

Design and Simulation of a new Tobacco Sales Floor Facility

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Executive Summary

Tribac management have established that as the company expands, due to its involvement with Japan Tobacco International, the current tobacco sales floor facility will not be able to cater for the increased demand. The goal of this project is to design a new tobacco sales floor for Tribac (Pvt.) Ltd.

This project utilizes common facilities planning principles together with time studies, line balancing calculations, statistical control charts and simulation modelling to assist in the development of alternative facilities plans.

These alternatives were then evaluated resulting in the selection of the most practical layout which was then developed further, in greater detail. This detailed design could potentially form the basis for the future development of a new tobacco sales floor for Tribac.

This report also recommends suitable material handling equipment that could be incorporated into the facility as well as a possible solution pertaining to the allocation of personnel throughout the facility.

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List of Abbreviations

TIMB	Tobacco Industry Marketing Board
TSF	Tobacco Sales Floors
JTI	Japan Tobacco International
SLP	Systematic Layout Planning

1.0 Introduction and Background



1.1 Tribac (Pvt.) Ltd

According to Kenneth Butchart, Finance Director of the Tribac Group, Tribac began operations in Zimbabwe in 1995. Initially, the Tribac Group was in the business of buying and selling tobacco. The tobacco was purchased direct from farmers in certain markets, and then it was processed and exported to a global group of cigarette manufacturers. Tribac also purchases tobacco on external auction sales floors depending on company needs and market requirements.

In recent years, Tribac has also been involved in the growing of the tobacco through contracted growers. Tribac provide all the inputs and expertise that are associated with tobacco farming to contracted growers and in return the farmers are obliged to sell their tobacco back to Tribac. Tribac has been conducting the tobacco buying process from one of its large warehouses. This large warehouse has allowed Tribac to purchase up to one thousand eight hundred bales of tobacco per day. This warehouse however, was originally designed to store boxes of processed tobacco meaning that a number of alterations had to be made in order for the buying process to take place.



1.2 Japan Tobacco International

Since 2009, Tribac has been part of Japan Tobacco International. Japan Tobacco International, according to its website (www.jti.com), is the international tobacco business of Japan Tobacco Inc., a leading tobacco product manufacturer, with a global market share of almost 10%. The company was formed in 1999 when Japan Tobacco Inc. purchased the international tobacco operations of the United States multinational R.J. Reynolds. The group employs a number of people all over world and sells its various products in numerous countries. The JTI Group manufacture various cigarette brands including Winston, Camel and Mild Seven.



Figure 1 Brands Manufactured by JTI

2.0 Problem Statement

Tribac management have established that as the company expands, due to its involvement with Japan Tobacco International, the current tobacco sales floor facility will not be able to cater for the increased demand. Not only will the current sales floor facility not be able to handle the required amount of tobacco on a day to day basis in future, but having the sales floor in the warehouse also reduces the increasingly valuable storage capacity of the warehouse. This has necessitated the need for a new tobacco sales floor facility.

Tribac have access to a piece of land, adjacent to the current warehouse, on which they intend to develop a custom-made tobacco sales floor. The buying process will in the future be held here. The new facility must be able to handle two thousand bales of tobacco per day with a view to increasing this number to two thousand five hundred bales per day as more growers are contracted.

3.0 Project Aim

The aim of this project is to design a potential tobacco sales floor facilities plan that will allow Tribac to meet its daily throughput requirements, whilst ensuring integration with existing facilities.

4.0 Project Scope

The intended scope of this project is to design a facilities plan for the Tribac Group which, potentially, will provide a basis for the future development of a customized tobacco sales floor. Emphasis will be given to:

- The layout of the customized sales floor
- Allocation of personnel in and around the facility
- Ensuring integration with existing facilities
- Movement in and around the facility
- Identification of suitable material handling equipment

5.0 Literature Review

Before attempting to design a tobacco sales floor based solely on principles found in academic literature, it is vital one has a good understanding of the processes involved in the operation of a sales floor as well as an idea as to the various concepts that are currently in operation. Making use of site visits as well as conducting a literature review allows one to identify the aforementioned concepts and to attain a thorough understanding as to the methods and techniques that apply to each concept.

5.0.1 Facilities Planning Defined

Facilities layout design is defined by Kundu and Dan (2010:39) as “a fundamental operation that involves planning, designing, and optimization of the physical arrangement of resources – man, machine, material, and attendant production systems – to streamline production” and they argue that such a system, once optimized, can actually help improve quality of the final product in many situations.

5.0.2 The Importance of Plant Layout and Material Handling

Meyers (1993) claims that plant layout and material handling affects the productivity and the profitability of a company more than almost any other major corporate decision. In order to design a successful facilities plan, it is vital that one thinks of a facility as a dynamic entity with emphasis being given to its adaptability and its suitability for use (Tompkins *et al.*, 2010). The layout of the facility must take into consideration operational factors such as vehicle egress and ingress, flows of material and personnel around the facility as well as supportive factors such as maintenance to ensure that a dynamic, integrated facility is developed.

Plant layout, as defined by Meyers (1993), “is the organization of the company’s physical facilities to promote the efficient use of equipment, material, people and energy.” He brackets plant layout, material handling, building design and plant location as sub-parts of a wider subject called facilities design. It must be noted that the location of the new facility has already been allocated and hence will not be discussed in great detail in this literature review. The building design is primarily an architectural job. It is vital that one is able to design a building capable of accommodating a new facility and hence is an extremely important consideration for a facilities design project.

Material handling is defined by Meyers (1993) as simply “moving material” and suggests that material handling equipment has positively affected working people more than

any other area of work design. The material handling equipment must take into consideration the health and safety of workers and must be economically feasible. Meyers (1993) also suggests that material handling and plant layout are so intertwined that they cannot be separated and argues that the choice of material handling equipment will have a direct affect on the plant layout design.

Effective facilities planning must encompass other factors that will also have a significant impact on the choice of material handling equipment and plant layout such as employee morale, management supervision, adaptability to satisfy future requirements, environmental impact, energy efficiency and sustainability (Tompkins *et al.*, 2010). In a country with high unemployment, like Zimbabwe, it is crucial that any optimized system has a healthy balance of man and machine whilst still maintaining quality and efficiency.

5.1 Existing Concepts

An investigation of existing tobacco sales floors lead to the identification of the following concepts. This investigation was carried out by making use of site visits as well as consultations with experienced personnel from industry. These concepts are briefly discussed together with their corresponding material handling equipment as well and the perceived advantages and disadvantages of each.

5.1.1 Concept 1 - Traditional

Concept 1 is the most common method of conducting tobacco sales and is in fact the method currently adopted by Tribac. This concept entails laying the bales of tobacco into lines on the sales floor (Figure 2) and utilizes a team of workers, using trolleys (Figure 3), to move the tobacco around the facility.



Figure 2 Bales laid into lines



Figure 3 Trolleys used to transport bales

After the bales have been off loaded from the vehicle the bales are weighed, given a bar-coded ticket and then sorted by grower before being taken to the sales floor by wheel barrow. The reason for the bales being sorted prior to being moved to the sales floor is due to the fact that there is often more than one grower delivering tobacco on the same vehicle. Once sorted the bales are then taken to the sales floor and laid into lines as seen in Figure 2. The bales are then opened, inspected for any foreign matter (for example mould, plastic, wood etc.) and then classified by an external Tobacco Industry Marketing Board (TIMB) officer according to the type and quality of the tobacco in the bale. If any foreign matter is found in the bale, the bale will not be sold and must be returned to the grower for re-handling. Only after the tobacco has been classified can the sale begin. The buyer will walk along the lines of tobacco and give a price per kilogram based on the classification and quality of the tobacco in each bale. Another TIMB officer will then check the price given to each bale and will adjust the price if necessary should the initial price be deemed too low. The grower, together with their representative, will then decide whether the price offered for the tobacco is suitable or not. If the price is too low, the farmer is free to remove any bale from the sale.

Once the bale has been bought an internal classification, based on the buying company's marking scheme, is given to each bale of tobacco. Should the sale be allowed to proceed, the bales are sewn closed and transported to a classification area where the bales of tobacco are sorted by internal classifications. As the bales arrive at the classification area a copy of each bale ticket, which now contains the weight of the bale, price per kilogram, internal and external classifications and buyers mark, is removed and sent for data capture. Once there are twelve bales of a particular classification in the sorting area, the bales are palletized and taken by forklift (Figure 4) to a storage area (Figure 5).



Figure 4 Forklift transporting pallet



Figure 5 Pallets in stack in storage area

Advantages

- Very little maintenance required.

Disadvantages

- This type of sales floor involves a large amount of material handling, resulting in significant damage to both the bale packaging as well as the tobacco itself. Damaged tobacco cannot be processed, damaged packaging takes time to repair.
- A large amount of space is needed to accommodate the bales that are to go on sale each day thus limiting the capacity of the sales floor.
- This large area of sales floor also requires a significant amount of lighting in order for the sale to proceed.

5.1.2 Concept 2 – Electric Carts and Trailers

Concept 2 involves placing the bales of tobacco onto individual trailers (Figure 6) which are then towed to and from the sales floor using a team of electric carts (Figure 7). This concept is currently employed at the Tobacco Sales Floors in Harare, Zimbabwe. The Tobacco Sales

Floors are in actual fact auction floors thus allowing many different companies to bid for the tobacco on sale.



Figure 6 Bales laid on trailers



Figure 7 Electric carts used to haul trailers

The procedures involved with the operation of a tobacco sales floor of this nature are similar to that of Concept 1. A significant difference between the first concept and this concept is the choice of material handling equipment.

The Tobacco Sales Floors (TSF) use slatted conveyors to move the bales of tobacco from the off loading platform to the sorting area. Once the bales have been sorted and are ready to be moved to the sales floor, the bales are placed back onto the conveyor and transported to a dispatch station. At the dispatch station, each bale is weighed and ticketed and then placed onto interlinked, individual trailers. These trailers are then towed through to the sales floor where they are parked, ready for sale.

The procedure involved in the buying process is exactly the same as that of Concept 1, except for the fact that each bale is auctioned rather than bought as is. Once the auction is complete, an electric cart will then haul the line of bales from the sales floor to a set of dispatch platforms (Figure 8) where the bales are off loaded from the trailers at the appropriate platform. At each platform, the bales are loaded onto the vehicle tasked with transporting the bales of tobacco back to each company's respective storage facility (Figure 9).



Figure 8 Dispatch Platform



Figure 9 Bales loaded onto trucks ready for dispatch

Advantages

- This concept involves minimal material handling thus reducing damage to both the tobacco and the packaging.

Disadvantages

- Again, a large amount of space is needed in order to accommodate the required number of bales for sale on a daily basis.
- Significant amounts of time and money can be spent on maintenance of the trailers and carts in order to maintain smooth efficient flows around the facility.
- Large amount of lighting required.

5.1.3 Concept 3 - Conveyor

Concept 3 is currently employed by Limpopo Tobacco Processors in Rustenburg, South Africa. A significant difference between this concept and the previous two concepts is that the boxes of tobacco move passed the buyers on a conveyor belt, rather than buyers having to walk up and down the lines of tobacco (Figure 10).

The bales are offloaded straight from the vehicle and taken to the sales area using a system of conveyor belts. The speed of the conveyor belts are controlled by the buyers. Once

a box has been opened, it is checked for foreign matter before it moves past the buyer. The buyer, who represents Limpopo Tobacco Processors, will classify the tobacco in each box; each classification having a set price. The box will then move past a data capture station (Figure 11) where the box is weighed and the corresponding classification information is captured. Once the information from the box has been captured, the box is closed and will continue along the conveyor belt to another vehicle that will transport the boxes to a storage facility



Figure 10 Boxes of tobacco on conveyor



Figure 11 Boxes moving passed data capture station

Advantages

- Conveyor belt used to move the tobacco around the facility thus reducing the amount of material handling required.
- Very little space required in order to conduct a sale.
- Does not require a large amount of lighting.

Disadvantages

- Maintenance of conveyor belts can be costly.

5.2 Discussion

Based on preliminary discussions with Tribac management, Concept 3 appears to be the idea that the company would like to look at in greater detail. This is largely due to the limited amount of space available to Tribac, as well as a desire to reduce the amount of damage to the tobacco bale by minimizing the amount of movement and handling the bales undergoes on the sales floor.

Preliminary investigations have highlighted a few significant changes that would have to be implemented in order for the concept to be adapted to the needs of Tribac. The main changes that would need to be made are as a direct result of the fact that the size of the bales differ significantly (50-70 kg in South Africa compared to 100-120 kg in Zimbabwe), and due to differences in the method of packaging (cardboard boxes in South Africa, paper and hessian wraps in Zimbabwe). The remainder of the literature review will be used to identify methods and equipment that can be used to accommodate these differences.

5.3 Layout Procedures

It is important to generate and evaluate a number of different layout alternatives. Generating different alternative layouts will allow the design to incorporate all of Tribac's requirements and to ensure a smooth, efficient flow around the facility. There are a number of documented layout procedures available that one utilize when attempting to design or improve a new or existing facility (Tompkins *et al.*, 2010). Some of these procedures are discussed below. Note that these procedures follow a logical, step by step process ensuring that each aspect of the facility is accounted for.

5.3.1 Apple's Plant Layout Procedure

According to Tompkins *et al.* (2010), Apple proposed the following sequence of steps in producing a plant layout.

1. Procure the basic data
2. Analyze the basic data
3. Design the productive process
4. Plan the material flow pattern
5. Consider the general material handling plan
6. Calculate the equipment requirements
7. Plan the individual workstations

8. Select specific material handling equipment
9. Coordinate groups of related operations
10. Design activity interrelationships
11. Determine storage requirements
12. Plan service and auxiliary activities
13. Determine the space requirements
14. Allocate the activities to space
15. Consider building types
16. Construct master layout
17. Evaluate, adjust and check the layout with the appropriate persons
18. Obtain approval
19. Install the layout
20. Follow up on implantation of the layout.

It must be noted that these steps needn't be performed in this specific sequence. This is due to the fact that no two layout design projects are the same and hence neither will be their procedures for developing them.

5.3.2 Reed's Plant Layout Procedure

According to Tompkins *et al.* (2010), Reed (1961) recommended the following "systematic plan of attack" as required steps in "planning for and preparing the layout."

1. Analyze the product or products to be produced
2. Determine the process required to manufacture the product
3. Prepare the layout planning charts
4. Determine the workstations
5. Analyze storage area requirements
6. Establish minimum aisle widths
7. Establish office requirements
8. Consider personnel facilities and services
9. Survey plant services
10. Provide for future expansion

Reed considers the third step; prepare the layout planning charts, the most important step of the design process as it incorporates:

1. Flow process, including operations, transportation, storage and inspections
2. Standard times for each operation
3. Machine selection and balance
4. Manpower selection and balance
5. Material handling requirements

5.3.3 Muther's Systematic Layout Planning Procedure

Freivalds (2009) argues that the goal of systematic layout planning as developed by Muther (1973) is to locate two areas with high frequency and logical relationships close to one another using a six step procedure:

1. Chart relationships
2. Establish space requirements
3. Complete activity relationship diagram
4. Identify layout space relationships
5. Evaluate alternative arrangements
6. Select layout and install

Having studied the different procedures for designing plant layouts, it was decided that Muther's Systematic Layout Planning procedure is the most appropriate for this project. This is largely due to the familiarity the author has with the procedure.

5.4 Basic Layout Types

Tompkins *et al.* (2010) identified types of basic layouts. These include:

- Production line product layout
- Fixed product layout
- Product family layout
- Process layout

The type of layout is dependent on the flow of products as well as the processes involved in the operation of the facility. One would classify the facility Tribac are considering implementing, which utilizes conveyors to move bales of tobacco around the facility, as a production line product layout. In a production line product layout the processing is sequential with minimal or no backtracking. In other words the flow of work follows the flow of bales (Tompkins *et al.*, 2010).

5.4.1 Production Line Product Layout

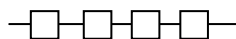
It is important to define the overall flow environment within which material movement take place. The principle of minimizing total flow represents the work simplification approach to material flow (Tompkins *et al.*, 2010). According to Tompkins *et al.* (2010), this approach to material flow includes:

1. Eliminating flow by planning for the delivery of materials, information, or people directly to the point of use and eliminating intermediate steps.
2. Minimizing multiple flows by planning for the flow between two consecutive points of use to take place in as few movements as possible, preferably one.
3. Combining flows and operations wherever possible by planning for the movement of materials, information, or people to be combined with a processing step.

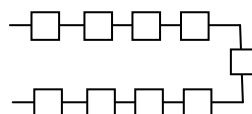
As previously mentioned, the flow of bales through the facility is sequential. Systems using conveyors will typically follow one or more of the following flow patterns namely (a) the line flow, (b) the spine flow, (c) the loop flow, and (d) the tree flow (Tompkins *et al.*, 2010). A few examples of these patterns are illustrated in Figure 12.

(a) The line flow

- Straight line flow



- U – Flow



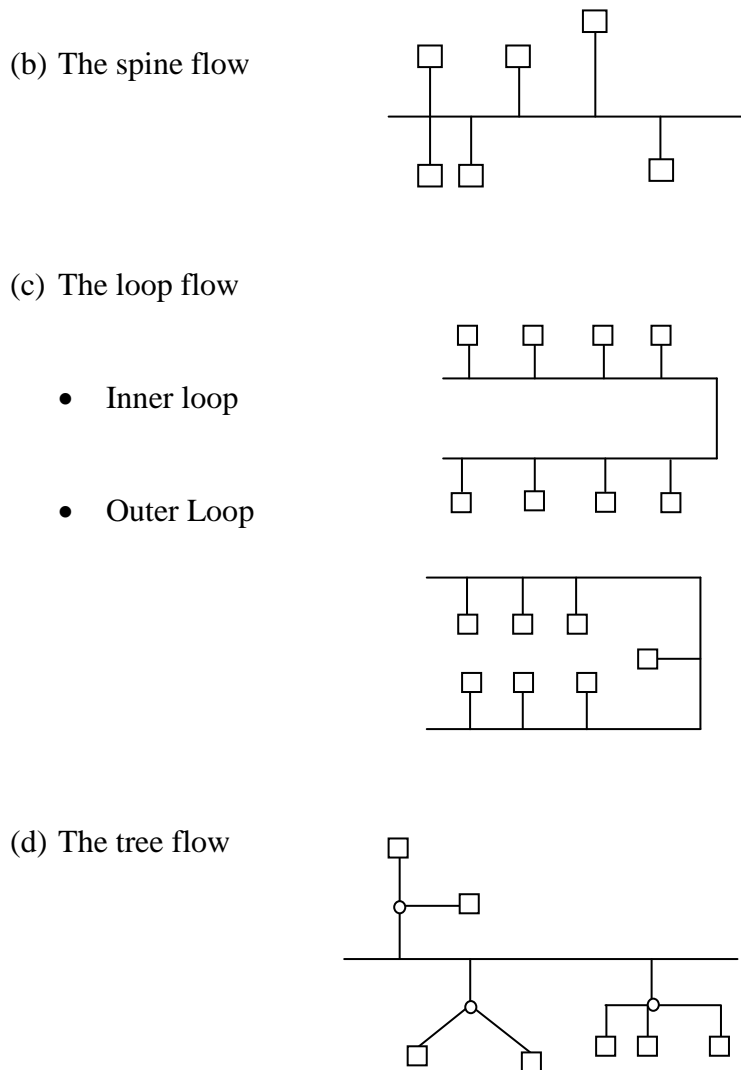


Figure 12 (a) Line Flow (b) Spine Flow (c) Loop Flow (d) Free Flow

The choice of flow patterns will depend on the space available for development. For example, a straight line production will result in a thin building shape which is inefficient in the use of space. Converting the straight line flow will help to “square off” the building and potentially increase the space utilization of the facility and in turn reduce construction cost (Tompkins *et al.*, 2010).

5.5 Tools and Techniques

There are a number of tools and techniques available that, when combined with one of the above mentioned layout procedures, allow one to ascertain the various spatial requirements and personnel configurations. The resulting information can be used to generate an accurate

facilities plan that could potentially form the basis for the future development of a customized tobacco sales floor for Tribac. These tools and techniques are discussed below.

5.5.1 Line Balancing

As previously mentioned, the proposed layout will be that of a production line product layout. The layout will entail groups of several workers, each performing consecutive operations. Line balancing can be used to determine the ideal number of workers to be assigned to the production line (Freivalds, 2009).

In order to perform the line balancing calculations, time studies of each process will need to be conducted. The processes and procedures that will need to be included on the proposed production line will be essentially the same as those currently in use at existing tobacco sales floors. This means that accurate time studies should result in useful information pertaining to the allocation of personnel along the production line.

5.5.2 Quality Management

There is a vast amount of data available regarding the number of bales rejected on a daily basis from the existing tobacco sales floor. This data, once plotted and analyzed using an attribute control chart, will allow one to establish the average percentage number of bales rejected each day.

The results obtained from this quality analysis can then be used to calculate the space requirements for a holding area for rejected tobacco bales, should a holding area be required, and to add a degree of accuracy when programmed into a simulation.

5.5.3 Simulation Modelling

Simulation modelling can be used to establish whether a proposed system will be able to cater for the requirements of Tribac management. The results of the time studies and subsequent line balancing calculations; as well as data obtained from the above mentioned quality management investigation can be used as the input data for the model.

Simulation modelling can also be used to investigate how changes to the allocation of personnel on the production line affect the throughput efficiencies, queue sizes and resource utilizations. The results of the simulations will also allow one to establish space requirements throughout the facility based on subsequent queue lengths and resource utilizations.

There is a number of different simulation modelling software packages on the market. These include Simio, Arena and Any Logic to name a few.

5.6 Material Handling Equipment

The design of the material handling system is an important component of the overall facilities design and is often considered inseparable from the layout design (Tompkins *et al.*, 2010). The choice of material handling equipment will have a direct impact on the efficiency of the new facility. Important factors to be considered when choosing material handling equipment include maintenance, space availability, and the ability of the operators to handle the equipment in a disciplined manner.

The material handling equipment that could potentially be implemented in the new tobacco sales floor is discussed below.

5.6.1 Conveyors

According to Tompkins *et al.* (2010), conveyors are normally used when material is to be moved frequently between specific points over a fixed path and suggests that there must be sufficient volume of movement to justify dedicating the equipment to the task.

There are numerous conveyors available. The choice of conveyor will depend on the type of load to be moved as well as the environment in which it will operate. In this instance, the bales of tobacco are typically between 60kg-120kg in weight, have dimensions of approximately 60x80x70 cm, and are wrapped in paper and hessian. The conveyors that would be able to handle the required loads have been identified and are discussed below.

Slat Conveyor

Slat conveyors are narrow slats of wood or metal attached to chains. The slats will travel down a pair of chains to the end of the line and run back to the beginning under the line (Meyers, 1993). Tompkins *et al.* (2010) recommend that slat conveyors be used for heavy loads with abrasive surfaces that might damage a belt. An example of a slat conveyor can be seen in Figure 13.



Figure 13 Slatted Conveyor

Roller Conveyor

Live or powered roller conveyors are usually belt or chain driven. Roller conveyors are used for conveying higher load capacities over a fixed path for long distance (Meyers, 1993). Because of the roller surface, the materials being transported must have a rigid riding surface (Tompkins *et al.*, 2010).



Figure 14 Powered Roller Conveyor

The non powered roller conveyor could be used at each station to allow bales to be pulled off the powered roller or slat conveyor. This will allow the operators to move the bales with ease without damaging the bale. An example of non powered roller conveyor can be seen in Figure 15. Note that the legs of the conveyor may have wheels attached thus allowing for the conveyor to be moved easily if necessary. The wheels can be locked to provide a stable work surface.

Another application for the non powered roller conveyor could be for use in the sorting and palletizing area. In this instance, the roller conveyor is almost at ground level (Figure 16). This application will allow the bales to be moved with ease and with little damage to the bale.



Figure 15 Non Powered Roller Conveyor



Figure 16 Ground level Roller Conveyor

5.6.2 Pallets

The pallets currently in use at Tribac are pictured in Figure 17 and can be stored up to four pallets high. These pallets hold up to twelve bales each. Each pallet, once full, will weigh up to one and a half tons. The forklifts in operation must have a carrying capacity capable of handling this weight.



Figure 17 Pallets in stack

5.6.3 Scales

The scales that will be used to weigh the bales of tobacco as they enter the sales floor should be built into the conveyor (Figure 18). The scale should have a heads up display for ease of reading for the clerk who will capture the bale weight. If the scale has a powered roller top

(Figure 19), very little or no physical handling will be required by an operator (Itin Scale Company, 2011). The scale should be capable of measuring up to 150kg and should be accurate so as to comply with government regulations.



Figure 18 Built in Scale - Belt Conveyor



Figure 19 Scale with Roller Top

5.6.4 Trolleys

Bales may need to be moved to parts of the facility that don't have access to the conveyor. Trolleys may be used in this instance. These trolleys should be capable of handling the weight of a bale and should be small enough to access narrow aisles. The trolleys currently in use by Tribac are illustrated in Figure 20. Other models of trolley are also shown below in Figure 21 and 22.



Figure 20 Trolleys currently in use



Figure 21 Low loading platform trolley



Figure 22 Folding Trolley

5.6.5 Forklifts

Forklifts will be used to transport pallets to and from the storage area. As previously mentioned, the pallets will weigh up to one and a half tons hence the forklifts used should have a carrying capacity of at least two tons. As the pallets are stacked four high in places, the forklifts should have a height reach of at least five metres. A forklift currently in use at Tribac can be seen in Figure 23.



Figure 23 Two ton forklift

5.6.6 Loading/Off-loading Concepts

In order to process the required number of bales per day, it is important that the bales are off loaded quickly and efficiently with as little damage to the bales as possible. The concept employed should cater for the different size trucks that will be delivering and collecting bales.

Scissor Lift

A concept that is currently in use at the Northern Tobacco sales floor in Harare, Zimbabwe is illustrated in Figure 24.

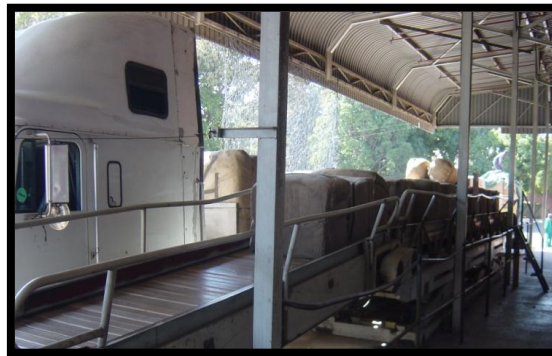


Figure 24 Scissor lift with Slatted Conveyor

This concept utilizes a scissor lift with a slat conveyor. The scissor lift allows the different sized trucks to be catered for, whilst the conveyor transports the bales to the sales floor with minimal handling.

Jib Crane

Floor or wall mounted jib cranes can also be used to load or un-load tobacco bales. Jib cranes are flexible allowing for a 360° rotation of the beam (Meyers, 1993); they can cater for the different sized trucks and will also minimize the amount of damage to the bales. An example of a floor mounted jib crane can be seen in Figure 25.



Figure 25 Jib Crane

Lift Conveyor

A lift conveyor that has the option of adjusting the height can also be used to cater for the different sized trucks (Meyers, 1993). An example of a lift conveyor can be seen in Figure 26. Some conveyors have wheels at the base thus allowing them to be moved around when required.



Figure 26 Lift Conveyor

6.0 Conceptual Design

As mentioned in the literature review, the procedure to be followed in designing this new tobacco sales floor will be Muther's systematic layout planning (SLP) procedure (Muther, 1973). It must be noted that the location of the sales floor has already been assigned by Tribac (Pvt.) Ltd. A diagram of the existing layout together with the area proposed for further development can be seen in Figure 27.

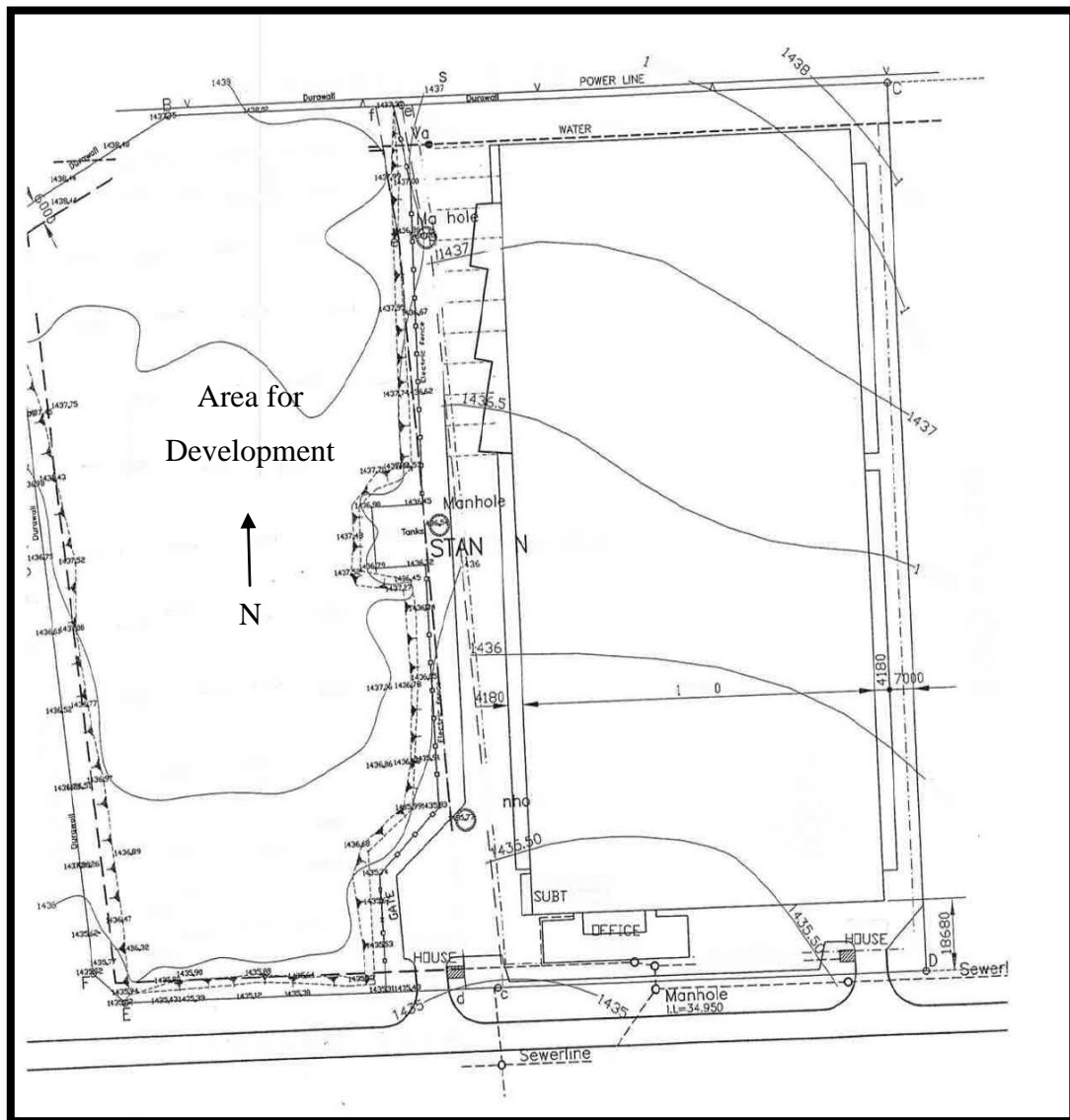


Figure 27 Tribac Property Layout

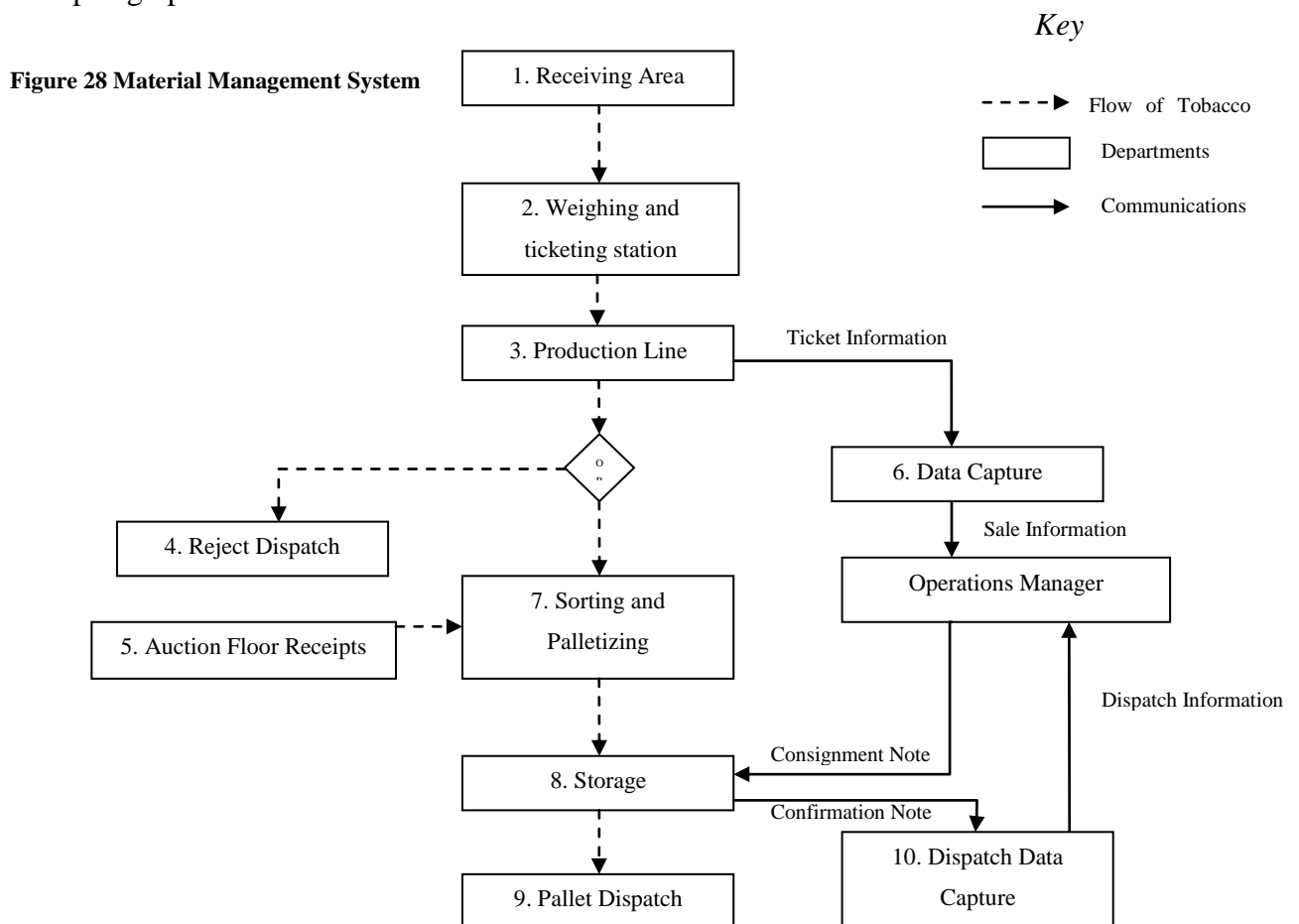
According to one of the Directors of Tribac, Kenneth Butchart, previous studies of the land proposed for development have calculated the maximum possible warehouse area at 16000m². This size warehouse will still allow for access to and from the facility. The warehouse currently in use is 20000m² and is used as a temporary tobacco sales floor and

storage facility for the tobacco passing through the tobacco sales floor. This warehouse was originally designed to store boxes of processed tobacco.

This change in use of the warehouse has resulted in the reduction of the storage capacity of the warehouse and has reduced its overall utilization. Since the temporary tobacco sales floor and storage facility were moved into the warehouse, the processed tobacco has been stored in another rented facility elsewhere in Harare. Tribac management have expressed a desire to move the processed tobacco back in to the current warehouse, and to develop a custom made sales floor facility and storage area on the piece of land adjacent to the current warehouse.

6.1 Area Relationships

Before one can define area relationships, it is important to understand the material flow system within a facility and the corresponding operations that allow for this material flow. The following material management system is a schematic representation of the processes and flow of material and communications that need to be incorporated into the facility (Figure 28). This flow together with a description of the process involved is discussed in the next paragraph.



According to Freivalds (2009), the first step in of Muther's SLP procedure is to chart the relationships between different areas on a relationship chart. Based on various site visits as well as consultations with Tribac management and experienced personnel from industry, the following areas have been identified and deemed necessary for implementation in order for a facility of this nature to be effective.

- 1. Receiving area** – This area is used to off-load the tobacco bales brought for sale from the delivery trucks.
- 2. Weigh and ticketing station** – After the bales have been off-loaded, the bales are weighed and provided with a bar-coded ticket. This ticket will eventually contain all the sale information relating to the TIMB classification, weight, price, date, buyers mark and internal classification. This ticket will allow the bales to be tracked wherever the bale is within the sales floor and storage area therefore increasing accountability.
- 3. Production line area** – All the processes involved in making the sale of the tobacco bales possible are included in the production line area. This includes areas for opening, checking, buying, classifying, viewing and closing of the bales.
- 4. Reject dispatch area** – Bales that have not been sold for whatever reason, be it foreign matter in the bale or the price offered deemed unacceptable by the farmer, must be removed from the sales floor facility before the bales get to the sorting area. These bales will be loaded back on to the vehicle that brought the bales in for sale at the reject dispatch area.
- 5. Auction floor receiving area** – Tribac also purchases tobacco at other external tobacco auction floors. This tobacco will have to be sorted and palletized upon delivery.
- 6. Data capture station** – This station will capture the data relating to the sale of each tobacco bale as gleaned from the aforementioned ticket. At the end of each sale, the staff at the data capture station will process all payments to the grower. Information relating to the sale is then passed onto operations department who manage and control the inventory of bales in storage.
- 7. Sorting and palletizing area** – Once the sale of the tobacco bales have been completed, the bales will continue through to the sorting and palletizing area. This sorting area will separate the different types of tobacco based on the internal classifications given to the bales. Once there are twelve bales of a particular

classification, the bales are loaded onto a metal pallet which is then taken off to the storage area.

- 8. Storage area** – The storage area will contain the pallets of tobacco that have been sorted in the sorting area. When an order is received from the operations manager for a consignment of pallets, personnel in the storage area will prepare the order by taking the relevant pallets to the pallet dispatch area.
- 9. Pallet dispatch area** – Pallets are loaded onto trucks before being taken to the processing plant
- 10. Pallet dispatch data capture station** – As the pallets of tobacco leave the storage area, the information relating to the bales of tobacco on each pallet are captured at this station. This will allow management to track which bales have been dispatched and which bales are still in storage. All information relating to bales leaving the storage area is sent back to the operations manager.
- 11. Grower/Employee lounge** – A lounge is to be installed for the growers to wait before or after their sale. This lounge will also serve the staff working on the sales floor.
- 12. Ablution facilities**
- 13. Parking** – Growers as well as staff working in the facility require parking that is within close walking distance and does not interfere with operations.

A relationship is the relative degree of closeness, desired or required, among different areas (Freivalds, 2009). The relationship chart seen in Figure 30 is based on qualitative information gleaned from site visits and consultations with Tribac management. Closeness between areas may vary from A (absolutely necessary) to X (Not desirable).

This relationship chart will be used to further develop an activity relationship chart as well as a space relationship layout for the new facility. This will ensure that areas or departments that are important are kept close together, and areas with undesirable relationships are not. Some important characteristics of the relationship chart pertain to the relationships between the reject dispatch (4) and storage areas (8), as well as the production line (3); weighing and ticketing area (2) data capture (6), and the sorting and palletizing areas (7).

It is vital that rejected bales do not get anywhere near the storage area. Should a reject bale be loaded onto a pallet, the rejected bale will end up being processed with the accepted bales and could result in severe repercussions for Tribac. The close relationship between the production line, the weighing and ticketing, data capture and sorting areas is vital in ensuring material flow in as few movements as possible (Tompkins *et al.*, 2010).

It is also crucial that the bales of tobacco from the external auction floor do not get onto the production line, the reject dispatch area or the grower receiving area. This could result in severe disruptions and possible backtracking to rectify the problem.

6.2 Space Requirements

The total area of the facility available for development, as previously mentioned, is 16000m². The space requirements for each area will be based on existing industry standards, extrapolations of existing data, company policies and simulations.

6.2.1 Receiving Area

Note that this receiving area will not be housed inside the warehouse, but rather on the periphery. Tompkins *et al.* (2010) suggests the following three steps for determining the space requirements for receiving and shipping areas:

- Determine what is to be received and shipped
- Determine the number and type of docks
- Determine the space requirements for the receiving and shipping area within the facility.

Determine what is to be Received and Shipped

A receiving and shipping analysis chart is used to document the different types of vehicles and their corresponding load sizes (Table 1) that are used to deliver and transport bales of tobacco to and from the facility. The information presented in the analysis is courtesy of Mr Tawanda Rusere, the Tribac warehouse manager.

Table 1 Receiving and Shipping Analysis Chart

Description	UNIT LOADS			Size of Shipment (No. of Bales)	TRANSPORTATION		MATERIALS HANDLING	
	Type	Size	Weight		Mode	Specifications (lxbxh)(m)	Method	Approx Time
Receive Bales	Bales	60x80x70cm	±100kg	220	30 ton truck	22x2.2.x3	Manual	45 mins
Receive Bales	Bales	60x80x70cm	±100kg	120	7ton truck+6ton trailer	10x2.1x2.2	Manual	21 mins
Receive Bales	Bales	60x80x70cm	±100kg	70	7 ton truck	6.1x2.1x2.2	Manual	12 mins

Determine the Number and Type of Docks

By virtue of the type of tobacco sales floor being proposed, only one sale may take place at a time. Therefore only one vehicle can be off loaded at a time. The vehicle will park parallel to the receiving platform due to spatial constraints around the warehouse. The waiting area will comprise of queue behind the vehicle being off loaded. The largest vehicle to be accommodated at the docking platform will be a haulage truck of length twenty two metres.

Determine Internal Receiving Area Requirements

As the bales are off loaded, they are will be weighed and ticketed before flowing through to the sales area. Adequate space at the docking platform is required for the movement of personnel and tobacco bales. Tompkins et al. (2010) state that the minimum aisle width requirements between a stationary object and an operating machine is ninety centimetres. Assume the working space along the conveyor will be approximately one metre in width. This assumption together with the aisle requirements and the fact that the width of the conveyor is approximately one metre means that the total platform width must be a minimum of three metres. This concept is illustrated in Figure 31 which is currently in use at Northern Tobacco Sales Floor in Harare.



Figure 31 Receiving Platform

Based on the truck lengths and recommended receiving principles, the total space requirements for the receiving area will be approximately twenty five metres in length and three metres wide (75m²). This will allow for trucks to quickly and easily manoeuvre into and away from the receiving area.

6.2.2 Weighing and Ticketing Area

The weighing and ticketing area will consist of a small work station situated next to the conveyor as the bales enter the warehouse. The scale will be built into the conveyor. After the information relating to each bale is captured, a bar-coded ticket is printed and placed on the bale. The equipment required at the work station consists of chairs, a desk, and computers. Chairs will be used by the clerks responsible for data capture as well as a security guard. The proposed set up will be similar to that seen in Figure 32.



Figure 32 Data Capture Station

According to the OfficeFinder Website (2011), the amount of space needed for a clerk is approximately 6m². The office will be designed to accommodate more than one clerk to ensure the office is large enough to accommodate more clerks should the need arise. The data capture station will be approximately 10m².

6.2.3 Production Line

A simulation using Arena is used to calculate the space requirements for the production line. This will be achieved by programming a theoretical production line, taking note of the corresponding worker utilizations and queue lengths at each station.

In order to get the simulation as accurate as possible, time studies were conducted at existing tobacco sales floors. This is based on the fact that the processes involved at each

tobacco sales floor are essentially the same in terms of the way the bales are handled. The results of these time studies can be seen in Table 5, Appendix A. The time distributions were calculated using the Input Analyzer function in Arena.

Line balancing was used to calculate the required number of people at each work station along the production line. The results of the line balancing calculations (Page 67, Appendix A) were used as a starting point for the simulations.

Information relating to the percentage of bales rejected on a daily basis was gleaned from the TIMB spreadsheets that are prepared on a daily basis for each tobacco sales floor. The results of this investigation can be seen on the P-chart together with the corresponding calculations in Table 6 and Figure 55, Appendix A. The amount of rejected bales will vary from day to day. One can use existing data regarding rates of rejection and extrapolate the data to calculate the number of bales rejected, at increased throughput levels, and in turn calculate the subsequent space requirements for the rejected bale dispatch area. Note that the P-chart indicates that there are a number of days at the beginning and the end of the season that are out of control. This is largely due to the low number of bales on sale at the beginning and end of the season. It was decided that the average number of bales rejected will be based on the data from the middle of the selling season (day 25 to day 61), where the chart indicates increased stability compared to the beginning and end of the season.

As the size of the tobacco bale is known, one can then calculate the corresponding amount of space required before each station based on the simulation results pertaining to the queue size at each station. The worker utilizations obtained from the simulation model will provide an indication as to the number of workers required at each station. This fact together with existing information relating to work space guidelines, will allow one to calculate the amount of space required at each station.

The simulation model was programmed in accordance with the required process order. This order is as follows:

1. Bales arrive
2. Bales are weighed and ticketed
3. Bales are opened
4. Bales are checked for foreign matter
5. Bales are classified according to TIMB classifications
6. Bales are bought
7. Price for each bales is checked
8. Assign internal classification

9. Bales are closed
10. Sale information captured
11. Bales released into sorting area

A screen shot of the Arena simulation can be seen in Figure 56, Appendix A. The model was designed to simulate a five day working week with two thousand five hundred bales of tobacco being processed each day. The results of the simulation can be seen in Table 2.

	Operators per Station	Operator Utilization	Queue Length
Weigh & Ticket	2	36%	5
Open Bale	2	52%	10
FM Check	2	36%	2
TIMB Classification	1	29%	1
Buy Bale	1	44%	2
Price Check	1	29%	1
Internal Classification	1	36%	2
Close Bales	3	45%	2
Data Capture	2	36%	2

Table 2 Personnel Allocation

The number of operators at each station was calculated using the line balancing technique mentioned previously. An iterative process was used to test whether the utilization of each station could be increased and to monitor the subsequent changes in queue lengths. Decreasing the number of people at a workstation resulted in an increase in the size of the queue at the station and a decrease in utilization of personnel at the following stations. Increasing the number of people at a particular workstation resulted in lower worker utilizations at the station and an increase in queue length at stations down the line. A pictorial representation of the resultant personnel configuration can be seen below in Figure 33.

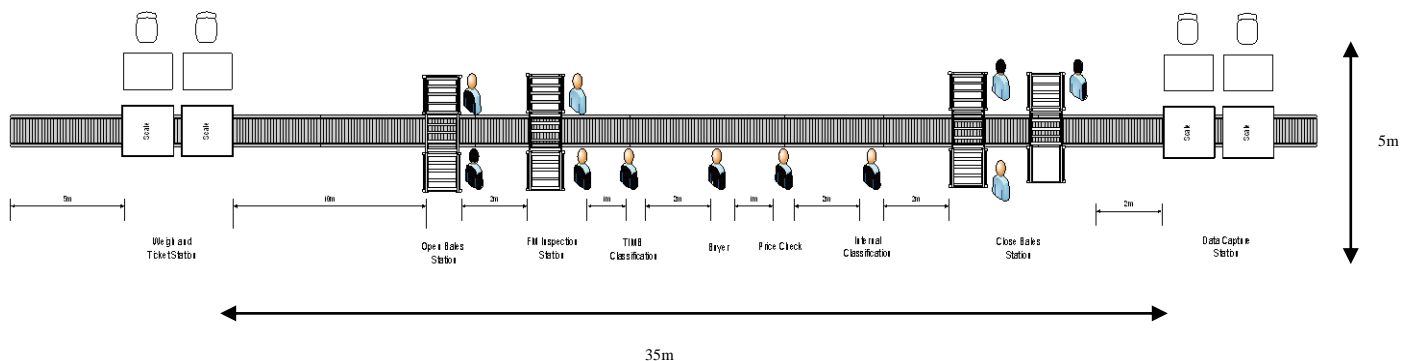


Figure 33 Personnel Allocation for Sales Floor

The queue space before each station is based on the queue size obtained from the simulation. Allowing for a length of 1m per bale will allow for the bales to be handled with ease without affecting other bales on the conveyor. The resultant height of the top of the bale on the conveyor belt must be conducive to good ergonomic working principles. A comfortable working height for a conventional able bodied person is approximately one metre twenty centimetres. The comfortable reach distance and typical width clearance for a conventional able bodied person is approximately seventy centimetres and fifty centimetres respectively (Tompkins *et al.*, 2010).

Based on the total length of the resultant configuration of the sales floor and approximation of the work space required for each workstation, the total area requirements for the 'production line' is approximately 175m². Note that the weighing and ticketing station as well as the data capture station areas have already been accounted for.

6.2.4 Rejection Dispatch Area

According to the data obtained from the TIMB daily reports (2011), see Figure 55, Appendix A, approximately 2% of bales are rejected on a daily basis. Causes for rejection include the presence of foreign matter inside the tobacco bale, for example plastic or mould, as well as discrepancies regarding the price offered for the tobacco. Designing the reject dispatch area to accommodate up to the upper control limit of 3% will ensure that about 99% of the time, there will be adequate space to accommodate the rejected bales. At the completion of each sale, the vehicle that delivered the bales of tobacco will be responsible for collecting any rejected bales. The rejection dispatch area should be large enough to allow for a twenty two metre long truck and trailer to park parallel to the platform and to accommodate up to 3% of the total bales brought for sale each day. 3% of two thousand five hundred bales equates to approximately seventy five bales. Each bale requires an area of approximately 0.45m², giving a total area requirement of approximately 40m² for rejected bales. A platform of at least three metres in width and twenty five metres in length will be sufficient to allow for movement of personnel and tobacco bales as well as a temporary storage area for rejected bales should there be a need to store the bales while the sale is in progress. Total area requirement for dispatch area is 75m². This reject dispatch area will not be housed inside the warehouse but rather on a platform on the periphery.

6.2.5 Auction Floor Receiving Area

The process performed to calculate the space requirements for receiving area of tobacco bales from external tobacco auction floors will be the same as that used in section 7.2.1. Note that this receiving area will not be housed inside the warehouse, but rather on the periphery. The procedure as documented by Tomkins *et al.* (2010) is as follows:

Determine what is to be Received

According to Tribac management, the company purchases up to two thousand bales of tobacco per day from other external auction floors. The bales will be delivered using large, thirty ton haulage trucks. Information relating to these vehicles and the corresponding specifications can be seen in Table 1.

Determine the Number and Type of Docks

Trucks will only be sent from the external auction floors once they are full or if the day's sales have come to an end. According to Tribac personnel there is usually only one truck delivering tobacco at any one time. The trucks will park parallel to the receiving platform, again due to the limited amount of space available around the warehouse. Should there be more than one truck delivering bales of tobacco at the facility at the same time, the waiting trucks will form a queue behind the truck off loading bales. One receiving dock will be sufficient to cater for the tobacco received from the external auction floors.

Determine the Receiving Area Requirements

Adequate space on the receiving platform will be required to allow for ease of movement for personnel and tobacco bales. The space requirements will be the same as those mentioned in 7.2.1 – 75m². The bales of tobacco, once off loaded, will flow through to the sorting and palletizing area on a conveyor where they will be sorted and palletized with the bales of tobacco from the production line. The concept for the design of the auction floor receiving area will be similar to that seen in Figure 34.

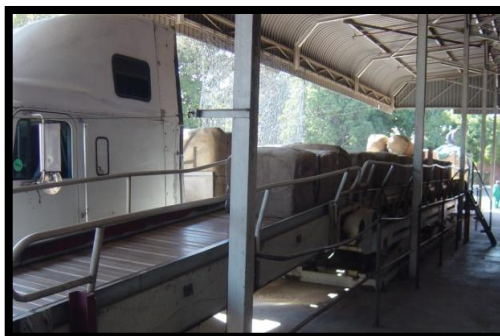


Figure 34 Receiving Platform

6.2.6 Data Capture Station

The data capture station will house the clerks and a security guard. One clerk will be required to process the ticket information pertaining to each bale flowing from the production line. The second clerk will be responsible for processing payments for the growers. The station will require a desk, a chair and a computer for each clerk as well as a printer and a chair for the security guard. If 6m² is sufficient for one clerk according to the OfficeFinder Website (2011), then 10m² should be sufficient for this data capture station.

6.2.7 Sorting and Palletizing Area

Tribac have one hundred and sixty different classifications. As the bales of tobacco flow through from the production line, they are sorted by internal classifications. Once there are twelve bales of a particular classification in a group, the bales are placed onto a pallet which is then taken to the storage area.

At present the lack of space in the classifying and palletizing area results in more than one class of tobacco being stored in the same row. This can lead to bales being mixed up as well as increasing the amount of material handling. Mr. Tawanda Rusere suggests that the width of the sorting area needn't be very wide if the length is sufficient to accommodate the respective classifications. Each bale is approximately sixty centimetres in width and seventy centimetres in length. Therefore the amount of space required for the sorting area will be approximately one hundred metres long and nine metres wide, resulting in a total area requirement of approximately 900m² for the sorting and classifying area.

6.2.8 Storage Area

The storage area will be used to store pallets of tobacco. The warehouse currently in use has a storage area of 11000m². Tribac management would like the storage area in the new facility to be at least the same size or larger if possible. Once all the space requirements for the other functions have been accommodated in the new facility, the remainder will be assigned to extra storage space.

6.2.9 Pallet Dispatch Area

The pallet dispatch area will be used to load the pallets of tobacco bales onto haulage trucks. These pallets are then taken to the processing plant where the bales are blended depending on

market requirements. The pallet dimensions are 145cm x 200cm x 170 cm, an example of pallets in stack can be seen in Figure 35.



Figure 35 Full Pallets in Stack

This dispatch area will also be located outside the warehouse. Adequate space should be provided to allow the forklift to manoeuvre easily when loading the truck. Each truck will carry up to six pallets. A pallet dispatch area of length twenty metres and width five metres (100m² in total) will permit the trucks and forklifts to manoeuvre with ease, allowing the trucks to be loaded as quickly and easily as possible.

6.2.10 Pallet Dispatch Data Capture Station

A clerk will be based at the data capture dispatch station. The clerk will receive the confirmation note from storage and will ensure that the pallets loaded onto the truck correspond to the order on the consignment note. This data capture station will require a desk, a chair and a computer. According to the OfficeFinder website (2011), the amount of space required for a clerk is 6m².

6.2.11 Grower/Employee Lounge

The size of the respective lounges will depend on the number of growers and employees present. The number of employees present total forty four and are allocated around the facility as shown in Table 3. These numbers were calculated using the results of the simulation mentioned previously and consultations with Mr. Tawanda Rusere. The number of

growers in the facility at any one time should not change significantly over the course of the day. This is due to the fact that the sales floor works on the basis of deliver today, sell today. The farmer will be told the time they can expect to sell their tobacco meaning a farmer can simply arrive just before the start of the sale. Only one grower can sell their tobacco at a time therefore the lounge need only be large enough to accommodate two growers waiting for a sale and two growers waiting for their sale to be processed and to be paid. The grower whose sale is being processed will not wait in the lounge but rather by the sale conveyor. Space for six growers should be sufficient should delays result in growers having to wait for longer periods of time. This lounge could be divided into separate rooms, with a room for growers and management and a room for warehouse staff. For this project, the lounge will not be separated and will accommodate growers, management and staff.

The lounge should provide a comfortable environment in which people can recuperate from work. Comfortable facilities show respect for employees and can help increase the work force productivity. Locating the lounge next to an outside wall may allow for an outside eating area which could provide a welcome respite to staff and growers alike from a sometimes hot and malodorous warehouse environment (Meyers, 1993).

Description	No. Of Employees
Off loading	8
Weigh/Ticket Clerks	2
Open Bale	2
FM Check	2
TIMB Classification	1
Buyers	1
Price Check	1
Internal Classification	1
Close Bales	3
Data Capture Clerks	2
Palletizing	8
Sweepers	3
Storage Clerks	8
Supervisors	2
TOTAL EMPLOYEES	44
Growers	6
TOTAL	50

Table 3 Employees Required

The OfficeFinder website recommends that a lunch room should allow for approximately 1.4m² per person. This gives a total area for the lounge of 70m².

6.2.12 Ablutions

Most of the people working in the facility will be male; however provision for separate male and female ablutions will be required. For the fifty people in the warehouse, the recommended minimum number of toilets is five (Tompkins *et al*, 2010). Tompkins *et al*. (2010) suggests that a toilet may be replaced by a urinal provided the number of toilets is not reduced to less than two thirds the minimum recommended numbers. For planning purposes, 1.2m² should be allowed for each toilet, and 0.6m² for each urinal. Tompkins et al (2010) also suggest that there should be at least one sink per three toilets, with each sink occupying 0.6m². Three toilets, two urinals and three sinks should be adequate for the needs of Tribac based on the number of males in the facility. As there are very few females who work or visit the warehouse, the female ablutions will consist of two toilets and one sink. The total space requirements for these ablutions, including a 50% allowance for aisle space and other clearances, are approximately 15m².

6.2.13 Parking

The only people who shall require parking are the growers and Tribac management. The remainder of the staff will use public transport to travel to and from the facility. At any one time there will be approximately six growers and five managers present. Provision for handicapped parking should be made. The dimensions for the conventional and handicapped parking bays can be illustrated in Figure 36 (Sport England, 1999).

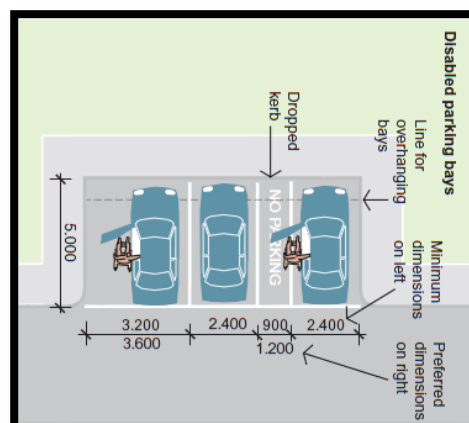


Figure 36 Parking Dimensions and Design

Based on the dimensions in the illustrated in Figure 36 and the number of parking bays required, total area requirements for the car park will be approximately 140m².

6.3 Activity Relationship Diagram

According to Freivalds (2009), the third step in Muther's systematic layout planning procedure entails drawing a visual representation of the different activities. The activities included in this diagram will correspond to the areas listed above in the relationship chart.

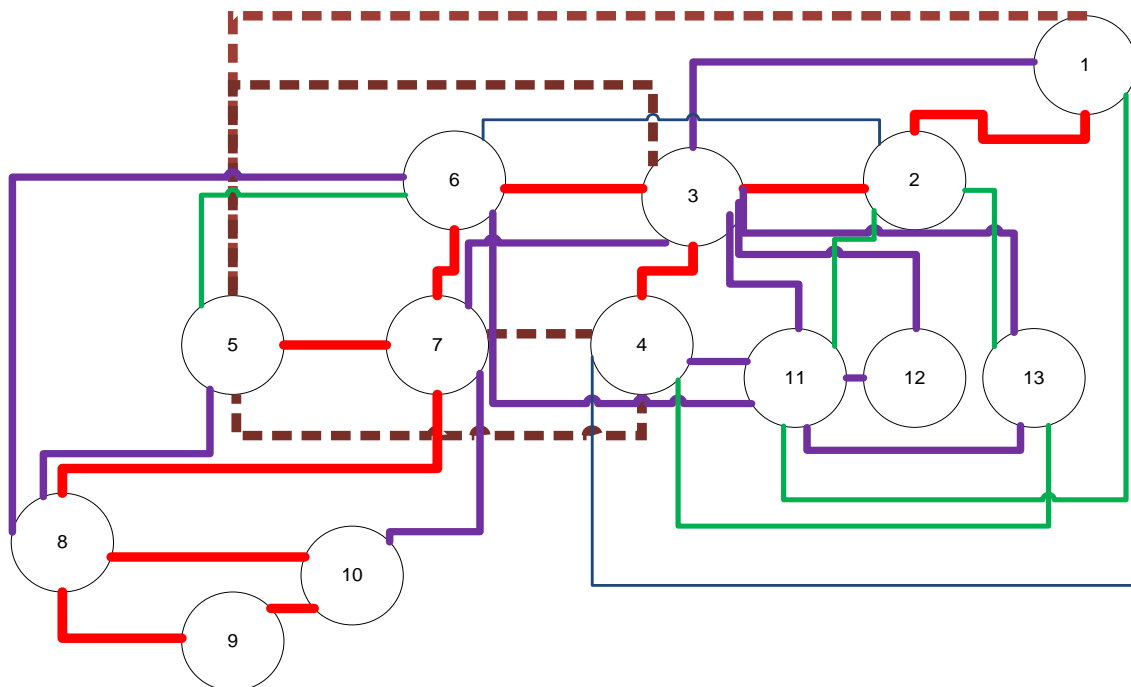


Figure 37 Activity Relationship Diagram

Relationship	Closeness Rating	Lines	Colour
Absolutely Necessary	A		Red
Especially Important	E		Yellow
Important	I		Green
Ordinary	O		Blue
Unimportant	U		
Not Desirable	X		Brown

1	Receiving Area	8	Storage
2	Weigh and Ticket Station	9	Pallet Dispatch Area
3	Production Line Area	10	Pallet Dispatch Data Capture
4	Reject Dispatch Area	11	Grower/Employee Lounge
5	Auction Floor Receiving Area	12	Ablutions
6	Data Capture Station	13	Parking
7	Sorting and Palletizing Area		

The areas with a high closeness rating are depicted in the diagram with red lines connecting the areas. Areas that should be kept as far apart as possible are depicted using a dotted, brown line.

6.4 Layout Space Relationships

Once the activity relationships have been established, the next step is to create a spatial representation of all the areas in terms of relative size (Figure 38). This will provide a basis from which floor plans can be designed.

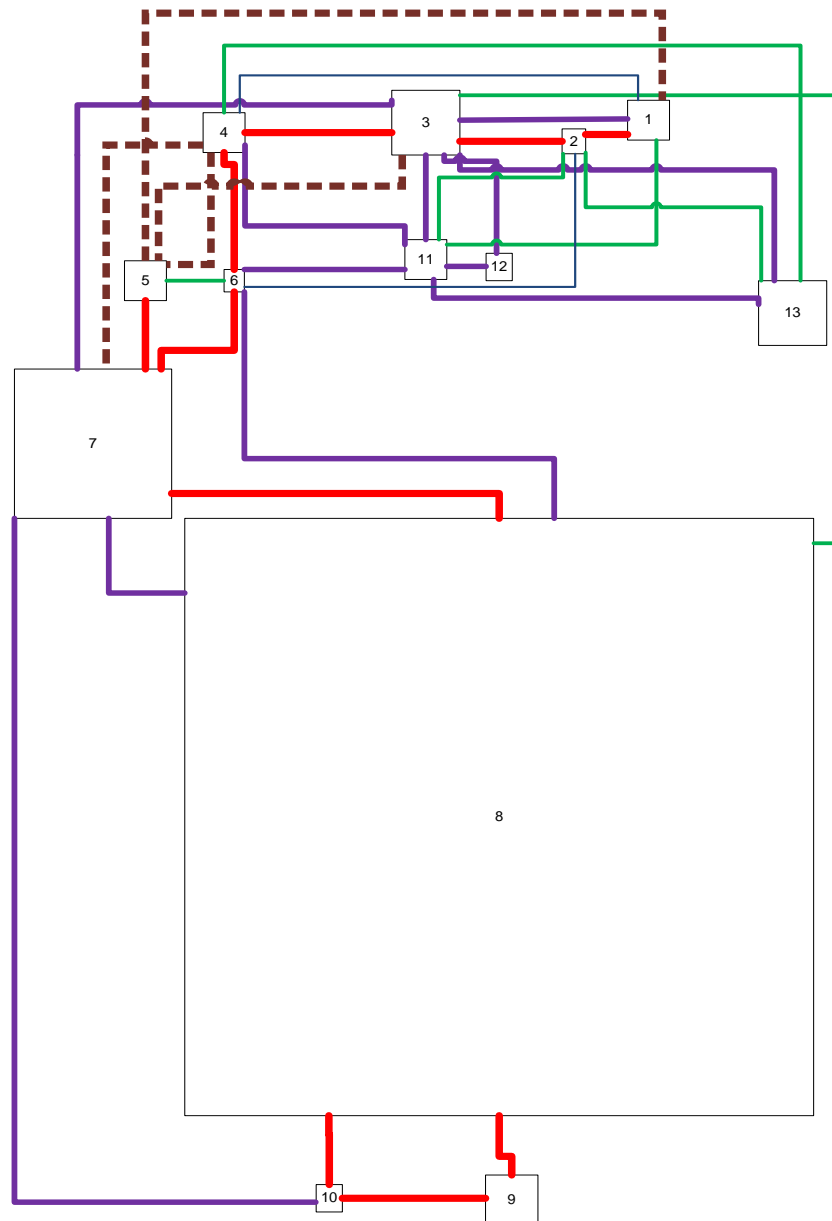


Figure 38 Space Relationship Layout

A scale diagram of the area proposed for future development can be seen in Figure 39. Due to the spatial constraints of the premises; 16000m² is the maximum floor area available for warehouse development and is identified in the figure below with a (*).

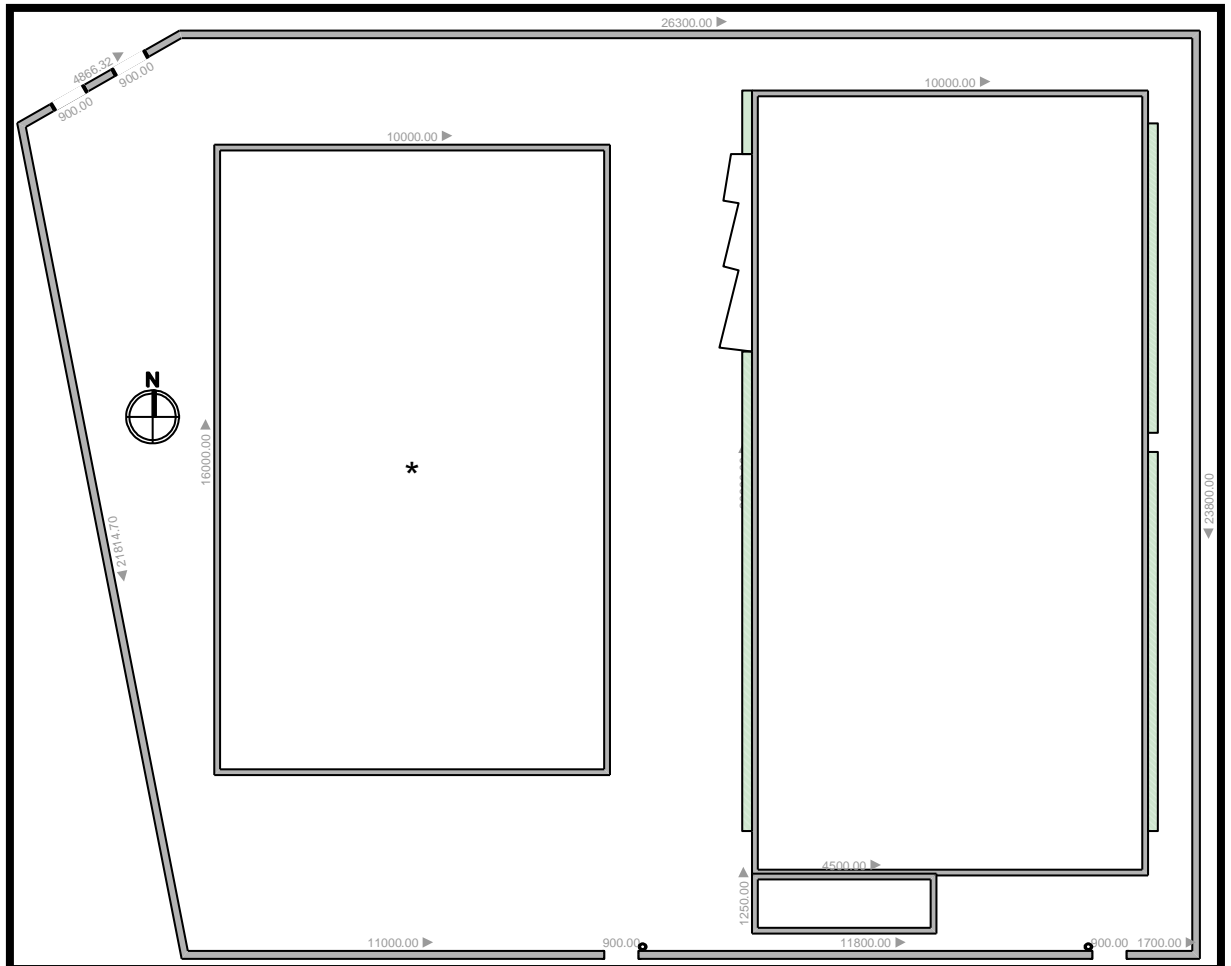


Figure 39 Current Premises Layout - Tribac

Based on the space relationship diagram above, the following alternative floor layouts were conceived. These alternative layouts make use of blocks, drawn to scale, to represent the functional areas in and around the facility. The benefits of each will be discussed in brief with an evaluation and comparison of the alternatives presented in section 6.5. Every effort has been made to ensure the important area relationships are upheld.

6.4.1 Alternative Layout 1

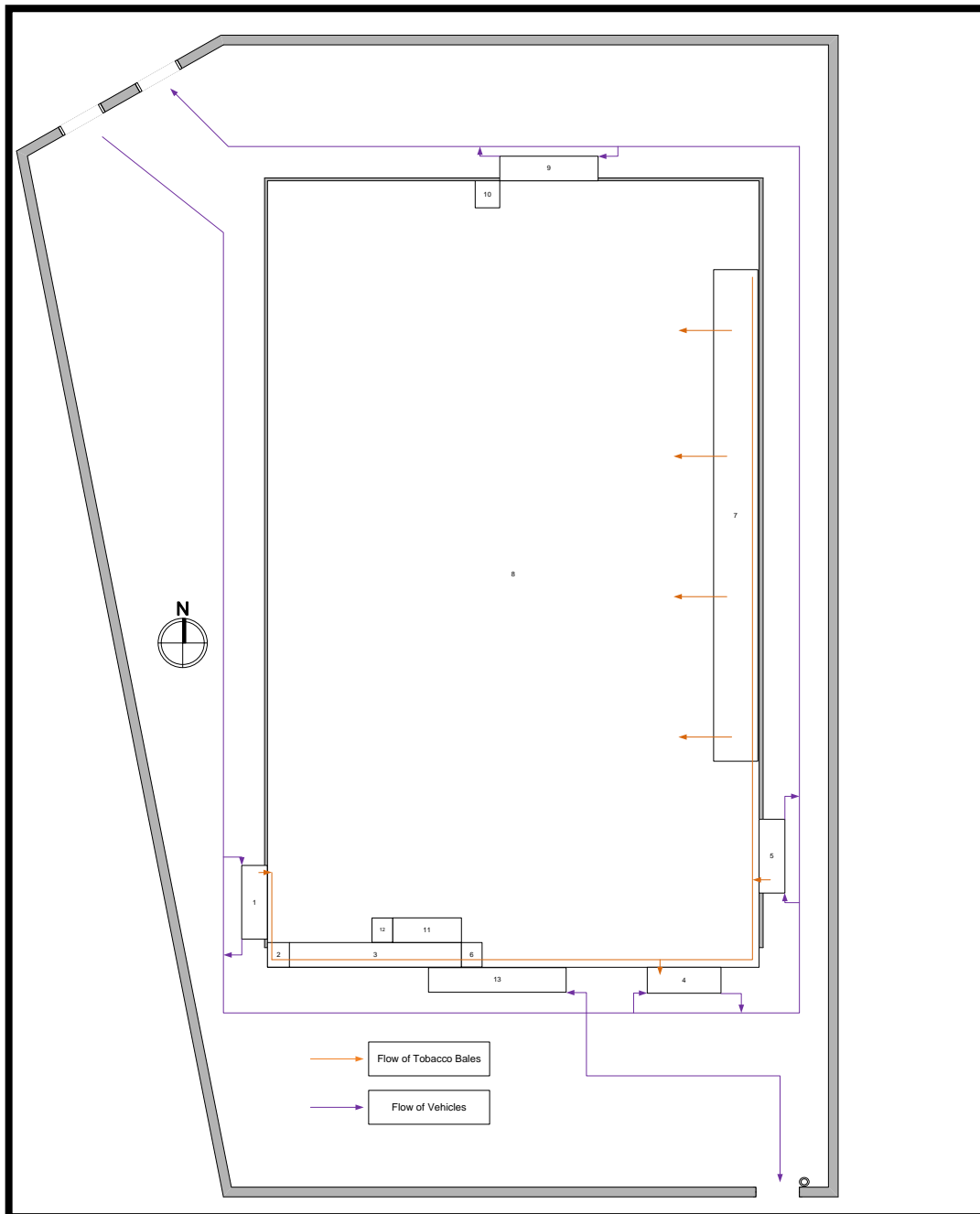


Figure 40 Alternative Layout 1

Accessibility

All trucks, whether delivering or collecting tobacco, will use the entrance and exit at the north western boundary. Growers and staff will use the entrance at the southern boundary and will park in a designated car park (13). The trucks will follow an anti-clockwise, single way route around the facility as indicated by the purple arrows.

Flow Efficiency

Off-loading of tobacco bales brought for sale will take place on the western side of the facility as indicated (1). The bales will then flow through to the weighing and ticketing station (2) before proceeding to the 'production line' (3). Once the sale has been completed the data relating to the sale is collected at the data capture station (6). Rejected bales are removed from the conveyor at the reject bale dispatch area (4). Bales of tobacco received from external auction floors will be off-loaded at a separate receiving area (5) situated on the eastern side of the warehouse. Bales that have been cleared for sale as well as bales brought from external auction floors will continue along a conveyor along the southern and eastern walls of the warehouse towards the sorting and palletizing area (7). The pallet dispatch area (9) and data capture station (10) are located along the northern wall of the facility. The grower/employee lounge (11) and ablutions (12) are situated so as to be close to where most people will be working, as well as to prevent growers and staff having to walk through the facility to get to the lounge from the car park.

Flexibility

Each dock will have enough space to accommodate a single truck. Trucks waiting to deliver or collect tobacco will form a queue behind the truck at the respective docking station. It must be noted that the queues could be as a result of disruptions within the facility hence it is vital the design caters for such disturbances. Docking stations that are likely to experience the longest queues are situated in areas that experience very little congestion and have adequate space for trucks to park whilst in the queue.

Future Expansion

The need for expansion may be accommodated in a number of ways. The length of the 'production line' can be extended along the whole southern wall, thus allowing more workers to be accommodated that in turn can process additional bales. Additional docks together with another production line, parallel to the existing line, may be added thus allowing more bales to be off loaded and processed at the same time, thus increasing the flow of bales through the facility. The lounge and ablution facilities are situated so as to be easily accessible to the majority of the people in the warehouse and can be expanded in the future should the need arise.

Supervision

The majority of the functional areas are situated along the southern end of the facility thus allowing increased management supervision.

Relationships

The flow of tobacco bales follows a logical path through this facility, thus ensuring that the important spatial relationships between the weighing and ticketing area (2), production line (3), data capture station (6) and the sorting and palletizing areas are upheld. Note that the storage area (8) will have to be fenced off from the production line (3) and reject dispatch area (4), thus ensuring tobacco bales are not mistakenly placed in storage.

6.4.2 Alternative Layout 2

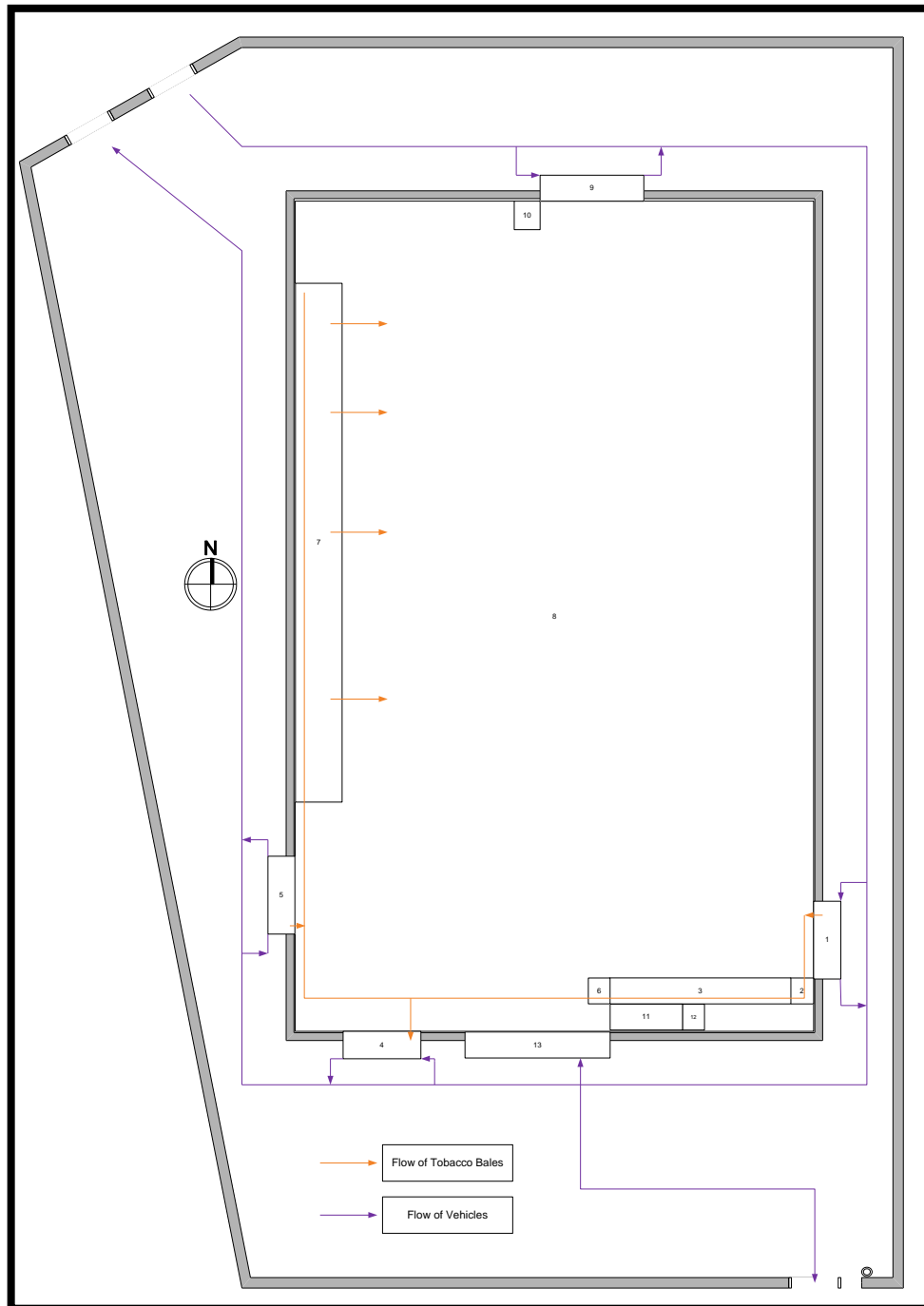


Figure 41 Alternative Layout 2

Accessibility

As was the case in Alternative 1; all trucks delivering or collecting tobacco will do so via the entrance and exit at the north western boundary. The growers and staff will arrive using the entrance at the southern boundary. In Alternative 2, the trucks will follow a clockwise single way route around the facility as indicated by the purple arrows. For a right hand drive

vehicle, it is often easier to turn right hence the reason for reversing direction of the route around the facility (Tompkins *et al.*, 2010).

Flow Efficiency

Note that the layouts of all the functional areas in and around the facility have been changed to accommodate the change in direction of flow around the facility. The flow of bales through the facility will follow order as that described in Alternative 1. A minor change from the previous design sees the lounge (11) and the ablutions (12) situated along the southern wall. This will allow for ease of access for growers from the car park and will prevent growers having to cross over the conveyor, as was the case in Alternative 1, to access the lounge. The lounge will also be open to the surrounding environment thus allowing workers and growers alike to get some ‘fresh air’ during breaks.

Flexibility

Again, each dock will have enough space to accommodate a single truck. Trucks waiting to deliver or collect tobacco will form a queue behind the truck at the respective docking station. Docking stations that are likely to experience the longest queues are situated in areas that experience very little congestion and have adequate space for trucks to park whilst in the queue.

Future Expansion

There will be room for expansion in future should the need arise. This will be achieved by using the same reasoning as mentioned in Alternative 1.

Supervision

As was the case in Alternative 1, most of the functional areas are situated along the southern end of the facility thus allowing increased management supervision.

Relationships

The flow of tobacco bales through this facility also follows a logical path thus ensuring that the important spatial relationships are upheld. These include the relationships between the weighing and ticketing area (2), production line (3), data capture station (6) and the sorting and palletizing areas. Note that the storage area (8) will also have to be fenced off from the production line (3) and reject dispatch area (4) ensuring tobacco bales are not mistakenly placed in storage.

6.4.3 Alternative Layout 3

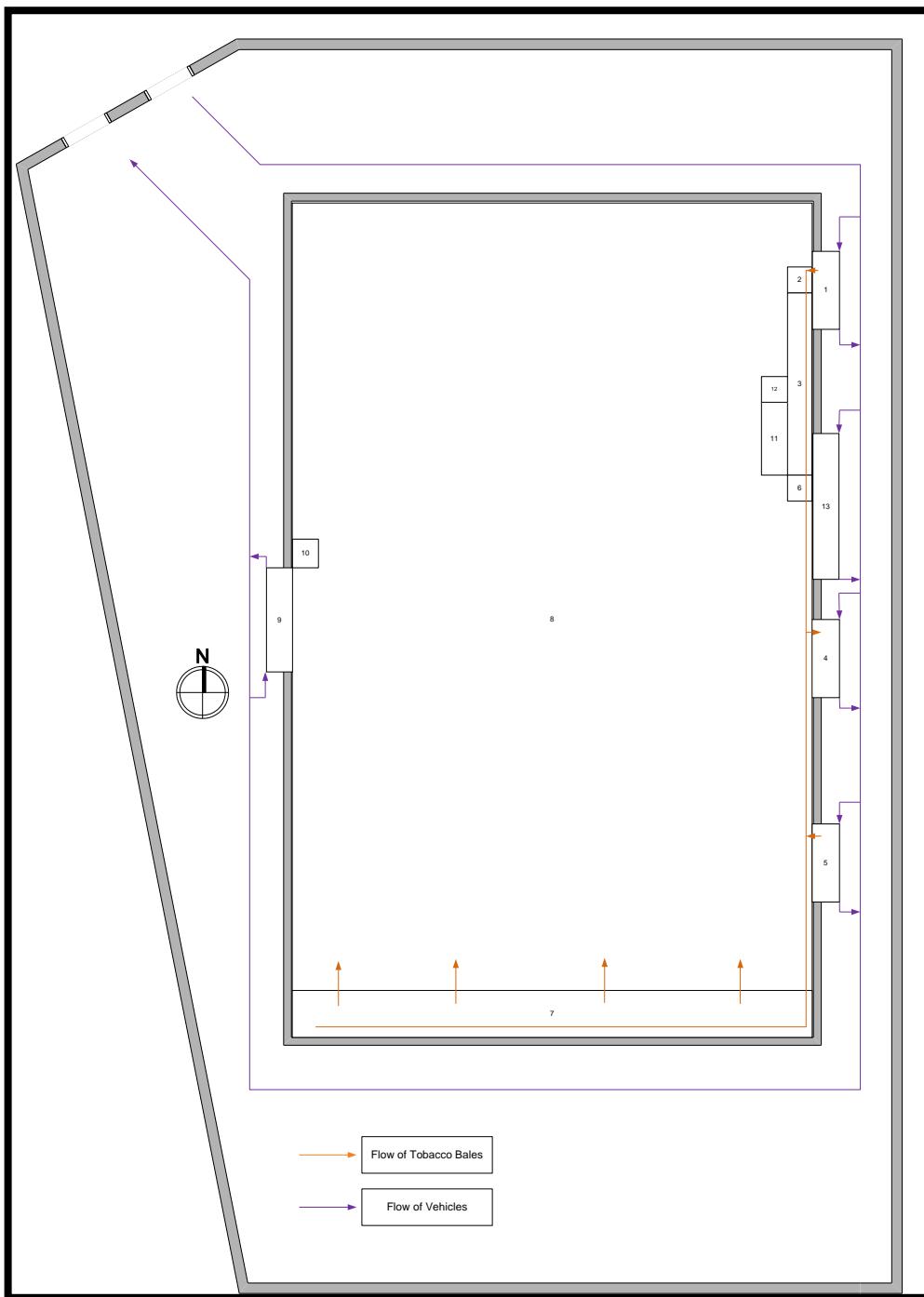


Figure 42 Alternative Layout 3

Accessibility

Alternative 3 utilizes a single set of entrances and exits for all vehicles, located on the north western boundary of the premises. Although this may cause congestion at the entrance and exit during busy times of the day, it does allow for increased security. The fewer entrances

and exits, the easier it will be to control who or what enters the premises. The vehicles will follow a single clockwise route around the facility.

Flow Efficiency

The majority of the functional areas required within the facility are located along the eastern wall of the warehouse. Off-loading of tobacco bales brought for sale will take place on the north eastern side of the facility as indicated (1). The bales will then flow through to the weighing and ticketing station (2) before proceeding to the 'production line' (3). Once the sale has been completed the data relating to the sale is collected at the data capture station (6). Rejected bales are removed from the conveyor at the reject bale dispatch area (4). Bales of tobacco received from external auction floors will be off-loaded at a separate receiving area (5) situated on the south eastern side of the warehouse. Bales that have been cleared for sale as well as bales brought from external auction floors will continue along a conveyor along the eastern walls of the warehouse towards the sorting and palletizing area (7) which will be located along the southern wall of the warehouse. The pallet dispatch area (9) and data capture station (10) are located along the western wall of the facility. The grower/employee lounge (11) and ablutions (12) are situated so as to be close to where most people will be working, as well as to prevent growers and staff having to walk through the facility to get to the lounge from the car park.

Future Expansion

This layout allows for expansion of critical areas such as the 'production line' should demand increase in years to come. The production line can be extended along the eastern wall of the warehouse to allow for more operators to be accommodated, thus increasing tobacco bale throughput. The lounge and ablution facilities can also be expanded in future should more staff be required.

Flexibility

The length of the warehouse will allow for more than one truck to be accommodated in queues at each docking station. The queues could be as a result of disruptions inside the facility or trucks not arriving at the prescribed times for sale. The single flow of vehicles around the facility will ensure that congestion is minimized around the premises.

Supervision

The majority of the functional areas are situated along the eastern side of the building allowing for increased management supervision.

Relationships

Again, the flow of tobacco bales through this facility also follows a logical path thus ensuring that the important spatial relationships are upheld. These include the relationships between the weighing and ticketing area (2), production line (3), data capture station (6) and the sorting and palletizing areas. Note that the storage area (8) will also have to be fenced off from the production line (3) and reject dispatch area (4) ensuring tobacco bales are not mistakenly placed in storage.

6.5 Evaluation of Alternative Arrangements

A qualitative analysis, based on the discussion of each of the three alternatives presented in section 6.4, was conducted based on the following factors; namely:

- Future Expansion - The ease with which the facility could be expanded to accommodate an increase in the number of tobacco bales required for sale on a daily basis.
- Flexibility - The ability of the facility to cope with disruptions due to breakdowns or system malfunction.
- Efficiency - The effectiveness of the flow of tobacco bales in and around the facility.
- Supervision - The extent to which the important functional areas are supervised.
- Accessibility - A measure of how accessible the premises and sales floor facility are by vehicle and by foot.
- Spatial Relationships - The ability of the design to comply with important spatial relationships.

Each of these factors has been given a weighting, on a 0-to-10 basis, based on their respective importance and can be seen in Table 4. Each alternative was then rated on a scale of 4 to -1, as suggested by Muther (1973), on its ability to satisfy each factor. 4 is almost perfect; 3, especially good; 2, important; 1, ordinary; 0, unimportant; and -1, not acceptable. The products for each alternative were then summed with the largest value indicating the best solution.

Table 4 Evaluating Alternatives

Plant: Tribac (Pvt.)Ltd		Alternatives	1		2		3	
Project: New Tobacco Sales Floor			South wall, anti- clockwise		South wall, clockwise		West wall, clockwise	
Date: 11-9-2011								
Factor/Consideration	Weight	Ratings and Weighted Ratings						
		1		2		3		
Future expansion	6	3	18	3	18	4	24	
Flexibility	6	3	18	3	18	2	12	
Flow efficiency	4	3	12	4	16	3	12	
Supervision	5	2	10	2	10	3	15	
Accessibility	4	3	12	4	16	3	12	
Relationships	6	2	12	2	12	2	12	
Totals		82		90		87		
Remarks: Alternatives evaluated based on discussion of each design in section 6.4								

6.6 Selection of Layout and Final Detailed Design

Based on the evaluation conducted in section 6.5, Alternative 2 appears to be the most suitable layout for the new tobacco sales floor. A detailed layout of Alternative 2 can be seen in Figures 43 and 44. Reasons for this selection are also discussed below.

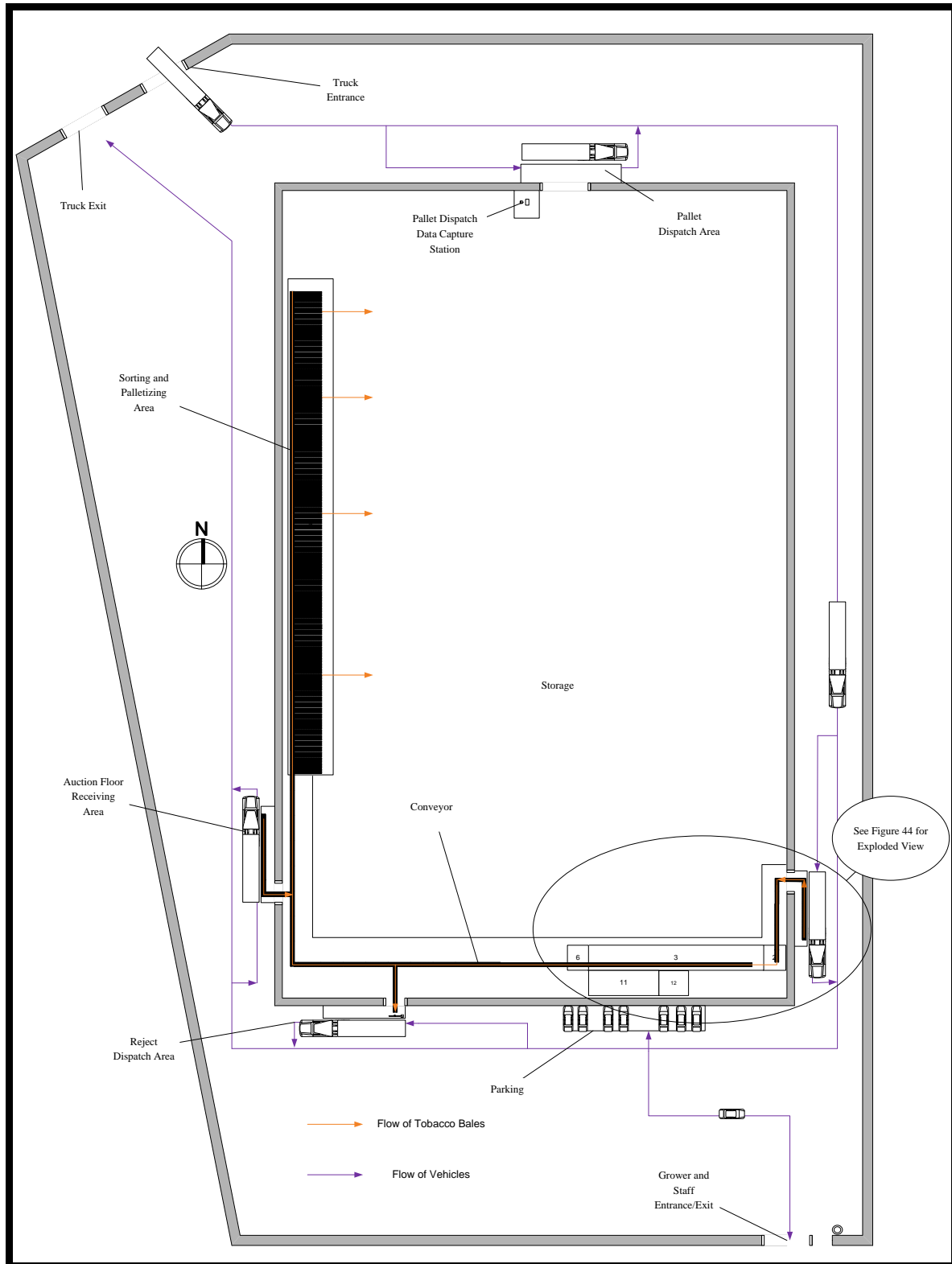


Figure 43 Detailed Layout - Chosen Alternative

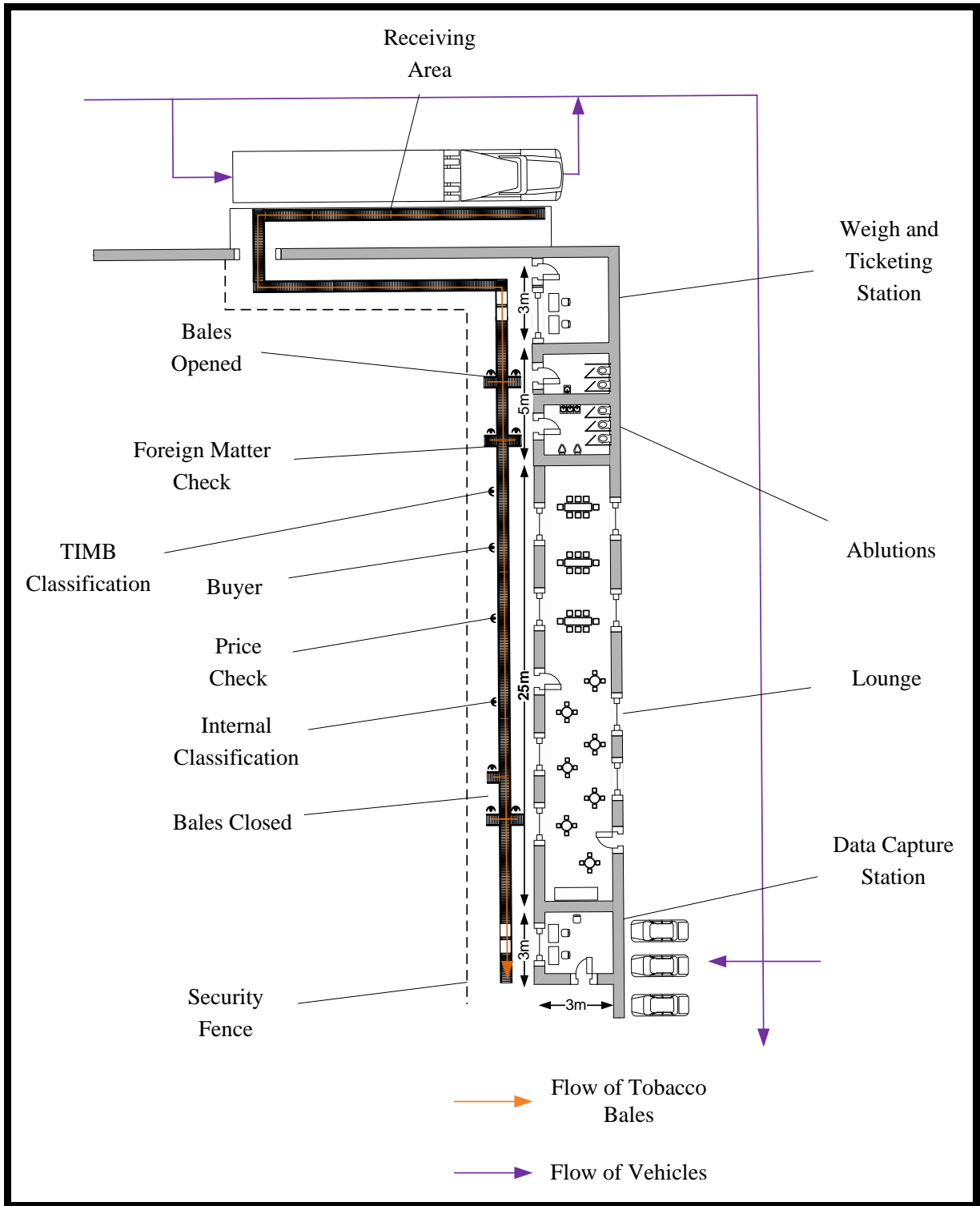


Figure 44 Exploded View of Production Line Area

Each functional area has been designed and sized in accordance with the space requirements described in section 6.2.

Future Expansion

As Tribac look to expand their operations, there may come a time when this facility may need to be upgraded thus allowing more bales of tobacco to be processed on a daily basis. There are a number of ways in which this facility can be altered to allow for additional tobacco bales to be processed.

The length of the production can be expanded along the southern wall of the warehouse thus allowing more personnel to be accommodated (Figure 45). Increasing the number of personnel at each station will allow more bales to be processed thus increasing the throughput of tobacco bales.

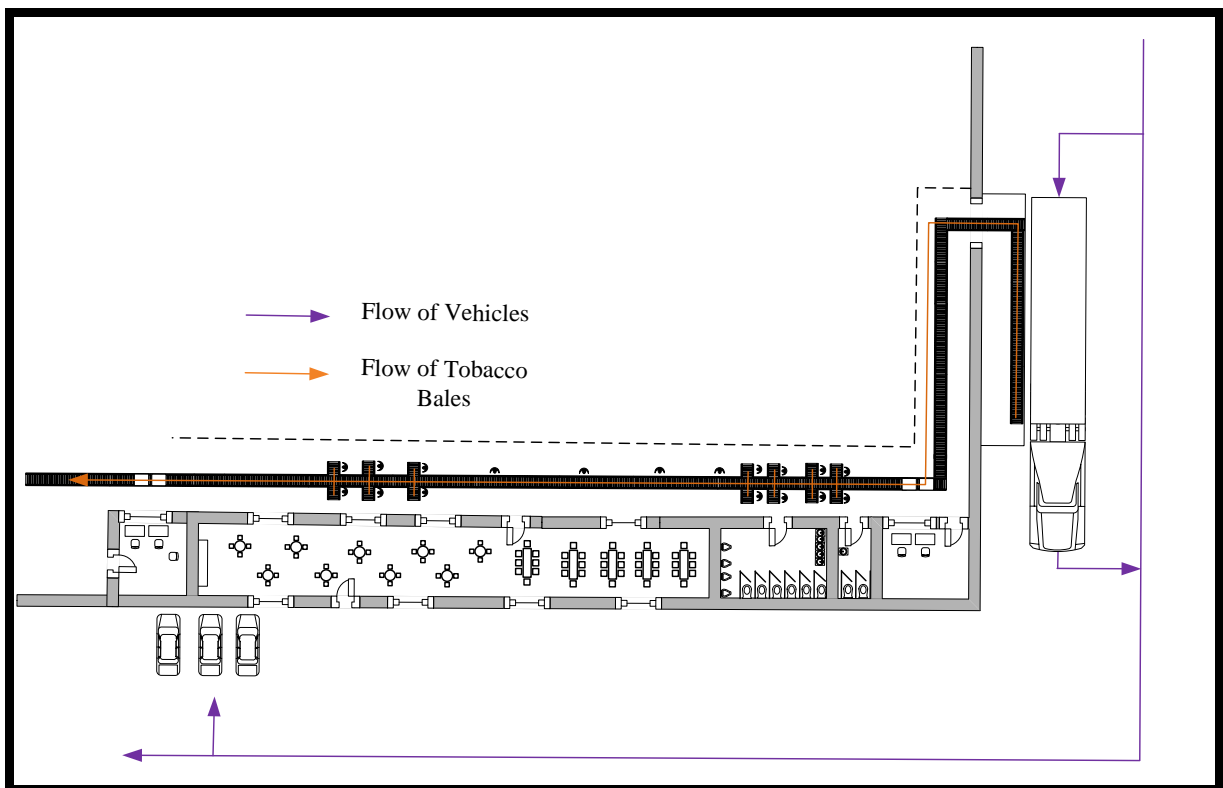


Figure 45 Extended Production Line

Additional docks together with another production line, parallel to the existing line, may be installed (Figure 46). This will allow for more bales to be off loaded and processed at the same time, thus increasing the flow of bales through the facility.

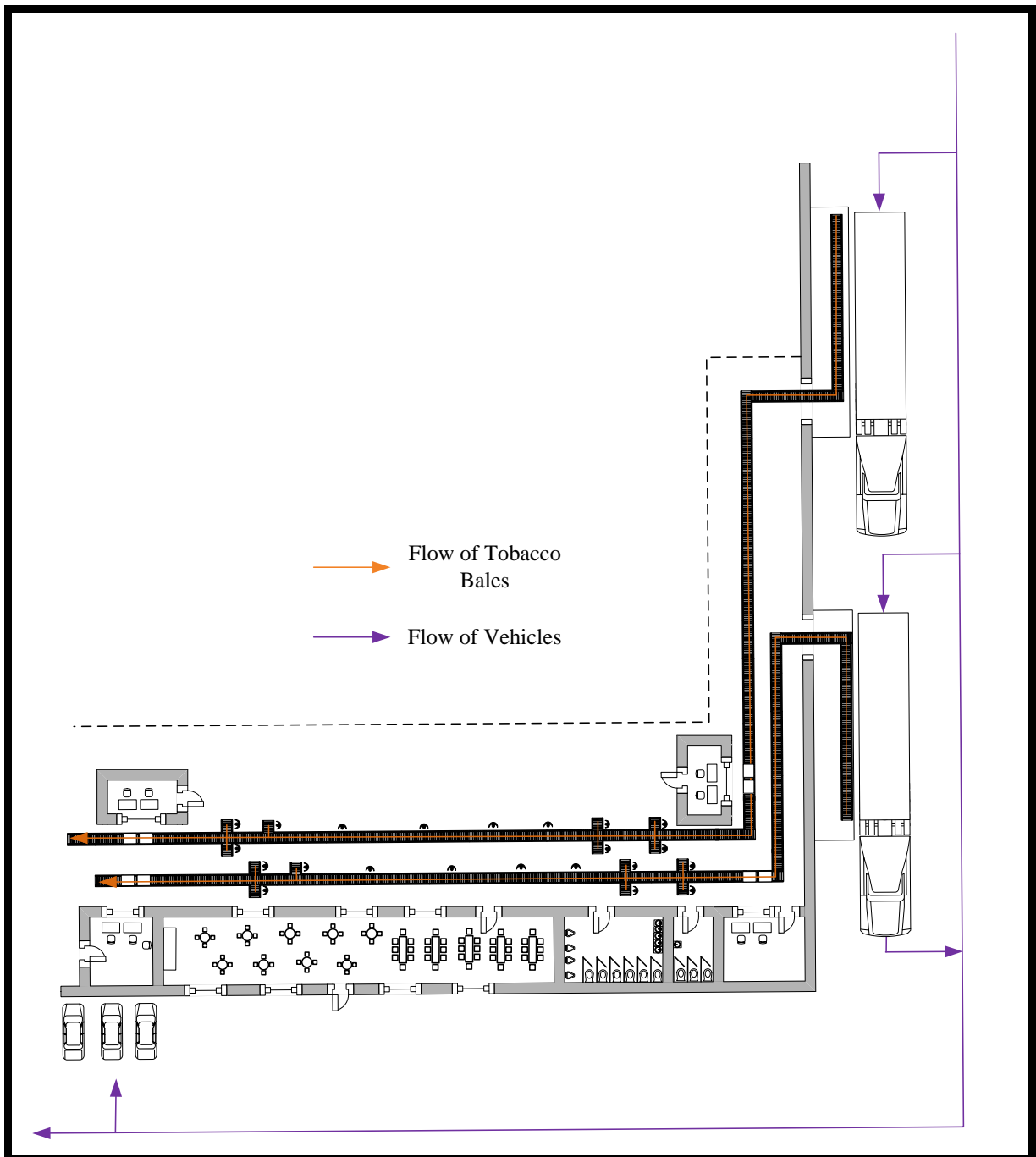


Figure 46 Additional Production Line

Should Tribac consider implementing one of the above mentioned concepts to increase processing throughput, provisions should be made to allow for the ablutions and lounge to also be expanded in order to accommodate the extra personnel associated with these developments. Note that in both Figures 45 and 46, the lounge and ablutions have been extended.

Flexibility

Should the tobacco sales floor encounter any disruptions, measures should be in place to cope with the resultant repercussions. The most likely scenario is a buildup of traffic around the facility. In the event of a disruption, each docking station has been designed to allow other trucks to form a queue behind the truck being serviced (Figure 47).

The docking station used to receive bales of tobacco for sale is likely to be the busiest docking station. This receiving station is located on the eastern side of the warehouse allowing multiple trucks to park without affecting the flow of other vehicles around the facility.

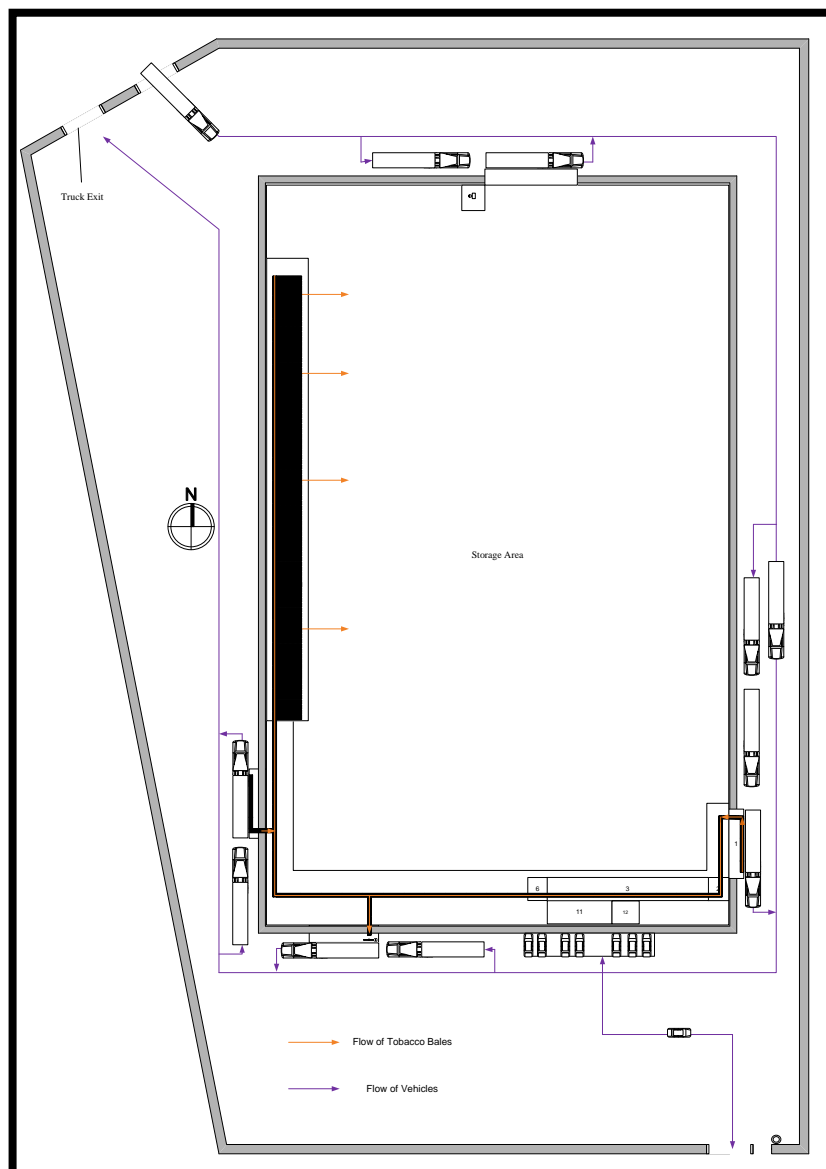


Figure 47 Provisions for Disruptions

Flow Efficiency

Off-loading of tobacco bales brought for sale will take place on the eastern side of the facility. The bales will then flow through to the weighing and ticketing station before proceeding to the production line. Once the sale has been completed the data relating to the sale is collected at the data capture station. Rejected bales are removed from the conveyor at the reject bale dispatch area. Bales of tobacco received from external auction floors will be off-loaded at a separate receiving area situated on the western side of the warehouse. Bales that have been cleared for sale as well as bales brought from external auction floors will continue along a conveyor along the southern and western walls of the warehouse towards the sorting and palletizing area. The pallet dispatch area and data capture stations are located along the northern wall of the facility. The grower/employee lounge and ablutions are situated so as to be close to where most people will be working, as well as to prevent growers and staff having to walk through the facility to get to the lounge from the car park.

The layout of the tobacco sales floor allows for a logical flow of tobacco bales through the facility. There is no need for backtracking; rejected bales are simply removed from the main conveyor and transported to the rejected dispatch area rather than back to the receiving area. The flow of tobacco bales through the facility is illustrated in Figures 43 and 44 by making use of orange lines.

Supervision

The majority of the functional areas within the facility are located along the southern wall of the warehouse. This allows for management to observe operations around the production line as well as the various receiving and dispatch areas. Security personnel could be placed at each of the docking stations, thus providing extra supervision and security.

Accessibility

All trucks delivering or collecting tobacco will enter or leave via the entrance and exit at the north western boundary. For a right hand drive vehicle it is often easier to turn right (Tompkins *et al.*, 2010), hence the trucks will follow a clockwise, single way route around the facility as indicated by the purple arrows in Figure 43.

Staff and growers will access the premises using the entrance situated along the southern boundary thus reducing possible congestion at the truck entrance and exit. The lounge can be easily accessed by staff and growers from the car park which is situated along the southern wall of warehouse.

Relationships

The flow of tobacco bales through this facility follows a logical path thus helping to ensure that the important spatial relationships discussed in section 6.1 are upheld and to reduce the amount of material handling required. The important relationships include the relationships between:

- The weighing and ticketing area and the production line,
- The production line and the data capture station and
- The data capture station and the sorting and palletizing areas.

Note that the storage area will be fenced off from the production line and associated functional areas ensuring tobacco bales are not mistakenly placed in storage as well as increasing security and control of tobacco bales.

7.0 Design of Alternative Material Handling Systems

A variety of material handling equipment will be required in order for the chosen layout to function effectively. The layout design process should go hand in hand with the design of the material handling system (Meyers, 1993). By focusing on the layout of the warehouse, one can reduce the amount of material handling that occurs as well as ensuring increased supervision and security.

7.1 Objective and Scope of the Material Handling System

The objective of the material handling system is to increase the flow of tobacco bales throughout the sales floor whilst ensuring minimal damage to the tobacco bales and reducing material handling costs. The scope of the material handling system will include the receiving and dispatch of tobacco bales as well as the movement of tobacco bales in and around the facility.

7.2 Requirements for Moving, Storing, Protecting and Controlling Material

Tobacco bales are very bulky and weigh up to one hundred and twenty kilograms. The material handling equipment should be able to withstand these heavy loads as well as allowing for the bales of tobacco to be moved throughout the facility efficiently with little or no stress to the operator.

Most of the material handling equipment will be used frequently hence it is crucial that the equipment can be fixed and serviced easily to prevent major disruptions.

Once sorted, the bales of tobacco are stored in pallets for protection and bulk movement. These pallets have been designed to hold up to twelve bales. Forklifts should be able to cater for these loads and should have a reach capable of storing the pallets up to four pallets high in storage.

The capturing of data relating to each bale of tobacco is a crucial factor in ensuring the security, control and efficiency of the tobacco sales floor.

7.3 Alternative Designs for meeting Material Handling Requirements

In order to meet the aforementioned material handling requirements, the following material handling equipment has been identified for possible future implementation.

Conveyors

Bales could potentially be moved throughout the tobacco sales floor using slatted conveyors (Figure 48). These conveyors are able to handle high loads and are already in use at other

existing sales floors. The slats could be made from wood or metal. A feasibility study could be conducted to ascertain whether the initial high costs of metal slats outweigh the costs associated with repairs and maintenance of wooden slats over time.



Figure 48 Slatted Conveyor

The workstations along the conveyor belts as well as the sorting area could make use of non powered roller conveyors (Figure 49). These workstations will be in the form of ‘legs’ coming off the slatted conveyor. As mentioned in the literature review, these non powered roller conveyors may have wheels allowing for ease of movement if required.



Figure 49 Non-Powered Roller Conveyor

Scales

The scales which will be used to weigh all the tobacco bales brought for sale should be built into the conveyor belt. This will allow for an efficient flow of bales around the facility, with little or no extra material handling required. There are several scales available on the market, a potential solution could be a set up similar to that seen in Figure 50.



Figure 50 Scale built into Slatted Conveyor

Loading/Off-loading Concepts

The receiving and dispatch areas could make use of scissor lifts or jib cranes, depending on the frequency of use. For instance, the receiving areas for tobacco bales brought for sale as well as the auction floor receiving area require a number of bales to be handled on a day to day basis thus justifying the expense of installing a scissor lift and slatted conveyor combination (Figure 51). On the other hand, the reject dispatch area does not have to handle as many bales on a day to day basis and therefore could make use of a simple jib crane (Figure 52).



Figure 51 Scissor lift/Slatted conveyor combination



Figure 52 Floor mounted Jib Crane

Forklifts

Forklifts could be used to move the pallets of tobacco bales from the sorting and palletizing area to the storage area as well as from the storage area to the pallet dispatch area. As mentioned previously, it is crucial that the chosen forklifts are able to handle the weight of a fully loaded pallet as well as having the necessary reach to store the pallets at the designated height. This will ensure the storage capacity of the warehouse is maximized. The forklifts currently in use are shown in Figure 53 and were deemed sufficient for use.



Figure 53 Forklift currently in use

Trolleys

Trolleys (Figure 54) may also be used to move bales around the facility. These trolleys should be able to handle the weight of a tobacco bale and should preferably only require one person to operate them. Once the facility is fully operational, an analysis of the flows and movements of tobacco bales will allow one to establish the number of trolleys required.



Figure 54 Trolleys currently in use

8.0 Conclusion

The final detailed design allows for up to two thousand five hundred bales of tobacco to be handled on a daily basis, thus meeting the requirements of Tribac management.

As the rate of unemployment in Zimbabwe is so high, an important consideration during the design of the final layout was to try and ensure that as many people as possible would retain their jobs in the new facility. The current facility employs up sixty five people, depending on throughput requirements, at any one time whereas the new tobacco sales floor will only make use of forty four people. However, due the physical nature of the work each person will be required to do, Tribac may consider implementing different work shifts over the course of the day. Implementing shifts will allow more people to maintain their jobs whilst increasing the throughput of bales through the facility. This is due to the fact that workers will not tire as quickly during a shift as they would over the course of the day. Tribac management may also require the buying process to be completed earlier in the day meaning that more people will be needed in each functional area to increase the throughput of bales through the facility.

The final layout allows for a smooth flow of tobacco around the facility with minimal material handling required and no back tracking. Reducing the amount of material handling results in less damage to the tobacco in each bale, thus reducing the amount of waste tobacco generated each day. Over time this reduction in waste tobacco could result in significant savings for Tribac. In order to maintain this efficient flow of tobacco around the facility, it is vital that the system is well supported and maintained thus reducing downtime and subsequent disruptions.

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9.0 Appendix A

9.1 Time Study Results

Table 5 Time Study Results

Weigh and Ticketing (Data Capture)		
<u>Observation</u>	<u>No of Bales</u>	<u>Time Per Bale(s)</u>
1	4	15
2	4	15
3	4	15
4	5	12
5	5	12
6	4	15
7	5	12
8	4	15
9	4	15
10	4	15
Average Time per Bale		14.1
Std Deviation		1.45
Triangular(11.5,15.3,15.5)		

Open Bales		
<u>Observation</u>	<u>No of Bales</u>	<u>Time Per Bale(s)</u>
1	3	20
2	2	30
3	3	20
4	2	30
5	3	20
6	2	30
7	3	20
8	3	20
9	5	12
10	4	15
Average Time per Bale		21.7
Std Deviation		6.325434
Triangular(15,21,25)		

Foreign Matter Check		
<u>Observation</u>	<u>No of Bales</u>	<u>Time Per Bale(s)</u>
1	5	12
2	6	10
3	6	10
4	5	12
5	5	12
6	5	12
7	5	12
8	5	12
9	3	20
10	3	20
Average Time per Bale		13.2
Std Deviation		3.675746
Triangular(9.5,12,20.5)		

TIMB Classification		
<u>Observation</u>	<u>No of Bales</u>	<u>Time Per Bale(s)</u>
1	14	4.29
2	11	5.45
3	14	4.29
4	10	6
5	11	5.45
6	11	5.45
7	9	6.67
8	10	6
9	10	6
10	8	7.5
Average Time per Bale		5.71
Std Deviation		0.98
Normal(5.71,0.929)		

Buying		
<u>Observation</u>	<u>No of Bales</u>	<u>Time Per Bale(s)</u>
1	10	6
2	9	6.67
3	7	8.57
4	8	7.5
5	8	7.5
6	8	7.5
7	5	12
8	10	6
9	8	7.5
10	7	8.57
Average Time per Bale		7.78
Std Deviation		1.73
Triangular(6,7.8,12)		

Price Check		
<u>Observation</u>	<u>No of Bales</u>	<u>Time Per Bale(s)</u>
1	14	4.29
2	9	6.67
3	5	12.00
4	15	4.00
5	20	3.00
6	21	2.86
7	11	5.45
8	7	8.57
9	9	6.67
10	10	6.00
Average Time per Bale		5.95
Std Deviation		2.78
Triangular(2,3,12)		

Internal Classification		
<u>Observation</u>	<u>No of Bales</u>	<u>Time Per Bale(s)</u>
1	9	6.67
2	7	8.57
3	9	6.67
4	8	7.5
5	8	7.5
6	12	5
7	9	6.67
8	12	5
9	8	7.5
10	7	8.57
Average Time per Bale		6.96
Std Deviation		1.25
Normal(6.96,1.18)		

Close Bales		
<u>Observation</u>	<u>No of Bales</u>	<u>Time Per Bale(s)</u>
1	2	30
2	3	20
3	2	30
4	3	20
5	2	30
6	2	30
7	3	20
8	2	30
9	2	30
10	3	20
Average Time per Bale		26
Std Deviation		5.16
Triangular(19.5,30,30.5)		

The time studies were conducted on site at Tribac’s current sales floor. The processes involved at the current sales floor are essentially the same as what will be installed in the new tobacco sales floor. These time studies will be used in the line balancing calculations and the simulation model. The time distribution of each process was calculated using the Input Analyzer function in Arena.

9.2 Line Balancing Calculations

Work Schedule : 0730-1030 Tea 1045-1300 Lunch 1330-1630

Available time= 495 min
 Number of bales per day= 2500 bales

Plant Rate R= 0.198 min/bale

Therefore Output per Station= 5.05 bales/min

Station	Average Time (sec)	Bales/ min	Req. Min No of People/ Station
Data Capture	14.1	4.26	2
Open Bale	21.7	2.76	2
FM Check	13.2	4.55	2
TIMB Classification	5.7	10.53	1
Buy	7.8	7.69	1
Price Check	5.95	10.08	1
Internal Classification	6.9	8.70	1
Close Bales	26	2.31	3
Data Capture	14.1	4.26	2

In order to process two thousand five hundred bales of tobacco per day, the required output for each station is approximately five bales per minute. The average time per activity was used to determine the number of bales per minute processed by a single person at each station. If the output for one person was less than five bales per minute, the number of people is increased until their total output is greater than or equal to five bales per minute. The resultant number of people required at each station was then used as the input data in Arena.

9.3 TIMB Data

Day	Bales Laid	Bales Rejected	Actual p	\bar{p}	UCL (p)	UWL (p)	LWL (p)	LCL (p)
4	1261	22	0.017	0.013358	0.02	0.02	0.01	0.00
5	1643	10	0.006	0.013	0.02	0.02	0.01	0.00
6	1433	12	0.008	0.013	0.02	0.02	0.01	0.00
7	1197	34	0.028	0.013	0.02	0.02	0.01	0.00
8	1538	27	0.018	0.013	0.02	0.02	0.01	0.00
9	1323	17	0.013	0.013	0.02	0.02	0.01	0.00
10	1345	36	0.027	0.013	0.02	0.02	0.01	0.00
11	1406	46	0.033	0.013	0.02	0.02	0.01	0.00
12	1433	90	0.063	0.013	0.02	0.02	0.01	0.00
14	1460	30	0.021	0.013	0.02	0.02	0.01	0.00
15	1432	60	0.042	0.013	0.02	0.02	0.01	0.00
16	1422	159	0.112	0.013	0.02	0.02	0.01	0.00
17	1390	48	0.035	0.013	0.02	0.02	0.01	0.00
18	1485	200	0.135	0.013	0.02	0.02	0.01	0.00
19	607	17	0.028	0.013	0.03	0.02	0.00	0.00
21	123	0	0.000	0.013	0.04	0.03	0.00	0.00
22	1004	6	0.006	0.013	0.02	0.02	0.01	0.00
23	229	5	0.022	0.013	0.04	0.03	0.00	0.00
24	1178	17	0.014	0.013	0.02	0.02	0.01	0.00
25	473	83	0.175	0.013	0.03	0.02	0.00	0.00
26	1568	81	0.052	0.013	0.02	0.02	0.01	0.00
27	950	17	0.018	0.013	0.02	0.02	0.01	0.00
28	1138	34	0.030	0.013	0.02	0.02	0.01	0.00
29	1310	81	0.062	0.013	0.02	0.02	0.01	0.00
30	1022	11	0.011	0.013	0.02	0.02	0.01	0.00
32	951	3	0.003	0.013	0.02	0.02	0.01	0.00
33	1173	15	0.013	0.013	0.02	0.02	0.01	0.00
34	1309	28	0.021	0.013	0.02	0.02	0.01	0.00
35	811	1	0.001	0.013	0.03	0.02	0.01	0.00
36	1587	8	0.005	0.013	0.02	0.02	0.01	0.00
37	690	22	0.032	0.013	0.03	0.02	0.00	0.00
38	1297	30	0.023	0.013	0.02	0.02	0.01	0.00
39	1642	47	0.029	0.013	0.02	0.02	0.01	0.00
41	1433	21	0.015	0.013	0.02	0.02	0.01	0.00
42	712	15	0.021	0.013	0.03	0.02	0.00	0.00
43	1878	55	0.029	0.013	0.02	0.02	0.01	0.01
44	1878	55	0.029	0.013	0.02	0.02	0.01	0.01
46	741	0	0.000	0.013	0.03	0.02	0.00	0.00
47	755	5	0.007	0.013	0.03	0.02	0.00	0.00
48	1546	29	0.019	0.013	0.02	0.02	0.01	0.00
49	681	4	0.006	0.013	0.03	0.02	0.00	0.00
50	1460	14	0.010	0.013	0.02	0.02	0.01	0.00
51	921	7	0.008	0.013	0.02	0.02	0.01	0.00
52	1548	22	0.014	0.013	0.02	0.02	0.01	0.00
53	747	0	0.000	0.013	0.03	0.02	0.00	0.00
54	1350	18	0.013	0.013	0.02	0.02	0.01	0.00
55	1684	31	0.018	0.013	0.02	0.02	0.01	0.00
56	938	0	0.000	0.013	0.02	0.02	0.01	0.00
57	1119	21	0.019	0.013	0.02	0.02	0.01	0.00

Day	Bales Laid	Bales Rejected	Actual p	\bar{p}	UCL (p)	UWL (p)	LWL (p)	LCL (p)
58	780	6	0.008	0.013	0.03	0.02	0.01	0.00
59	1225	21	0.017	0.013	0.02	0.02	0.01	0.00
61	915	0	0.000	0.013	0.02	0.02	0.01	0.00
62	1391	19	0.014	0.013	0.02	0.02	0.01	0.00
64	1469	24	0.016	0.013	0.02	0.02	0.01	0.00
65	1384	16	0.012	0.013	0.02	0.02	0.01	0.00
67	742	2	0.003	0.013	0.03	0.02	0.00	0.00
69	1231	28	0.023	0.013	0.02	0.02	0.01	0.00
71	1300	17	0.013	0.013	0.02	0.02	0.01	0.00
72	1011	15	0.015	0.013	0.02	0.02	0.01	0.00
73	1148	18	0.016	0.013	0.02	0.02	0.01	0.00
74	1413	28	0.020	0.013	0.02	0.02	0.01	0.00
75	826	27	0.033	0.013	0.03	0.02	0.01	0.00
76	1280	96	0.075	0.013	0.02	0.02	0.01	0.00
77	810	49	0.060	0.013	0.03	0.02	0.01	0.00
78	745	20	0.027	0.013	0.03	0.02	0.00	0.00
79	778	9	0.012	0.013	0.03	0.02	0.01	0.00
82	959	23	0.024	0.013	0.02	0.02	0.01	0.00
83	438	8	0.018	0.013	0.03	0.02	0.00	0.00
84	319	3	0.009	0.013	0.03	0.03	0.00	0.00
85	313	0	0.000	0.013	0.03	0.03	0.00	0.00
87	574	21	0.037	0.013	0.03	0.02	0.00	0.00
88	146	2	0.014	0.013	0.04	0.03	0.00	0.00
89	461	0	0.000	0.013	0.03	0.02	0.00	0.00
90	361	25	0.069	0.013	0.03	0.03	0.00	0.00
91	1222	10	0.008	0.013	0.02	0.02	0.01	0.00
93	220	15	0.068	0.013	0.04	0.03	0.00	0.00
94	10	0	0.000	0.013	0.12	0.09	0.00	0.00
95	190	2	0.011	0.013	0.04	0.03	0.00	0.00
97	303	2	0.007	0.013	0.03	0.03	0.00	0.00
98	6	0	0.000	0.013	0.15	0.11	0.00	0.00
100	25	0	0.000	0.013	0.08	0.06	0.00	0.00
101	648	2	0.003	0.013	0.03	0.02	0.00	0.00
102	10	0	0.000	0.013	0.12	0.09	0.00	0.00
103	14	1	0.071	0.013	0.11	0.07	0.00	0.00

Table 6 TIMB Extracted Data

The table indicates the number of bales laid each day together with the corresponding number of bales rejected each day. “Actual p” is the proportion of rejected bales to bales laid for each day. \bar{p} is the overall fraction of rejected tobacco bales, calculated by summing the total number of rejected bales and dividing by the total number of bales laid. The upper and lower control limits (UCL (p) and LCL (p)) are found by adding and subtracting three times the standard error from “Actual p”. The upper and lower warning limits (UWL(p) and LWL(p)) are found by adding and subtracting two times the standard error from “Actual p” .

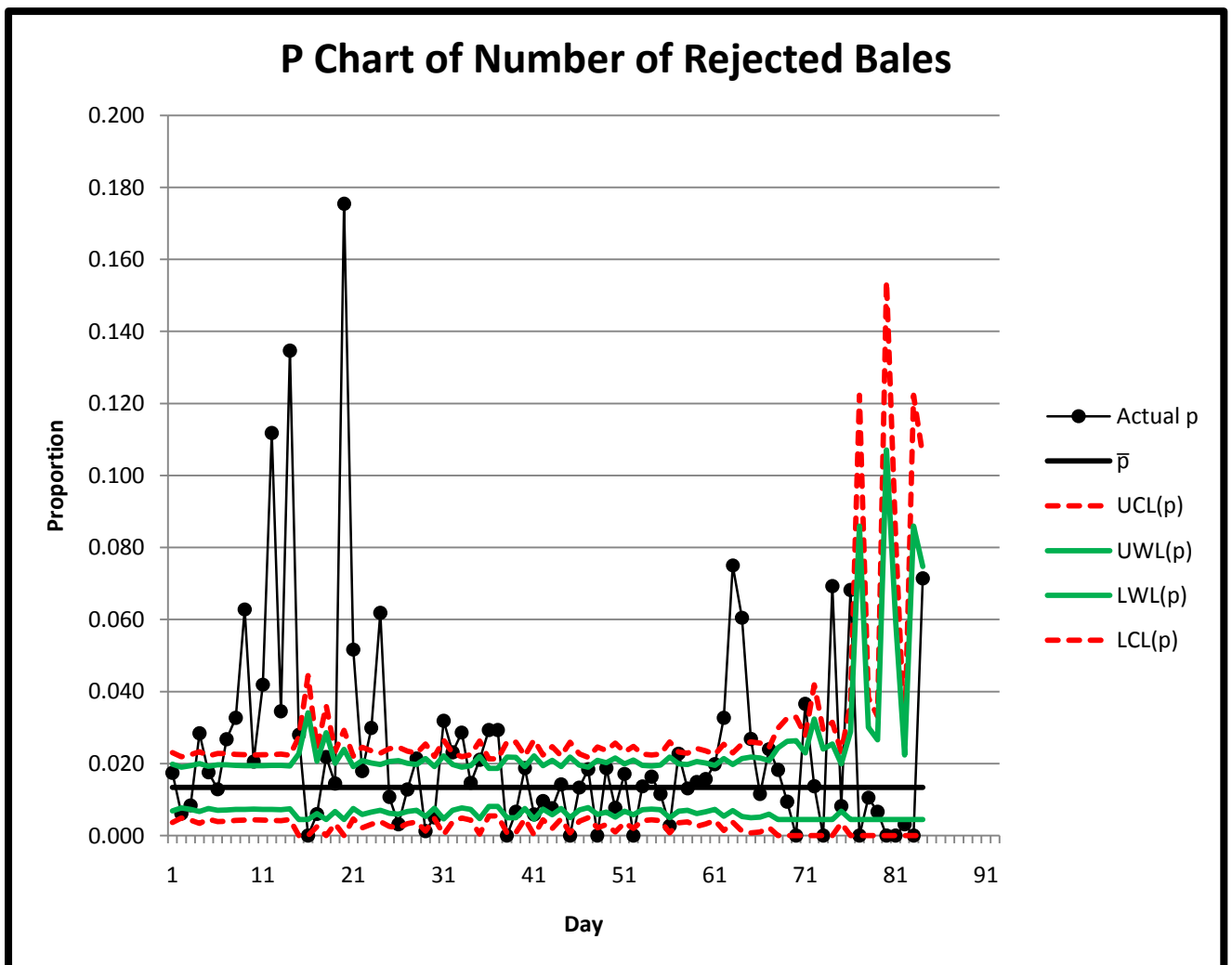


Figure 55 P-Chart of Rejected Bales

In order to calculate the amount of space needed to accommodate rejected bales on a day to day basis, a P-chart was constructed (Figure 55) using data extracted from the TIMB reports that are published each day (Table 6).

As can be seen in the chart, there are a number of days at the beginning and end of the season that appear out of control. Upon further investigation, it was noted that the total number of bales for sale each day at the beginning and end of the season are much lower than those normally processed thus resulting in abnormal proportions of rejected bales. The space requirements will be based on the data from the middle of the season where there is increased stability as shown in the P-chart, namely days 25 to 61.

9.4 Arena Model

A screen shot of the Arena Model can be seen in Figure 56. This model was designed to simulate a five day working week on the sales floor. The results of the simulation were used to calculate space requirements as well as to ascertain the required number of people at each station.

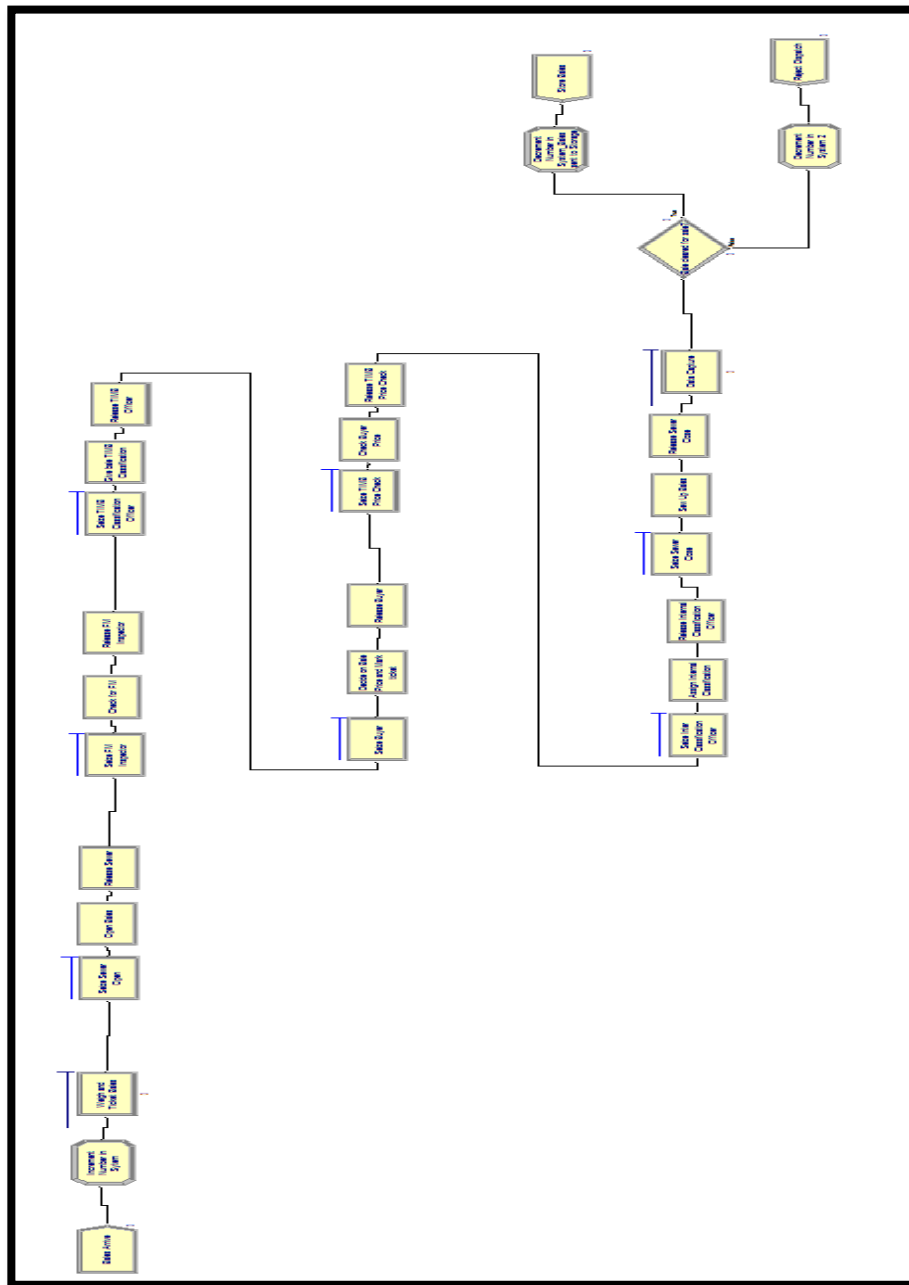


Figure 56 Arena Model