connect to the system through a wireless radio frequency connection. The readers should be able to receive input through an interactive keypad as can be found on PDA type barcode readers. They should then also communicate any inputs to the system and update the relevant information instantly.

Chapter 3 -Methods, Tools and Techniques

In order for any project to be a success it is vital that the appropriate methods, tools and techniques are identified and properly researched. The main activities that need to be completed to successfully approach this project were identified in the project proposal. These activities are to:

- Analyse the existing system and procedures
- Conduct a requirements study
- Conduct a system feasibility analysis
- Compare alternatives using feasibility analysis matrix
- Implement the new system
- Integrate the new system into enterprise resource planning (ERP) system

For each of these activities an appropriate method, tool and technique must be identified. To successfully analyse the existing system a material and information flow diagram will be constructed. After the current and prospective system has been defined, the next step is to determine the requirements of the system. During this study the appropriate software and hardware will be identified and selected. Various other factors such as the locations and placement of bar-coding terminals will also be determined. In order to determine if the new system will be the appropriate course of action and whether a bar-coding system will appropriately address all the issues defined in the problem statement a system feasibility analysis will need to be conducted. The feasibility study will provide management with enough information to decide whether the project would be beneficial to the company and what alternatives should be considered.

3.1 Material and Information Flow Diagram

It is extremely important that a big-picture view of the entire system is developed and that the areas that may require improvement are identified. Without an overall understanding of the inner workings of the organisation it can be near impossible to adequately determine the functional requirements of the system and this can lead to an inferior or ineffective system design. The principle of "Genchi Genbutsu" or "go and see", coined by the Toyota Production System team, will be applied to ensure that the working of the system is understood correctly and to identify all the relevant processes and departments. This principle maintains that the best way to find out about the inner workings of a supply chain is to physically go to the factory floor and observe the processes at work.

The first step in constructing the material and information flow diagram is to identify and categorise all the relevant departments that provide input or receive output from the system. The next step is to determine what process documents are used to track these material and information flows through the system. The third and final step in this process is arranging these departments and documents in the correct sequence and connecting the relevant elements to effectively depict the complete material and information flow sequence throughout the organisation.

3.2 Requirements Study

In order to determine the main requirements of the new system a requirements study needed to be conducted. One of the techniques available to determine these requirements is a PIECES analysis. According to Bentley & Whitten (2007) a PIECES analysis consists of six categories:

P - Performance requirements

I - Information requirements

E - Economic requirements

C - Control requirements

E - Efficiency requirements

S - Service requirements

By investigating and defining each of these requirements TFM can ensure that the new system will effectively address all the identified problems. There are various techniques that can be used towards requirements gathering. Research, site visits, working environment observation, questionnaires and interviews are all useful techniques that can aid TFM in determining the specific system requirements.

Performance requirements include factors such as the rate at which information can be entered into the system as well as the rate at which the system can process this information. Information requirements include the quality, timeliness, accuracy levels and format of the information entered into the system. Economic requirements are used to identify areas were costs can be saved and profits can be increased by implementation of the new system.

Control requirements determine the level of security and control that needs to be present on the system; this includes the privacy of the information and deciding which persons in the organization have access to this information. Efficiency requirements represent the ways in which the old system's weaknesses can be eliminated by the new system. Lastly the service requirements determine administrative issues related to the system such as training, documentation and reliability.

3.3 Feasibility Analysis

According to Bentley & Whitten (2007) feasibility is: "The measure of how beneficial or practical a system will be to an organization." The feasibility analysis is the process by which these benefits are determined. Feasibility is a measure that must be determined at various stages throughout a project as it can change as the project progresses. Six main tests of feasibility should be considered:

- Operational feasibility is a measure of whether the system will adequately address all system requirements.
- Cultural feasibility is a measure of how the employees will be affected by the system.
- Technical feasibility is a measure of how the technical aspects of the project will be implemented and maintained.
- Schedule feasibility is a measure of whether or not the project schedule is reasonable.
- Economic feasibility measures whether the project would be economically viable.
- Legal feasibility is a measure of how legal and contractual obligations will be affected by the system.

Assessing these six criteria will help TFM to ensure that the new system will be feasible on all levels of the business. The project must address the problem effectively, timely and technically without alienating the employees and in a legal and cost-effective manner. If this cannot be achieved then the project would not be worthwhile and could waste valuable company time and money.

Operational feasibility could be measured through time and motion studies, while technical feasibility can be determined through case studies and interviews with bar-code system manufacturers. Cultural feasibility has been an issue for TFM in the past and it is therefore critical that the new system is explained and discussed with floor supervisors and employees.

The project schedule can be assessed by planning key milestone dates associated with the project and determining whether the timeline will be realistic or not. Economic feasibility can be measured through various cost-benefit analysis techniques. Legal feasibility is not such a critical concern in TFM's case as the implementation of the system will not directly affect any contractual obligations towards their clients.

Another valuable feasibility analysis tool is the feasibility analysis matrix which can be used to evaluate different alternative solutions or possibilities related to the project. The matrix lists the six main tests of feasibility in the first column, while each possible alternative is listed in the first row of the matrix. Each alternative is given a score based on its ability to satisfy each individual test of feasibility. Once all the possibilities have been evaluated a total score is calculated, the alternative with the highest score can then be proclaimed as the most feasible solution to the problem. An example of a feasibility analysis matrix taken from Bentley & Whitten, (2007) can be seen in Figure 9.

Sample Feasibility Analysis Matrix

	Wt	Candidate 1	Candidate 2	Candidate 3
Description		Purchase commercial off-the-shelf package for member services.	Write new application in-house using new company standard VB. NET and SQL Server database	Rewrite current in-house application using Powerbuilder.
Operational feasibility	15%	Supports only Member Services requirements. Current business process would have to be modified to take advantage of software functionality. Also, there is concern about security in the system. **Score: 60**	Fully supports user-required functionality. **Score: 100**	Fully supports user-required functionality. **Score: 100**
Cultural feasibility	15%	Possible user resistance to nonstandard user interface of proposed purchased package. **Score: 70**	No foreseeable problems **Score: 100**	No foreseeable problems **Score: 100**
Technical feasibility	20%	Current production release of Platinum Plus package is version 1.0 and has been on the market for only 6 weeks. Maturity of product is a risk, and company charges and additional monthly fee for technical support. Required to hire or train Java J2EE expertise to perform modifications for integration requirements. **Score: 50**	Solution requires writing application in VB. NET. Although current technical staff has only Powerbuilder experience, it should be relatively easy to find programmers with VB. NET experience. **Score: 95**	Although current technical staff is comfortable with Powerbuilder, management is concerned about acquisition of Powerbuilder by Sybase Inc. MS SQL Server is the current company standard for database, which competes with Sybase DBMS. We have no guarantee that future versions of Powerbuilder will "play well" with our current version of SQL Server. **Score: 60**
Economic feasibility Cost to develop: Payback (discounted): Net present value: Detailed calculations:	30%	 Approx. $350,000 Approx. 4.5 years Approx. $210,000 See Attachment A **Score: 60**	 Approx. $418,000 Approx. 3.5 years Approx. $307,000 See Attachment A **Score: 85**	 Approx. $400,000 Approx. 3.3 years Approx. $325,000 See Attachment A **Score: 90**
Schedule feasibility	10%	Less than 3 months **Score: 95**	9–12 months **Score: 80**	9 months **Score: 85**
Legal feasibility	10%	No foreseeable problems **Score: 100**	No foreseeable problems **Score: 100**	No foreseeable problems **Score: 100**
Weighted score	100%	67	92.5	87.5

Figure 9 - Example Feasibility Analysis Matrix (Bentley & Whitten, 2007)

3.4 Implementation and Integration

The most critical phase of this project is the successful implementation and integration of the new system. Ensuring that the system works as it should and communicates with the existing ERP system is extremely important. The implementation of the system will be done with the help of two external consultancy firms, RedBrush Solutions and AccTech Systems. AccTech Systems are experts in ERP software and have a great deal of experience in implementing successful ERP solutions. RedBrush Solutions is a consulting firm that specialises in the implementation of technological systems and the reengineering of business process. Companies in different industries can often end up confusing one another with technical terms and jargon. For this reason RedBrush Solutions will act as an intermediary between the manufacturing world of TFM and the internet technology world of AccTech Systems to ensure that all involved are on the same level and speak the same language.

Together with the advice and guidance of these two companies the bar-coding system will be gradually implemented and integrated into the existing processes and systems currently in place at TFM. Implementation of the new system will only commence once the necessary steps required to define and justify the system have been completed.

3.5 Training

Once the system has been properly implemented it is extremely important to ensure that all employees are comfortable with the use of the new technology. Training sessions can also be used to remind employees of the importance of accurate and timely data capturing. These sessions will also be critical to the success of the project since it will be the employees and supervisors on the factory floor who will determine whether the project is a success or failure in the long run. If the new technology is not utilised correctly and effectively the entire project could be a waste.

In order to simplify the training process one option could be to conduct a training session with the relevant supervisors from each department. This training session will be facilitated by key persons that were involved in the planning and implementation of the project. RedBrush Solutions and AccTech Systems would be able to provide qualified persons to conduct the first round of training. Once the supervisors have been trained they will be able to convey this knowledge to the relevant employees in each of their departments. This would ensure that employees are given individual attention and that training is conducted by persons that they know and trust.

A key aspect of implementation and training is to ensure that all employees are aware of the correct operating procedures that should be followed when using the new system. For this reason the appropriate operating procedures that are required by each step in the process need to be specified and grouped together in a user manual.

Chapter 4 - Application of Methods, Tools and Techniques

4.1 Material and Information Flow Diagram

The final material and information flow diagram uses square blocks to depict the various departments and diamond shaped blocks to indicate the relevant process documents associated with each step of the process as seen in Figure 10 on page 27. The right hand side of the diagram shows the relevant codes that are issued to a specific document or part at each step in the process. Partial examples of each process document can be seen in Appendix B.

4.1.1 General Order Process

The process starts when the sales department consult a customer and complete the relevant job card containing all the customer's details as well as the customer's requirements for a specific order. This process creates a unique job number for each product ordered, which is used to track the job throughout the process. From there the sales team forwards the job card to the design department. Another important process code found on the job card is the general assembly (GA) number.

The design department uses the GA number and the customer's specifications to develop a data pack containing the required technical drawings in order for the manufacturing and production departments to correctly manufacture and assemble all the required parts. The design department also then creates the bill of materials (BOM) which specifies all the relevant parts and assemblies and the specific breakdown of how the parts form together to create the necessary assemblies and the final product. The BOM also contains the unique part numbers issued to each part or raw material. These numbers are used extensively to retrieve the relevant drawings as required and to track the inventory levels of all parts.

The planning department then receives the job card, data pack and BOM. A pick list is then generated using the BOM. The pick list splits up parts into project parts that need to be purchased, parts that need to be manufactured, standard replenishment parts such as nuts, bolts or sticker packs and raw materials. Each part number is linked to a unique bin number that indicates the physical location of each part in the various storage areas of the factory. Standard replenishment or stock parts are issued with part numbers that start with the numbers 888 or 777.

The pick list is then transferred to the stock control department. Stock controllers use the pick list to check the current levels of the specified parts and then report this information back to the supply chain manager. This information is however not updated on the enterprise resource planning (ERP) system, as the planning department does not have access onto the system to edit stock levels. The list is then used to determine how much of each item should be routed by subtracting the available stock from the required stock and in some cases adding a safety stock level. This process is done manually using Microsoft Excel by the production manager. If enough raw materials are available for certain parts to be manufactured the process will skip to the manufacturing order (MO) creation stage.

Whatever standard replenishment parts are required are split from the pick list and transferred to the replenishment department. Whatever project parts, such as shafts or bushes, and raw materials are required are split from the list and sent to the purchasing department. These two departments then create the relevant request to purchase (RTP) orders containing a unique RTP number for the purposes of linking the RTP to the purchase orders (PO) created later. RTPs are then sent to upper management for approval.

After the RTPs have been approved the purchasing department will create separate POs for each of the relevant suppliers. POs are not necessarily linked to a specific job as multiple orders are often placed at the same time. The PO contains the RTP number, a PO number, all the relevant part numbers and the bin location numbers. The PO number is used to track the purchase order on the system and to acknowledge receipt of the parts later on. The POs are then forwarded to each specific supplier.

As soon as the parts are delivered the received quantity is checked using a PO check sheet. The PO check sheet looks very similar to the PO but contains the quantity ordered as well as the quantity received. Once the receiving department have verified the contents of the delivery the PO can be closed on the system, automatically updating the stock levels on the ERP system. If a PO is not complete the PO will be marked as partially complete indicating to the employees that not all the parts have been received.

Once the necessary raw materials are available the planning department can create the relevant manufacturing orders (MOs). An MO contains the GA number, part numbers, bin numbers and the MO number, which is used to indicate the start of the manufacturing process and to close the manufacturing order once the parts have been received. The MO also specifies the relevant manufacturing processes that should be performed in order to create the part. Once an MO is marked as open on the system the required raw material (RM) is transferred to work in process (WIP) which consequently updates the RM stock levels on the ERP system.

Upon receipt of the MO the manufacturing department retrieves the required RM from the steel yard. The parts are then manufactured according to the relevant drawings and processes specified by the MO. Once all the parts have been manufactured they are transferred to the receiving department and placed in the correct bin locations. The receiving department then close the MO if all parts have been received, which update the inventory levels on the ERP system. If the not all the parts are received the MO is marked as partially complete.

Once all the required parts are available the planning department can create the assembly manufacturing orders (Assy. MOs). Assy. MOs are very similar to normal MOs and contain the same information. Once an Assy. MO has been marked as open the parts are transferred from stock to WIP. The Assy. MOs are then transferred to the picking/packing department and are used to collect all the specified parts and place them in a bin. Once all the parts have been picked the bin along with the Assy. MO are transferred to the assembly department.

The assembly department receives the required parts and Assy. MO and proceeds to assemble the parts into the assembly specified by the document and relevant drawings. Once the assemblies are complete they are transferred back to the receiving department. The same process as with MOs is then followed to capture the assemblies onto the ERP system.

Once all the parts and assemblies that are required by the final or general assembly (GA) are available, the planning department creates the GA order. Again, the GA order is very similar to the MO and Assy. MO documents. Once the GA order is opened on the system the relevant parts and assemblies are transferred from stock into WIP on the ERP system. The parts and assemblies are then picked and packed and transferred to the final assembly department. Some processes such as painting form part of the final assembly process. Once the all the parts and assemblies have been attached to the truck chassis the GA order is transferred to the quality control department.

After a thorough quality inspection the GA order is transferred to the receiving department and the GA order as well as the job card is closed on the system. The truck can then finally be delivered to the customer. Throughout this entire process all data capturing is done by hand and can be extremely time consuming and sometimes inaccurate.

4.1.2 Stock Take

The company conducts quarterly inventory stock takes during which all inventory levels are zeroed on the ERP system and are replaced with an accurate count of all parts, raw materials and assemblies. During these stock takes the picking and packing department are unable to issue any parts or assemblies to the assembly departments as this will affect the accuracy of the stock take. It is also imperative that no process documents are captured at this time as it will also affect the accuracy of the stock take.

The stock take starts by placing blank stickers on each bin location, which will be used to write down the quantity of parts that are available in that specific bin. Each stock controller receives a check sheet with certain bin numbers, and then proceeds to count the number of parts in each specific bin. Once the parts have been counted the quantity is written down on the sticker as well as on the check sheet. Once a controller has finished with the check sheet it is returned to the data controllers.

The data controllers will then select a certain percentage of random bins for a second round of counting. These bins are then recounted and the quantities are written down once more. The data controllers then use these counts to determine a percentage discrepancy between the first and second count. If this percentage is too high the data controllers will proceed with a third count. If the percentage discrepancy is acceptable it is accepted that the accuracy of the count was acceptable.

Once the data controllers are satisfied that the count is accurate the check sheets are transferred to the data capturers. The data capturers then individually capture all the quantities onto the ERP system by hand. Because certain parts have already been transferred to the assembly departments, the stock controllers need to conduct a sweep of the factory floor to capture any parts that are not in the correct bin locations. Once the sweep has been completed, these quantities are also captured on the ERP system manually.

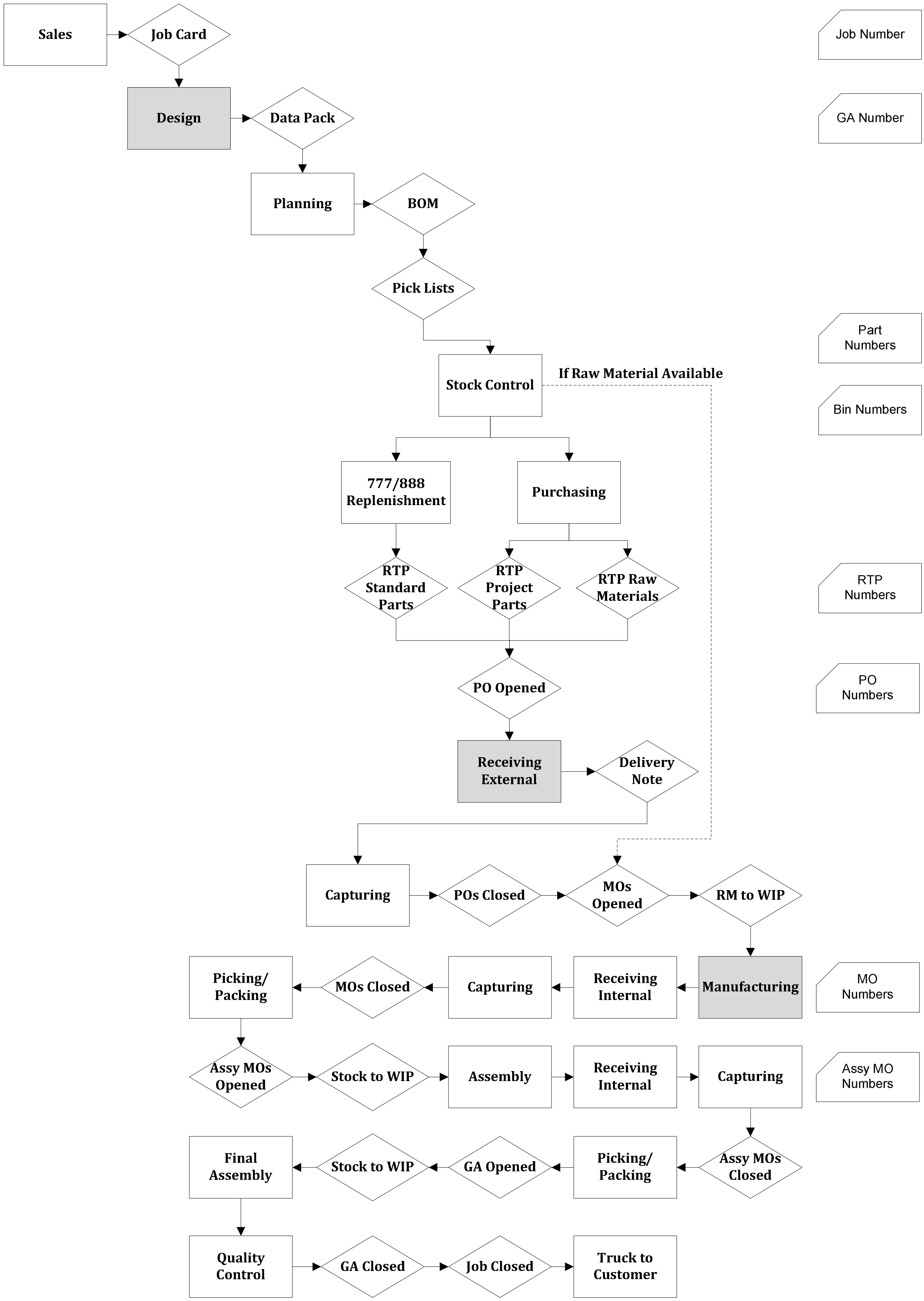

Figure 10 - Material and Information Flow Diagram

4.1.3 Process Shortcomings

The current process suffers from a range of shortcomings that negatively affect the overall performance of the system as well as the accuracy of the information captured onto the system. Some of these shortcomings include bottlenecks, negative stock levels, customer specification changes and a lack of control and updating of stock levels.

The blocks indicated in grey on the material and information flow diagram denote the three main bottleneck departments in the system. The design department can be seen as a bottleneck as there are often major issues when it comes to the development of the data packs and BOM. Creating these documents are an extremely time consuming process and can often lead to long delays throughout the rest of the process. Without these documents the planning department cannot proceed with checking stock and ordering the correct parts, and therefore often times resorts to substituting the specific data pack and BOM with similar versions that have been used for other projects, but that only contain about 80 to 90 percent of the required parts and assemblies. The missing parts are then completed later on once the correct data pack and BOM have been created. This is not an ideal situation as it can lead to confusion and unnecessary or surplus parts being manufactured or ordered.

The external receiving department can be seen as a bottleneck process as the company often times experience huge delays and setbacks when waiting for parts from external suppliers. A large majority of the parts that are ordered from external suppliers are received long after the expected due dates. This then ultimately leads to lengthy delays in the assembly of certain critical parts and even in the assembly of the final chassis.

One of the main manufacturing processes that are required to manufacture the necessary parts is the use of a plasma cutting machine. The machine is used extensively to cut certain parts from steel plates. This machine is however running at full capacity, as it is used to cut parts for all of TFM's Olifantsfontein operations. Parts need to be nested beforehand to ensure that the minimum amount of scrap and off-cuts are generated. This nesting process takes a considerable amount of time and as a result parts need to be ordered well in advance. The machine is operating 24 hours a day, six days a week and is at full capacity. This means that some parts take a very long time or have to be ordered from external suppliers at extra costs and at extra time.

Negative stock levels occur when a part or assembly is fast tracked straight to the next step in the process instead of capturing the part or assembly onto the ERP system using the MO. When the Assy. MO or GA is then opened, these parts are transferred from stock to WIP. According to the system the MO has not been closed yet, meaning the part has not been manufactured yet and has not been updated as stock in the ERP system. This results in "non-existent" parts or assemblies being transferred to WIP, causing negative inventory levels on the system. Parts are fast-tracked when they are urgently required to complete a specific project, but are grouped together using a single MO. The MO might contain parts required by several different projects, at different stages of completion. The assembly departments can therefore often times not wait for the entire MO to be completed and captured onto the ERP system.

Stock levels are currently only updated by using the appropriate process documentation or during the quarterly stock takes. This means that the stock controllers cannot directly change stock levels on the ERP system on a day to day basis. In an ideal system this would not be necessary as the stock levels would be accurately maintained using the relevant process documentations. No system is perfect however and errors do occur. The system currently does not allow for these errors to be corrected directly on the system and causes major discrepancies in the accuracy of the system information.

As far as the stock take is concerned, the entire process can take up to five days. As mentioned before during these five days no new parts can be issued to the assembly departments which could lead to major production hang ups. The company tries to ensure that all the necessary parts are issued ahead of the stock take; this is however not always the case and the assembly departments often run into trouble when they need an urgent part or assembly which cannot be issued. The accuracy of the stock take is also not up to standard as human errors can still find their way onto the system during the capturing phase of the stock take.

4.1.4 Remedying process shortcomings

By addressing these shortcomings appropriately, TFM can eliminate the main sources of frustration, inaccuracy and schedule overruns and can dramatically improve the overall flow and control of information and materials throughout the system.

Reducing the bottlenecks by streamlining the design process, minimising the amount of parts ordered from external suppliers and by alleviating the current pressure on the plasma cutting machine will definitely steer TFM towards a more efficient order processing system. Most of these bottlenecks can be reduced through better planning. By minimising the amount of variety currently present in the parts and assemblies the company can ensure that the data packs and BOMs can be used more widely and interchangeably between different projects. By controlling the manufacturing process better, the company can reduce the amount of parts that are sourced from outside manufacturers and reduce the amount of time spent on waiting for parts. The company can also consider purchasing an additional plasma cutting machine to increase the current plasma cutting capacity.

By increasing the number of data capturing locations and by capturing a part or assembly as soon after it has been completed as possible, TFM can eliminate the issue of negative stock levels. If a part is captured onto the system as soon as it has been manufactured, it can be transferred directly to the next step in the process if required. This level of data capturing should however be done directly on the factory floor by the workers in the manufacturing department using handheld wireless scanners. The implementation of such a system will be discussed in more detail in Chapter 5.

During the stock take process, barcode readers can be used to combine the counting and capturing phases. By capturing the stock levels directly onto the system during the count TFM can dramatically reduce the time required to complete the stock take. This results in less labour hours being spent on stock take and reduces the amount of "down-time" experienced by the assembly departments.

4.2 Requirements Analysis

Through a series of interviews, observations, site visits and questionnaires the main requirements of the new bar-coding system were determined. These requirements are grouped according to the PIECES methodology as discussed in Chapter 3, with an extra category that describes the physical requirements of the bar-coding system.

4.2.1 Performance

From a performance perspective it is essential that the system can process documents at a higher rate. Manually typing all the information contained within the various process documents can take quite long. The bar-coding system should enable TFM to be able to process these documents much faster by scanning the relevant barcodes printed on these documents. Typing the information by hand can also lead to errors caused by typing mistakes or negligence. Scanning the barcodes should eliminate a lot of the typing and should automatically update information on the system as required. The system should also be much easier to use with a user friendly interface that can decrease data capturing effort and frustration.

4.2.2 Information

The information captured by the bar-coding system must be extremely timely, reliable and accurate. The information should also be compatible with the ERP system and the ERP system should be able to use this information to update the stock levels and process progress. It should be a centralised information centre that can be accessed by all relevant employees and should give the company greater control over this information. Some of the inputs that the new system should be able to process include: Stock quantity available, stock quantity received, manufacturing station progress updates, opening and closing of manufacturing, assembly and purchasing orders and transferring stock/raw material to WIP. Some of the outputs that the system should provide to the users include: Stock order quantity, current stock levels, part production progress and labour time spent per part or per order.

4.2.3 Economy

The bar-coding system should enable TFM to reduce the amount of stock that is ordered unnecessarily and should decrease the amount of labour hours spent capturing information onto the ERP system. The system should also help TFM to reduce the number of parts that are outsourced due to avoidable emergencies. By increasing the scanning points to include each step of the manufacturing process, the company should be able to calculate more accurate labour hours and consequently estimate more accurate labour cost figures. Even though the bar-coding system might cost TFM quite a lot of money, the system should aid the company to make significant reductions in operating costs.

4.2.4 Control

TFM should be able to control all access to the system, and each specific group of employees should be granted different levels of access. Some employees should be able to provide inputs to the system while others should only be able to receive outputs from the system. This system should function as a centralised system of management that can be used by the relevant employees to maintain all the information that is necessary to successfully manage the entire process described in the material and information flow diagram.

4.2.5 Efficiency

The bar-coding system should enable TFM to decrease the time and effort required to capture information onto the system. It should also decrease the amount of errors that are captured onto the ERP system and should increase the timeliness of the data by instantly capturing and updating information as it is entered onto the wireless barcode readers. By increasing the accuracy of the information the bar-coding system should also enable the company to decrease the number of production hang-ups that are caused by unordered stock and missing parts.

4.2.6 Service

The bar-coding system will be used mainly in the stores, stores offices, planning offices and on the factory floor. The system should be able to accommodate different types of users, who are interested in different types of functions. The system should consist of a number of mobile scanning devices that can be stored away and locked up when not in use. Extensive user manuals should be included with each barcode reader to ensure that employees can at any time troubleshoot any errors that are picked up when using the readers. An operational manual should also be supplied to ensure that employees know exactly what procedures should be followed during each step of the process. Adequate training session should be supplied to ensure that employees are comfortable with the new technology and system.

4.2.7 Physical

In order for the new system to work effectively TFM will require about ten or twelve barcode readers. These readers should be able to communicate with the ERP system wirelessly and should be fairly rugged as the working conditions are quite tough. Secure storage locations should also be assigned to each barcode reader and the reader should be locked up in theses storage locations whenever not in use. It would also be preferable if the barcode readers can be hanged around a worker's neck or securely connected to the worker's belt to ensure that hands free operation when heavy or cumbersome parts need to be carried. The barcodes themselves should also be able to withstand fairly rough conditions, such as rubbing, scratching and dirt. If barcodes are to be placed on each part the specific locations of the barcodes need to be specified and standardised to ensure quick location and scanning of each barcode.

4.3 Feasibility Analysis

The feasibility analysis matrix is used to compare the most suitable alternative systems and rate them according to a weighted average method. Each alternative is assigned a score based on how well it satisfies the criteria for each of the seven measures of feasibility. From Table 5, it can clearly be seen that a bar-coding system would be the most feasible solution, with an overall score of 70.5.

Feasibility Criteria	Weight	Current Manual System	Bar-coding System	Alternative Technology (RFID)
Operational Feasibility Will all the system requirements be addressed?	25%	The current system is extremely flawed and is a root cause of information handling problems.	This system will adequately address most of the system requirements identified during the PIECES analysis.	This system will only address some of the system requirements identified during the PIECES analysis.
	Score:	30	80	70
Cultural Feasibility Will the employees accept and utilise the system?	15%	Employees are comfortable with current system. Some unhappiness exists as a result of frustration and difficulties experienced when using the current system.	Some resistance might be met, due to increase in responsibilities. Might be welcomed because of increased user friendliness.	Some resistance might be met, due to increase in responsibilities. Might be welcomed because of increased user friendliness.
	Score:	70	50	50
Technical Feasibility Will the system be effective and can it be maintained?	25%	The current system is not effective at all. If TFM continues with this system, it might cause huge problems down the line.	This system will be effective, as has been seen in the various case studies. Bar-coding systems have a strong existing infrastructure and support base for future maintenance.	These types of systems are better suited to other types of organisations such as fast moving consumer goods. They are still relatively new and do not have a good support base.
	Score:	30	80	60
Schedule Feasibility How long would it take to fully implement the new system?	10%	The current system can be implemented immediately. Some minor changes can have an impact within less than 2 months.	This system would take anywhere from six to fourteen months to fully implement.	This system would take anywhere from eight to sixteen months to implement.
	Score:	100	60	60
Economic Feasibility Is the system economically viable?	20%	Sticking to the current system will not cost TFM any money, but might cause the company to lose some money as a result of overstocking or lost opportunities.	Bar-coding systems have a number of hardware costs as well as the implementation cost. But might save the company some money by eliminating the current system issues.	As seen in the literature study RFID systems can be much more expensive than the other two options.
	Score:	80	60	40
Legal Feasibility How will the system affect contractual obligations?	5%	No foreseeable problems.	No foreseeable problems.	No foreseeable problems.
	Score:	100	100	100
Weighted Score	100%	56.5	**70.5**	59

Table 5 - Feasibility Analysis Matrix

Chapter 5 - Implementation Plan and Operating Procedures

The successful implementation of a system is an integral part of any information system design. If the new system cannot be implemented correctly and effectively, then all the work that has been done previous to this point has been for nothing. As part of this section it is also extremely important that the appropriate operating procedures are specified to ensure that all employees use the bar-coding system correctly and efficiently. The first section of the implementation plan is specifying where exactly the barcode scanners should be implemented.

5.1 Barcode Scanning Locations

It is extremely important to specify the exact locations on the factory floor where the bar-coding system should be implemented. Figure 11 below shows a basic floor plan of the areas where the bar-coding system will be most widely used. In order to update stock levels when goods are received from outside suppliers a barcode reader should be available at the front end external receiving area. This should be a personal digital assistant (PDA) type reader that can receive inputs related to the quantities of parts that are received, and update these levels on the enterprise resource planning (ERP) system wirelessly.

Inside the stores and planning offices readers will be used to open, update and close the relevant process documents. As most of the scanning inside the offices will be done directly onto the system it is possible to use wired readers that are attached via a universal serial bus (USB) cable to the data capturing station. This will enable TFM to cut down on costs, as wired barcode readers are much more cost effective.

Furthermore, in the stores area, barcodes containing the relevant bin number of each bin location should be placed on each storage rack. As the part numbers are always linked to a corresponding bin number it is unnecessary to place both these numbers on the storage racks. Wireless PDA type readers should be used during stock control to scan bin numbers and update the stock levels of the particular part on the ERP system. These readers should also be used during the picking and packing process to transfer parts from the relevant bin location into work in process (WIP). Each type of raw material (RM) is also assigned a bin number and a wireless PDA type barcode reader should be used to check and update the RM levels on the ERP system.

At the back entrance to the stores parts and assemblies are received internally from the manufacturing and assembly departments. As with the external receiving area, a PDA type wireless reader should be available to update the stock level on the ERP system as parts and assemblies are received. The possibility of using these readers interchangeably throughout the stores should also be considered. This would allow the company to save costs by reducing the number of barcode readers that need to be purchased.

The last location that the bar-coding system will be used is on the factory floor in the manufacturing and assembly areas. Wireless PDA type barcode readers should be available in these areas to enable workers to capture manufacturing orders (MOs) and assembly manufacturing orders (Assy. MOs) onto the system and possibly update the progress status of a specific part or assembly.

It is extremely important that all the barcode readers are properly managed. These readers can be extremely costly and will be subject to theft. They are also fairly susceptible to damage if they are not handled and managed correctly. Each barcode reader should be marked with a unique code and paired with its own docking station. Whenever the readers are not in use they should be returned to these docking areas to ensure that each reader can be traced whenever they are needed. A check list could be implemented to ensure that the company knows who used the reader last, when it was checked out and when it was returned. Alternatively the company could decide to assign each reader to a specific employee from each department, who will be responsible for keeping the reader safe as well as for scanning the relevant documents and parts.

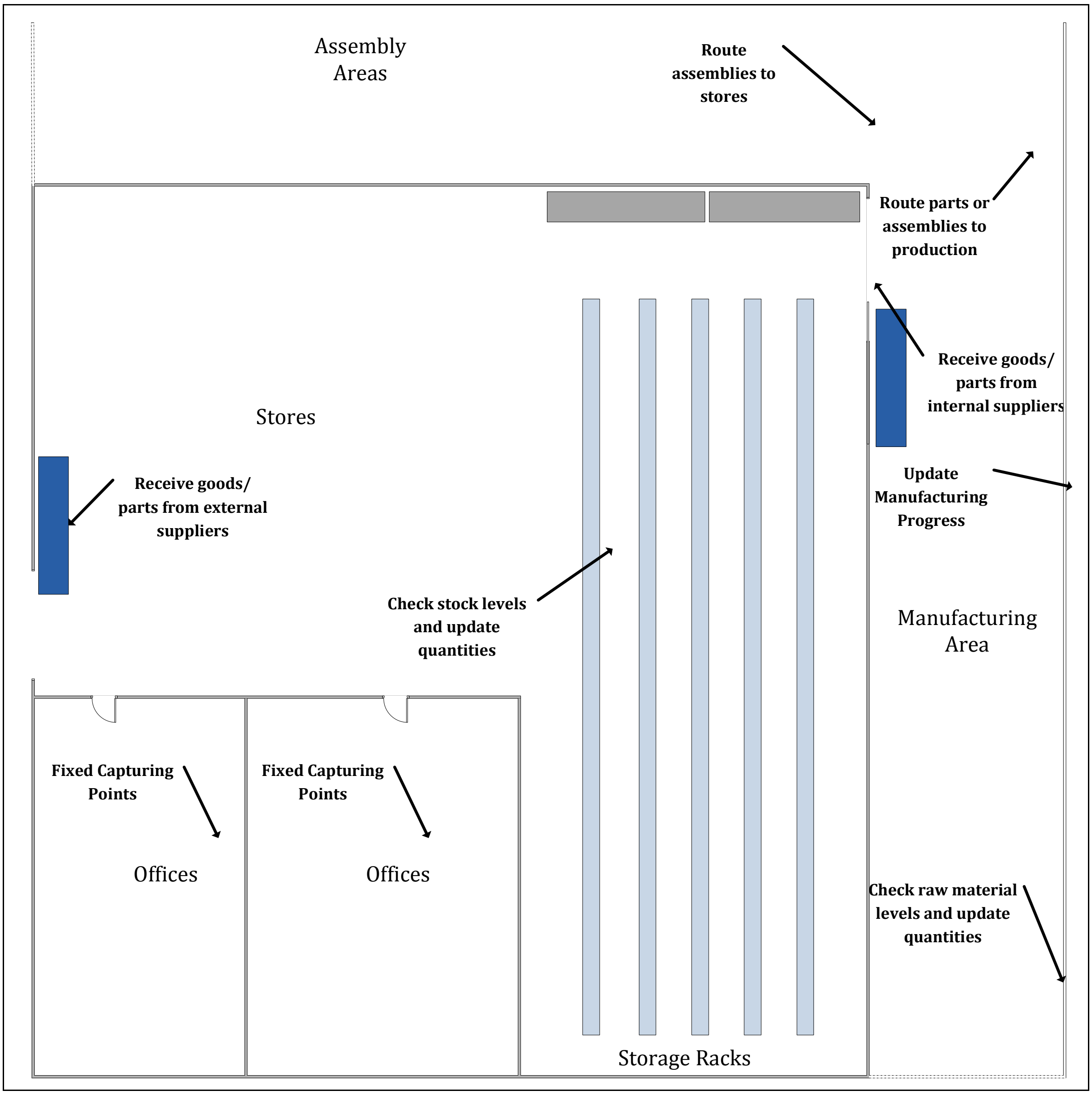

Figure 11 - Barcode Scanning Locations

5.2 Manufacturing Department Data Capturing Area

A proposed method of managing the barcode scanning operation in the manufacturing department can be seen in Figure 12. The seven main manufacturing processes that are performed by the manufacturing department are cutting, drilling, punching, bending, plasma cutting, grinding and profile cutting using a flame cutting machine. Each of these processes has been assigned a station number that is specified on the relevant MO. Each part will follow a certain procedure, depending on what kind of manufacturing processes are required to complete the MO. By adding a barcode containing the appropriate station number TFM might be able to ensure that the progress of each MO can be traced throughout the entire manufacturing process. The company would also be able to easily determine the precise location of any given part or MO on the factory floor. By doing so the company can then roughly estimate the amount of time that will be required to complete the remainder of the MO, and use this information to plan other key milestones related to a specific job or to estimate the amount of labour hours that was spent on each MO.

The system will consist of a blank wall situated close to the manufacturing area. The wall will be split up into seven sections, one for each individual manufacturing process. Each section will have its own document box to hold all the relevant MOs and its own bin to hold all the completed parts. The barcode reader should be mounted close to this area with its own docking station that can be securely stored when not in use.

Once an MO has been created, it should be placed in the appropriate process' document box. These boxes should be checked by the various departments on a regular basis. The employees responsible for completing that specific process should scan the MO when they have started with the operation. Once the first manufacturing process has been completed the parts should be transferred to the next process and the MO should be scanned again to indicate that the first manufacturing process has been completed. The MO should then be placed in the document box of the next manufacturing process. This process will be repeated until all the required manufacturing processes have been completed and the parts can be transferred to the stores and captured onto the ERP system as inventory. Whoever completes the final manufacturing process on a set of parts should be responsible for delivering the parts and MO to the stores.

By scanning the MO before and after each manufacturing process the company will be able to see exactly where a specific part is and at what stage of completion it is. As stated earlier this information can be extremely useful when predicting the completion times of a part or job and can even be used to calculate more precise labour hours spent per part or job. This process will rely heavily on the discipline of the employees and the management skills of the floor supervisors and will only be successful if each section does its part.

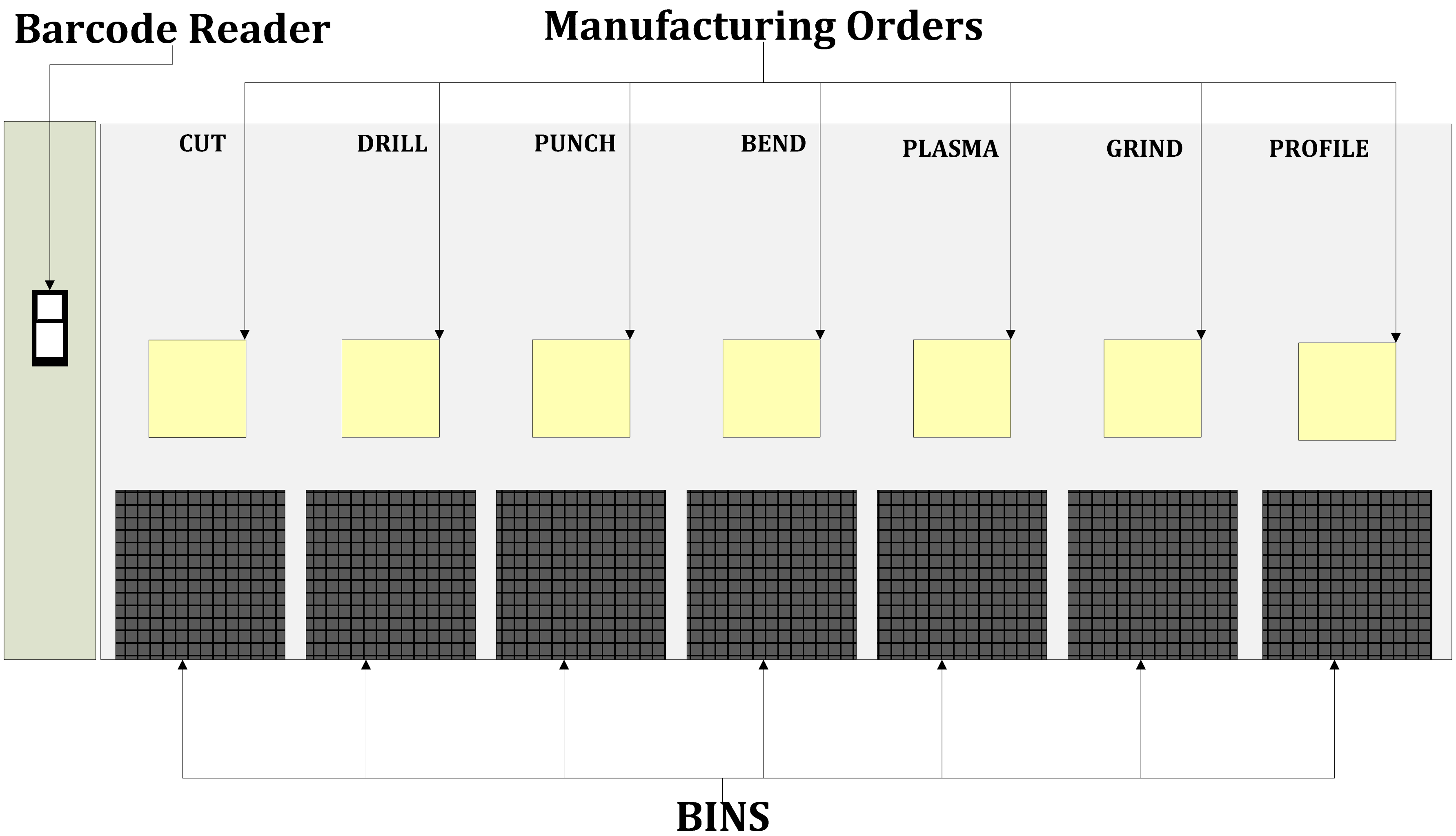

Figure 12 - Manufacturing Department Data Capturing Area

5.3 Bar-coding Operating Procedures

It is critical that each employee is comfortable with the new system and that they know exactly what steps to follow to utilise the system effectively. For this reason it is important that the correct operating sequences or procedures are clearly specified for each step of the process. The sales, design and planning departments will not directly utilise the bar-coding system, but will rather be responsible for creating the correct process documents, with the correct identification numbers at the correct time. From there on the other departments will have to follow the steps described in the material and information flow diagram on page 27. To shed more light on how exactly the bar-coding system should be utilised the following steps were identified:

Stock Control

- Receive the pick list from the planning department
- Scan the job number or the general assembly number to link the stock to a specific job
- Scan the first bin number
- Count the number of parts available in the bin
- Enter part inventory level on the PDA barcode reader
- Proceed to the next bin number
- Continue until all the parts have been checked
- System should create an order list by calculating the number of parts that need to be ordered

Purchasing and Replenishment

- Create a request to purchase from the order list
- Send the request to purchase for management approval
- When the request to purchase has been approved, create separate purchase orders for each specific supplier
- Scan the RTP number to add it to the purchase order
- Scan the part number to add parts to the purchase order
- Enter the quantity of parts required and the due date
- Send each purchase order to the relevant supplier

Receiving External

- Receive parts delivery from the external suppliers
- Scan the purchase order number on the purchase order check sheet to indicate to the system which document is being processed
- Scan the first part number on the purchase order check sheet
- Enter the quantity received on the PDA barcode reader interface
- Repeat this process for all the remaining parts on the check sheet
- Scan the purchase order number to close the purchase order on the ERP system if all the parts have been received correctly
- If the order is incomplete, mark the purchase order as partially completed on the ERP system
- Place the received parts in the correct bin locations

Manufacturing

- Receive the manufacturing order from the planning department
- Collect or gather the required raw materials as specified by the manufacturing order
- Scan the manufacturing order number to indicate the start of the manufacturing process
- Scan the process or station number to indicate which process is being completed
- Manufacture the parts as specified by the manufacturing order
- Scan the manufacturing order number when the parts have been manufactured
- Scan the process or station number to indicate the completion of the manufacturing process
- Place the completed parts in the relevant bin
- Enter the quantity placed in the bin on the PDA barcode reader
- Repeat this process whenever 30% of the total parts have been processed to ensure that the other stations can continue with their part of the process
- Scan the process or station number whenever parts are collected from a bin to indicate that the next process is being completed
- Scan the manufacturing order once all the parts have been completed and placed in the bin
- Deliver the manufacturing order and the parts to the stores

Receiving Internal

- Receive the parts from the manufacturing department
- Scan the manufacturing order number
- Scan the part number to acknowledge receipt of the parts
- Enter the quantity of parts received into the PDA barcode reader
- If all the parts have been received, close the manufacturing order on the ERP system
- If the manufacturing order is incomplete, mark the manufacturing order as partially completed on the ERP system
- Place the part in the correct bin locations

Picking and Packing

- Receive the assembly manufacturing order from the planning department
- Scan assembly manufacturing order number to indicate the start of the picking/packing process
- Scan the part numbers as the parts are placed in the assembly bins
- Enter the amount of parts taken from each bin into the PDA barcode reader to indicate that the parts have been transferred to work in process
- Deliver the bin with all the required parts and assembly manufacturing order to the assembly department

Assembly

- Receive the parts and assembly manufacturing order from the pickers/packers
- Scan assembly manufacturing order number to indicate the start of the assembly process
- Start assembling the parts
- Scan assembly manufacturing order number when the assembly has been completed
- Repeat for all subsequent assemblies
- When all the assemblies have been completed, transfer the assembly and assembly manufacturing order to the stores
- Follow the same internal receiving process

Final Assembly

- Receive the parts and general assembly order from the pickers/packers
- Scan the general assembly order number to indicate the start of the final assembly process
- Start the final assembly
- When the assembly has been completed scan the general assembly order number
- Transfer finished truck and general assembly order to the quality control department

Quality Control

- Scan the general assembly order number to indicate the start of the inspection process
- Perform the necessary quality checks
- Scan the general assembly order number once the inspection has been completed
- Close the general assembly order on the ERP system
- Close the job card on the ERP system
- Deliver the truck to the customer

Stock Take

- Place the printed barcode labels containing the bin number on each of the bin locations
- Count the quantity of parts in each bin location
- Scan the bin number on the printed barcode
- Enter the quantity of parts into the PDA type barcode reader
- Update the relevant quantities on the ERP system database
- Determine which bins should be scanned for second count
- Recount the quantities of parts in these bin locations
- Rescan these bin numbers
- Enter the quantity of parts into the PDA type barcode reader
- The system should be able to store both counts separately and calculate the percentage discrepancies between the two counts
- Depending on this percentage decide whether to continue with an additional round of counting
- Repeat process for additional rounds of counting
- Sweep for parts without bin locations
- Use new classification system to identify specific factory areas as bin locations, MIX-A for example would denote Block A on the Mixer Line
- Printed barcode labels should be visible on each part
- Scan the part number on the printed barcode
- Enter the quantity and location of each part into the PDA type barcode reader
- Update the inventory levels on the ERP system

These operating procedures are quite extensive and labour intensive and should be investigated through practice runs to determine which steps are completely necessary and which steps can be refined further. If all the employees follow these operating procedures, TFM can be sure that all the information required by the ERP system will be accurate and up to date. The company will have greater control over the scheduling of important process documents and will have access to a larger range of process information.

5.4 Training

Training the employees to use the new system effectively is extremely important. There are a number of methods that can be used to facilitate this process. These include induction training, on the job training, off the job training and workshops.

Induction training will be completed for any new employees that are required by the system. It aims to aid new workers to become acquainted with the company's policies and operating procedures much quicker to ensure that they can start bringing value to the organisation as soon as possible. This can be done by pairing any new employees with existing workers who can show them the ropes and answer any questions they might have.

On the job training can be done through demonstrations, coaching, discussions and lectures. The advantage of this type of training is the fact that employees work and add value to the organisation while they learn. Employees pick up new concepts quicker through demonstration and coaching as they learn by doing and can visualize what the new tasks encompass. During this stage the supervisors of each section can act as the coaches and ensure that employees are comfortable with their new duties and responsibilities.

Off the job training is conducted when employees are taken away from the work place to receive specialised training. The supervisors can be trained by outside experts and specialists during workshops and contact sessions away from the workplace and can then carry over this information to the lower level employees. This initial round of training can be conducted as soon as the first barcode readers have been purchased and should be completed as soon as possible.

The best opportunity for training the employees to use the new system will be during a stock take. This will allow employees to become comfortable with the barcode scanners while the system is relatively idle. During the stock take the production line slows down and will therefore allow the employees to learn to use the new system without being pressured by the deadlines experienced during normal day to day operation. Only once all the employees have been properly trained and are comfortable with the new system can TFM expect to start seeing improvements in the data capturing and information management processes.

Chapter 6 - Conclusions and Recommendations

In the first stages of the project the main goal was to define the project problem statement, aim and scope. It was identified that a new technological system would be the best solution to TFM's information management issues. The next step was to identify what technologies would be best suited to the project and research each option extensively. Following this review it was determined that a bar-coding system would be the most appropriate option.

The analytic hierarchy process (AHP) was then used to determine the technical requirements of the bar-coding system. This involved choosing the best barcode type, the best barcode reader type and the best connection type to communicate information between the barcode reader and enterprise resource planning (ERP) system. Upon completion of the AHP method it was decided that a Code 128 type barcode would be the best option. It was also determined that a laser type barcode reader, with an interface for inputting data, that can connect to the ERP system through a wireless radio frequency (RF) connection would be the best solution to TFM's information handling problems. Through an extensive literature study it was also determined that a thermal transfer type barcode printer would be the best option for printing the barcode labels.

After deciding on the bar-coding system and specifying the technical requirements of such a system, the next stage was to identify the available methods, tools and techniques required to analyse the problem feasibility and requirements. Material and information flow diagrams were identified as the best tool for analysing the current system and illustrating how the new system could potentially function. A requirements study and a feasibility analysis were identified as appropriate techniques to determine the desirable requirements that need to be incorporated into the new system and to determine whether the new system will be a viable option and an appropriate solution.

The material and information flow diagram shed some light on the complexity of the system and aided in identifying the key areas that require improvement. The requirements analysis aided in discovering TFM's needs and will be used to explain these needs to the system developers. The feasibility study was formulated in a feasibility matrix that proved that the proposed system would be a viable solution. This study will be expanded further in the final project document. The last step was to determine how the system should be implemented and to develop clear instructions and procedures for employees to follow once the system is operational. By following these operating procedures, TFM can be sure that all the information required by the ERP system will be accurate and up to date.

It is recommended that TFM consider all the suggested changes very carefully and that the company continues with the implementation of this project as it will lead to a significant reduction in frustration and communication errors. This project forms the basis for all future improvements and will aid TFM in the development of a world class organization that can successfully compete in the growing market place.

Bibliography

A2B Tracking Solutions. (2007). *AIM Global*. Retrieved May 4, 2012, from AIM Global Case Studies: http://www.aimglobal.org/members/news/templates/template.aspx?articleid=3450&zoneid=20

BarcodesInc. (2012). *BarcodesInc*. Retrieved October 16, 2012, from http://www.barcodesinc.com/

Bellis, M. (2000). *About.com.* Retrieved March 26, 2012, from About.com Inventors: http://inventors.about.com/od/bstartinventions/a/Bar-Codes.htm

Bentley, L. D., & Whitten, J. L. (2007). *Systems Analysis and Design for the Global Enterprise.* New York: McGraw-Hill International.

BlueStar Nordic. (2012). *ADC Nordic*. Retrieved May 6, 2012, from BlueStar Nordic News: http://www.adcnordic.com/news/bar-code-wip-visibility.php

Bonsor, K. (2011). *howstuffworks*. Retrieved April 30, 2012, from High-Tech Gadgets: http://electronics.howstuffworks.com/gadgets/high-tech-gadgets/rfid2.htm

Burke, H. E. (1984). Handbook of Bar Coding Systems. New York: Van Nostrand Reinhold Company Inc.

Gathiani, J. I. (2004). *Bar Codes: A competitive tool for enhanced supply chain management in the fast moving consumer goods (FCMG) industry.* Pretoria: University of Pretoria.

Glover, B., & Bhatt, H. (2006). *RFID Essentials.* O'Reilly Media.

IBM. (2011). *IBM*. Retrieved March 26, 2012, from IBM Case Studies: https://www-01.ibm.com/software/success/cssdb.nsf/cs/STRD-8NDGGX?OpenDocument&Site=gicss67sap&cty=en_us

Kato, H., Tan, K. T., & Douglas, C. (2010). Barcodes for Mobile Devices. New York: Cambridge University Press.

Lahiri, S. (2005). *RFID Sourcebook.* Massachusetts: IBM Press.

MISys inc. (n.d.). *MISys inc.* Retrieved March 19, 2012, from www.misysinc.com: http://www.misysinc.com/assets/marketing/brochure/MISys-Manufacturing-Brochure.pdf

RFID Journal. (2011). *RFID Journal*. Retrieved April 30, 2012, from RFID Journal Glossary: http://www.rfidjournal.com/article/glossary/3#125

Roberti, M. (2012). *RFID Journal*. Retrieved April 30, 2012, from The History of RFID Technology: http://www.rfidjournal.com/article/view/1338/2

Saaty, T. L. (1980). *The Analytic Hierarchy Process.* New York: McGraw-Hill International.

Staff, M. A. (2010, April 26). *Manufacturing Automation*. Retrieved May 4, 2012, from Automation Mag News: http://www.automationmag.com/news/case-study-barcode-scanners-eliminate-excessive-paperwork.html

Terblanche, N. (1998). Retail Management. Johannesburg: International Thomson Publishing (Southern Africa).

Thomas, R. (2008). *RFID 100 Success Secrets.*

Toptroniq. (2007, December 11). *Toptroniq.* Retrieved March 26, 2012, from http://www.toptroniq.com/top/easypicture0203.jpg

White, G. R. (2007). A Comparison of Barcoding and RFID . *Journal of Information, Information Technology, and Organizations* , 121.

Zebra Technologies. (2011). *Zebra Technologies*. Retrieved September 4, 2012, from Zebra White Papers: http://www.zebra.com/content/dam/zebra/white-papers/en-us/barcoding-101-en-us.pdf

Appendix A - Analytic Hierarchy Process Matrices

A1 Barcode Type

	Character Range	Size and Density	Compatibility	Availability	Functionality	Intermediate Matrix					Weight
Character Range	1.00	5.00	3.00	3.00	1.00	0.35	0.26	0.36	0.29	0.37	0.33
Size and Density	0.20	1.00	0.33	0.33	0.14	0.07	0.05	0.04	0.03	0.05	0.05
Compatibility	0.33	3.00	1.00	1.00	0.33	0.12	0.16	0.12	0.10	0.12	0.12
Availability	0.33	3.00	1.00	1.00	0.20	0.12	0.16	0.12	0.10	0.07	0.11
Functionality	1.00	7.00	3.00	5.00	1.00	0.35	0.37	0.36	0.48	0.37	0.39
Sum	2.87	19.00	8.33	10.33	2.68						

Character Range	Code 39	Code 128	Code 93	Intermediate Matrix			Weight
Code 39	1.00	0.20	0.33	0.11	0.13	0.08	0.11
Code 128	5.00	1.00	3.00	0.56	0.65	0.69	0.63
Code 93	3.00	0.33	1.00	0.33	0.22	0.23	0.26
Sum	9.00	1.53	4.33				

Size and Density	Code 39	Code 128	Code 93	Intermediate Matrix			Weight
Code 39	1.00	0.20	0.25	0.10	0.06	0.14	0.10
Code 128	5.00	1.00	0.50	0.50	0.31	0.29	0.37
Code 93	4.00	2.00	1.00	0.40	0.63	0.57	0.53
Sum	10.00	3.20	1.75				

Compatibility	Code 39	Code 128	Code 93	Intermediate Matrix			Weight
Code 39	1.00	3.00	5.00	0.65	0.71	0.50	0.62
Code 128	0.33	1.00	4.00	0.22	0.24	0.40	0.28
Code 93	0.20	0.25	1.00	0.13	0.06	0.10	0.10
Sum	1.53	4.25	10.00				

Availability	Code 39	Code 128	Code 93	Intermediate Matrix			Weight
Code 39	1.00	3.00	5.00	0.65	0.71	0.50	0.62
Code 128	0.33	1.00	4.00	0.22	0.24	0.40	0.28
Code 93	0.20	0.25	1.00	0.13	0.06	0.10	0.10
Sum	1.53	4.25	10.00				

Functionality	Code 39	Code 128	Code 93	Intermediate Matrix			Weight
Code 39	1.00	2.00	0.50	0.29	0.40	0.25	0.31
Code 128	0.50	1.00	0.50	0.14	0.20	0.25	0.20
Code 93	2.00	2.00	1.00	0.57	0.40	0.50	0.49
Sum	3.50	5.00	2.00				

Final Scores	
Code 39	0.307
Code 128	0.369
Code 93	0.324

A2 Barcode Reader Type

	Accuracy and Ease of Use	Cost	Physical Characteristics	Availability	Technical Functionality	Intermediate Matrix					Weight
Accuracy and Ease of Use	1.00	0.50	2.00	2.00	0.33	0.14	0.09	0.22	0.22	0.14	0.16
Cost	2.00	1.00	2.00	2.00	0.33	0.29	0.18	0.22	0.22	0.14	0.21
Physical Characteristics	0.50	0.50	1.00	1.00	0.33	0.07	0.09	0.11	0.11	0.14	0.11
Availability	0.50	0.50	1.00	1.00	0.33	0.07	0.09	0.11	0.11	0.14	0.11
Technical Functionality	3.00	3.00	3.00	3.00	1.00	0.43	0.55	0.33	0.33	0.43	0.41
Sum	7.00	5.50	9.00	9.00	2.33						

Accuracy and Ease of Use	Pen	Laser	CCD	Intermediate Matrix			Weight
Pen	1.00	0.14	0.20	0.08	0.09	0.06	0.08
Laser	7.00	1.00	2.00	0.54	0.61	0.63	0.59
CCD	5.00	0.50	1.00	0.38	0.30	0.31	0.33
Sum	13.00	1.64	3.20				

Cost	Pen	Laser	CCD	Intermediate Matrix			Weight
Pen	1.00	3.00	3.00	0.60	0.50	0.67	0.59
Laser	0.33	1.00	0.50	0.20	0.17	0.11	0.16
CCD	0.33	2.00	1.00	0.20	0.33	0.22	0.25
Sum	1.67	6.00	4.50				

Physical	Pen	Laser	CCD	Intermediate Matrix			Weight
Pen	1.00	0.33	0.33	0.14	0.10	0.18	0.14
Laser	3.00	1.00	0.50	0.43	0.30	0.27	0.33
CCD	3.00	2.00	1.00	0.43	0.60	0.55	0.52
Sum	7.00	3.33	1.83				

Availability	Pen	Laser	CCD	Intermediate Matrix			Weight
Pen	1.00	0.50	0.50	0.20	0.20	0.20	0.20
Laser	2.00	1.00	1.00	0.40	0.40	0.40	0.40
CCD	2.00	1.00	1.00	0.40	0.40	0.40	0.40
Sum	5.00	2.50	2.50				

Functionality	Pen	Laser	CCD	Intermediate Matrix			Weight
Pen	1.00	0.20	0.33	0.11	0.12	0.10	0.11
Laser	5.00	1.00	2.00	0.56	0.59	0.60	0.58
CCD	3.00	0.50	1.00	0.33	0.29	0.30	0.31
Sum	9.00	1.70	3.33				

Final Scores	
Pen	0.218
Laser	0.449
CCD	0.333

A3 Reader Connection Type

	Connection Speed	Cost	Functionality	Availability	Range of Operation	Intermediate Matrix					Weight
Connection Speed	1.00	0.50	0.50	1.00	0.20	0.09	0.12	0.07	0.08	0.09	0.09
Cost	2.00	1.00	2.00	3.00	0.50	0.18	0.23	0.29	0.25	0.22	0.23
Functionality	2.00	0.50	1.00	2.00	0.33	0.18	0.12	0.14	0.17	0.15	0.15
Availability	1.00	0.33	0.50	1.00	0.20	0.09	0.08	0.07	0.08	0.09	0.08
Range of Operation	5.00	2.00	3.00	5.00	1.00	0.45	0.46	0.43	0.42	0.45	0.44
Sum	11.00	4.33	7.00	12.00	2.23						

Connection Speed	Wired/USB	Bluetooth	RF	Intermediate Matrix			Weight
Wired/USB	1.00	3.00	2.00	0.55	0.50	0.57	0.54
Bluetooth	0.33	1.00	0.50	0.18	0.17	0.14	0.16
RF	0.50	2.00	1.00	0.27	0.33	0.29	0.30
Sum	1.83	6.00	3.50				

Cost	Wired/USB	Bluetooth	RF	Intermediate Matrix			Weight
Wired/USB	1.00	3.00	2.00	0.55	0.50	0.57	0.54
Bluetooth	0.33	1.00	0.50	0.18	0.17	0.14	0.16
RF	0.50	2.00	1.00	0.27	0.33	0.29	0.30
Sum	1.83	6.00	3.50				

Functionality	Wired/USB	Bluetooth	RF	Intermediate Matrix			Weight
Wired/USB	1.00	2.00	2.00	0.50	0.50	0.50	0.50
Bluetooth	0.50	1.00	1.00	0.25	0.25	0.25	0.25
RF	0.50	1.00	1.00	0.25	0.25	0.25	0.25
Sum	2.00	4.00	4.00				

Availability	Wired/USB	Bluetooth	RF	Intermediate Matrix			Weight
Wired/USB	1.00	4.00	3.00	0.63	0.73	0.50	0.62
Bluetooth	0.25	1.00	2.00	0.16	0.18	0.33	0.22
RF	0.33	0.50	1.00	0.21	0.09	0.17	0.16
Sum	1.58	5.50	6.00				

Range	Wired/USB	Bluetooth	RF	Intermediate Matrix			Weight
Wired/USB	1.00	0.14	0.11	0.06	0.03	0.08	0.06
Bluetooth	7.00	1.00	0.33	0.41	0.24	0.23	0.29
RF	9.00	3.00	1.00	0.53	0.72	0.69	0.65
Sum	17.00	4.14	1.44				

Final Scores	
Wired	0.327
Bluetooth	0.240
RF	0.434

Appendix B - Examples of Process Documents

B1 - Job card

TFM Industries (Pty) Ltd

JOBCARD - CONSTRUCTION

Date of order	14/05/2012	**Allocated JOB Number**	MPC0002479
Customer Name and Address		**Product Type**	TIPPER
		Contact Telephone No	
		TFM Quote No & Date	
Payment Terms		Contact Person	
End User		Chassis Make & Model	
Sales Consultant		Mass Distribution No	
Order No		CDA No	
Build Specification No		Natis No	

MIXER — *MK* ___ *STETTER* ___ *SIZE* ___

CONC. PUMP — *MODEL* ___ *TYPE* ___

DOLL — *MODEL* ___

DONKEY ENGINE — *TYPE* ___ *SIZE* ___

TIPPERS — *FOB* ___ *UNDER BODY* ___ *SIZE* 12m³

SIZE SPECIFICATION ___

CYLINDER MEILLER CYLINDER *Head Board Angle* °

TANKERS — *SIZE* L *VACUUM* ___ *WATER* ___ *FUEL* ___

GRAVITY FEED ___

EXTRAS

Spare Wheel Carrier	X	Position		
Air & Fuel Tank Protector	X	Position		
Rotating beacon (Std)		Rotating beacon (Strobe)	X	Pos:
Tail Light Protector	X			
GEARBOX TYPE:		Type		
PLM 7		Type		
PK 4300		Type		
Bonfiglioli		Type		
HYDRAULIC PUMP				
Eaton		Reverse Buzzer	X	
Rexroth		Fire Extinguisher		
Sauer				

BODY SPEC (raw material): TAILGATE 6MM HARDOX, FLOOR 8MM HARDOX; SIDES &, HEADBOARD 6MM 50C

PAINT SPEC: ESORFRANKI BLUE

OTHER:

GA DRAWING NO: 035 000 000 223 — *TOTAL PRICE IMPLICATION*

*REGULATORY / STATUTORY REQUIREMENTS ADDRESSED BY TECHNICAL. SIGN: DATE:

C

JOBCARD APPROVAL

SALES ___________ TECHNICAL* ___________ PRODUCTION ___________ CRC ___________

DATE ___________ DATE ___________ DATE ___________ DATE ___________

Sub Total	R -
VAT (14%)	R -
Total	R -

B2 - Pick List

Assembly:	***12m³ Meiller Tipper***	
GA 035 000 000 223 Rev: A QTY=4		
14 May 2012		
Part Number	**Description**	**Bin Number**
	Make Items	
010 004 109 164	LADDER TREAD PLATE	M02A05
010 004 109 166	LADDER RUNG SPACER	M02A03
011 004 156 006	CROSSMEMBER	O02C10
011 004 156 011	RAIL TUBE A	O02E03
011 004 157 012	DISH BAR	O03C09
011 004 158 009	SHORT RAIL TUBE	O03D07
	Purchase Items	
011 004 153 040	REFLIEF VALVE HOSE	O02B06
011 004 157 009	SPRAY DISH OUTLET	O01E08
011 004 157 010	FLOW ADJUSTER PIPE	O01B07
011 004 178 043	4" MAIN FLEX HOSE	QB01B01
011 004 081 024	NOZZLE - BRASS*SPRAY * TANKER	O02F02
011 004 156 013	HANDRAIL END PIECE	O03G02
	Stock Items	
011 777 203 155	REDUCER - CONCENTRIC WELD-ON 4" - 3" (BS1640)	QA02E06
011 888 000 100	PERROT COUPLING MALE 4" (100mm)	C06C02
011 888 000 2003	TORNADO MANUAL BUMPER MONITOR	
011 888 001 081	PERROT COUPLING FEMALE 3"	C06C05
011 888 004 051	VALVE - RELIEF 40mm (1 1/2")	C06E02
011 888 004 054	VALVE - BUTTERFLY WITH PNEUMATIC ACTUATOR 4"	GBOXC01B
	Raw Material	
RM52267	BAR FLAT MS 60 x 8mm	02STL06
RM53015	BAR SQU MS 16 x 16mm	02STJ02
RM53395	PIPE MS 114 x 3.5mm WALL *BLACK (SABS62)	02STC01
RM53410	TUBE ROUND MS 60.3 x 3.94mm	02STG13
RM58660	PLATE S 355 JR+AR 2500 x 1200 x 5mm	02STPD06
RM58741	PLATE MS 3000 x 1500 x 3mm	02STPG02

B3 - Request to Purchase

12M3 TIPPER QTY=4		TFM INDUSTRIES REQUEST TO PURCHASE					
080 001 000 013/2							
DATE	**14 May 2012**				**RTP NUMBER**	**MP5149**	
TO BE COMPLETED BY ORIGINATOR							
PART NUMBER	**DESCRIPTION**	**QTY**	**DATE REQD**	**JOB NR**	**PARENT PRODUCT**	**SUGGESTED SUPPLIER**	**ORIGINATOR**
555 000 000 004	NON-STD BUY-OUTS - MACHINING 010 004 204 042	4.00	URGENT	MPC2412	AGICAR	JADE	DEON
038 004 035 003	BUSH, BIN STOPPER	20.00	18-May-12		REPAIR	JADE	DEON
031 000 000 057	PURCHASE 2-HOLE STEEL LIGHT BOX ASSY	8.00	04-Jun-12	MPC0002479	12m3 TIPPER	JADE	DEON
028 004 020 004	SHAFT - ROD 20 x 330	8.00	04-Jun-12		12m3 TIPPER	WYNBERG	DEON
028 004 020 007	BUSH	8.00	04-Jun-12		12m3 TIPPER	WYNBERG	DEON
035 004 089 168	FASTNER RING FOR RAM PIN	8.00	04-Jun-12		12m3 TIPPER	WYNBERG	DEON
035 004 097 308	PIVOT	4.00	04-Jun-12		12m3 TIPPER	WYNBERG	DEON
035 004 097 360	WHEEL CARRIER	8.00	04-Jun-12		12m3 TIPPER	WYNBERG	DEON
035 004 097 364	PIN	8.00	04-Jun-12		12m3 TIPPER	WYNBERG	DEON
035 004 100 114	LOCK HINGE PIN	16.00	04-Jun-12		12m3 TIPPER	WYNBERG	DEON
035 004 110 086	LOCKSHAFT BEARING PLATE	8.00	04-Jun-12		12m3 TIPPER	WYNBERG	DEON
035 004 110 087	LOCKSHAFT BEARING GUSSET	8.00	04-Jun-12		12m3 TIPPER	WYNBERG	DEON
035 004 110 105	SPACER BUSH FOR SUBFRAME MOUNT	128.00	04-Jun-12		12m3 TIPPER	WYNBERG	DEON
RM52040	BAR FLAT MS 100 x 6mm	4.00	21-May-12		12m3 TIPPER		DEON
RM52160	BAR FLAT MS 30 x 8mm - 6 MTRS	4.00	21-May-12		12m3 TIPPER		DEON
RM52193	BAR FLAT MS 40 x 10mm - 6 MTRS	2.00	21-May-12		12m3 TIPPER		DEON

APPROVED BY:____________________ **DATE:**________________ **SIGNATURE:**____________________

B4 - Purchase Order

TFM INDUSTRIES (PTY) LTD

PO Box 1200, Olifantsfontein, 1665
Tel: (011) 316 4161 Fax: (011) 316 4786

VAT registration number : 434 017 0424
Co Registration Number : 1966 / 005 974 / 07

	Page
	Page 1 of 2

Purchase Order Number:
MPO000055987

M P 0 0 0 0 0 5 5 9 8 7

Purchase Order

Original

SUPPLIER	SHIP TO
TFM WYNBERG MANUFACTURING (PTY) LTD	33 Industry Road
P O BOX 46131	Clayville Ext. 4
ORANGE GROVE	Olifantsfontein
PHONE: 011 7867015 FAX: 0118874740/786-2845	PO Box 1200
, 2119 .	Olifantsfontein, 1665

Order Date	Ship Via	RTP No	Terms	Buyer	Freight
15/05/2012	DEON	MP5149	30 DAYS NETT	Dudu Nkosi	

Line	Item Number / REV ID	Description	Quantity	UOM	Due	Price	Extended
1	028 004 020 004 0 2 8 0 0 4 0 2 0 0 0 4	SHAFT - ROD 20 x 330	8.00	EA	04/06/2012		
2	028 004 020 007 0 2 8 0 0 4 0 2 0 0 0 7	BUSH	8.00	EA	04/06/2012		
3	035 004 089 168 D 0 3 5 0 0 4 0 8 9 1 6 8	FASTNER RING FOR RAM PIN	8.00	EA	04/06/2012		
4	035 004 097 308 0 3 5 0 0 4 0 9 7 3 0 8	PIVOT	4.00	EA	04/06/2012		
5	035 004 097 364 0 3 5 0 0 4 0 9 7 3 6 4	PIN	8.00	EA	04/06/2012		

ORDER E-MAILED TO DAVID

Please acknowledge contents and acceptance of this order in writing. Note that orders will be deemed to have been accepted upon the terms mentioned herein if no formal acknowledgement, acceptance or contradictions is received within 1 day hereof.

Subtotal	**R**
	R
VAT	
Total	**R**

B5 - Purchase Order Check Sheet

TFM INDUSTRIES (PTY) LTD

PO Box 1200, Olifantsfontein, 1665

Tel: (011) 316 4161 Fax: (011) 316 4786

VAT registration number : 434 017 0424

Co Registration Number : 1966 / 005 974 / 07

Page
Page 1 of 2

Purchase Order Number:

MPO000055987

MPO000055987

MPO000055987 PO RECEIVE CHECK LIST

TFM005	TFM WYNBERG MANUFACTURING (PTY) LTD

Order Date	Ship Via	RTP No	Terms	Buyer	Freight
15/05/2012	DEON	MP5149	30 DAYS NETT	Dudu Nkosi	

Line	Item Number / REV ID	Description	Quantity	UOM	Due	Bin	Received
1	028 004 020 004 Inspect 028 004 020 004	SHAFT - ROD 20 x 330	8.00	EA	04/06/2012	K05C01 K05C01	8.00
2	028 004 020 007 Inspect 028 004 020 007	BUSH	8.00	EA	04/06/2012	K05C011 K05C011	8.00
3	035 004 089 168 035 004 089 168	FASTNER RING FOR RAM PIN	8.00	EA	04/06/2012	K05C010 K05C010	8.00
4	035 004 097 308 Inspect 035 004 097 308	PIVOT	4.00	EA	04/06/2012	K05C04 K05C04	0.00
5	035 004 097 360 035 004 097 360	WHEEL CARRIER	0.00	EA	04/06/2012	P07E01 P07E01	0.00
6	035 004 097 364 Inspect 035 004 097 364	PIN	8.00	EA	04/06/2012	P02C07 P02C07	8.00
7	035 004 097 365 035 004 097 365	THREADED BAR (MEILLER REPLACEMENT PART)	10.00	EA	04/06/2012	P02C06 P02C06	10.00

B6 - Manufacturing Order

080 005 002 004 /1	PRODUCTION ROUTE CARD

TFM	12M3 MEILLER TIPPER MB3335	**Order No.: MO00748329 SHH**	M O 0 0 7 4 8 3 2 9 S H H

DRG NO:	Revision: K	JOB NUMBER:	STOCK
035 004 089 080	DRG. TITLE: LIFTING LUG	RELEASE DATE:	18/05/2012
0 3 5 0 0 4 0 8 9 0 8 0		QUANTITY REQ:	24
		REQ. BY DATE:	20/07/2012
	Creator SANDRAH	LOCATION:	MPCS
	Start Date 18/05/2012	QTY ON HAND:	27

OPERATION	STATION	OPERATING SEQUENCE	DONE BY	SIGN 1ST OFF SAMPLE	SIGN FINAL	DATE	REMARKS
000100		HIGH DEF PLASMA CUT					

ITEM	DESCR	REVID	REQQTY	ISSUED QTY	Q STK	UOM	P OR M	PICK	STATION
R M 5 8 5 9 0	PLATE S 355 JR+AR 2500 x 1200 x 16mm		0.10		3.05	EA	P		

Outside Processing Required

Service NO	DESCRIPTION	PURCH OR MANUF	QTY REQ TO BUILD

QTY	DATE	REC BY	PROCESSED		QTY	DATE	REC BY	PROCESSED	STORES RECEIPT	
									QUANTITY RECEIVED:	
									RECEIVED BY:	
									RECEIVED DATE:	
									SIGNATURE:	

B7 - Assembly Manufacturing Order

080 005 002 004 /1	PRODUCTION ROUTE CARD		
TFM	12M3 MEILLER TIPPER MB3335	Order No.: MO00748270 SHH	M O 0 0 7 4 8 2 7 0 S H H

DRG NO:	Revision: B	JOB NUMBER:	STOCK
035 002 219 002	DRG. TITLE: SIDE WALL ASSY LH	RELEASE DATE:	17/05/2012
0 3 5 0 0 2 2 1 9 0 0 2		QUANTITY REQ:	4
		REQ. BY DATE:	19/07/2012
	Creator SANDRAH	LOCATION:	MPCS
	Start Date 17/05/2012	QTY ON HAND:	4

OPERATION	STATION	OPERATING SEQUENCE	DONE BY	SIGN 1ST OFF SAMPLE	SIGN FINAL	DATE	REMARKS
000100		ASSEMBLE AND WELD					

ITEM	DESCR	REVID	REQQTY	ISSUED QTY	Q STK	UOM	P OR M	PICK	STATION
0 3 5 0 0 4 0 8 9 0 8 0	LIFTING LUG	K	12.00		27.00	EA	M	P 0 3 C 0 9	
0 3 5 0 0 4 0 9 7 0 7 9	STEP	C	12.00		0.00	EA	M	P 0 2 D 0 5	

QTY	DATE	REC BY	PROCESSED		QTY	DATE	REC BY	PROCESSED	STORES RECEIPT	
									QUANTITY RECEIVED:	
									RECEIVED BY:	
									RECEIVED DATE:	
									SIGNATURE:	

B8 - General Assembly Order

080 005 002 004 /1	**PRODUCTION ROUTE CARD**		
TFM	ESOR FRANKI # 13	**Order No.: MO00751043 DEE**	M 0 0 0 7 5 1 0 4 3 D E E

DRG NO:	**Revision:**	B	**JOB NUMBER:**	MPC0002479
035 000 000 223 0 3 5 0 0 0 0 0 0 2 2 3	12m3 MEILLER TIPPER MB3335 K/33		**RELEASE DATE:**	28/06/2012
			QUANTITY REQ:	1
			REQ. BY DATE:	30/08/2012
	Creator	GDE	**LOCATION:**	MPCS
	Start Date	28/06/2012	**QTY ON HAND:**	0

OPERATION	STATION	OPERATING SEQUENCE	DONE BY	SIGN 1ST OFF SAMPLE	SIGN FINAL	DATE	REMARKS
000100		ASSEMBLE AND WELD					

ITEM	DESCR	REVID	REQQTY	ISSUED QTY	Q STK	UOM	P OR M	PICK	STATION
0 3 5 0 0 1 1 0 0 0 0 7	REST PAD ASSY FOR TIPPER		4.00		95.00	EA	P	P 0 4 E 0 1	
0 3 5 0 0 4 0 8 9 1 6 9	RAM PIN		2.00		14.00	EA	P	K 0 7 D 0 7	

QTY	DATE	REC BY	PROCESSED		QTY	DATE	REC BY	PROCESSED	STORES RECEIPT	
									QUANTITY RECEIVED:	
									RECEIVED BY:	
									RECEIVED DATE:	
									SIGNATURE:	

Appendix C - Quotations

CASIO DT-X8 Quote

Portable Data Management
P.O. Box 12783 Mill Street
8010
Phone +27 21 461-2100
Fax +27 21 461-2552
E-Mail pdman@iafrica.com

Please see below the requested quotes.

ITEM	CODE	DESCRIPTION	PRICE	QTY	TOTAL
1	DT-X8-10E	WIN CE 6.0, LASER, 802.11B/G, BLUETOOTH	R 8,018.50	15	R 120,277.5
2	HA-K23XLBAT	LARGE CAPACITY BATTERY	R 782.38	15	R 11,735.7
3	HA-F32DCHG	DUAL SPARE BATTERY CHARGER	R 973.68	8	R 7,789.44
4	AD-S42120BE	AC ADPATER FOR HA-F32DCHG	R 343.65	3	R 1,030.95
		TOTAL (EXCL VAT)			R 140,833.59

ITEM	CODE	DESCRIPTION	PRICE	QTY	TOTAL
1	DT-X8-10E	WIN CE 6.0, LASER, 802.11B/G, BLUETOOTH	R 8,295.00	6	R 49,770.00
2	HA-K23XLBAT	LARGE CAPACITY BATTERY	R 809.36	6	R 4,856.16
3	HA-F32DCHG	DUAL SPARE BATTERY CHARGER	R 1,007.25	3	R 3,021.75
4	AD-S42120BE	AC ADPATER FOR HA-F32DCHG	R 355.50	1	R 355.50
		TOTAL (EXCL VAT)			R 58,003.41

Notes.

1. **All prices quoted are exclusive of the VAT.**
2. **All prices quoted are subject to the exchange rate fluctuations.**

Best regards

Peter Malczyk

PEOPLE | PRODUCT | PASSION

QUOTATION

Attention :
Company :
Date :

Herewith pricing as requested:

Part Number	Description	SP	Qty	Sub
851-082-205	Universal power supply	R 391.04	2	R782.08
PB22A10004000	PB22 (2) Two Inch Rugged Mobile Direct Thermal Label-Receipt Printer	R 5 172.74	2	R10345.48

Thank you for the opportunity to quote you and should you have any further enquiries please do not hesitate to contact me directly.

Regards

Wayne Davidson
Business Development Manager
Enterprise Mobility
Switchboard: +27 11 265 3000
Direct: +27 11 265 3319

Terms & Conditions:

All prices exclude VAT. This quotation is based on an indicative exchange rate of R8.60=US$1.00 and must be confirmed at time of order. Lead times for non-stock items are 6-8 weeks from date of order. Pinnacle Africa's Standard Terms & Conditions Apply. Errors and Omissions excluded (E&OE). Orders are subject to cancellation at Pinnacle Africa's discretion, be it due to force Majeure or any cause beyond the control of the organisation. Pricing will be valid for the day of quote only. Notwithstanding the above, if the Rate of Exchange increases by more than 2% then this quote will no longer be valid.