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# MODELPAK FACILITY DESIGN

## Final Document

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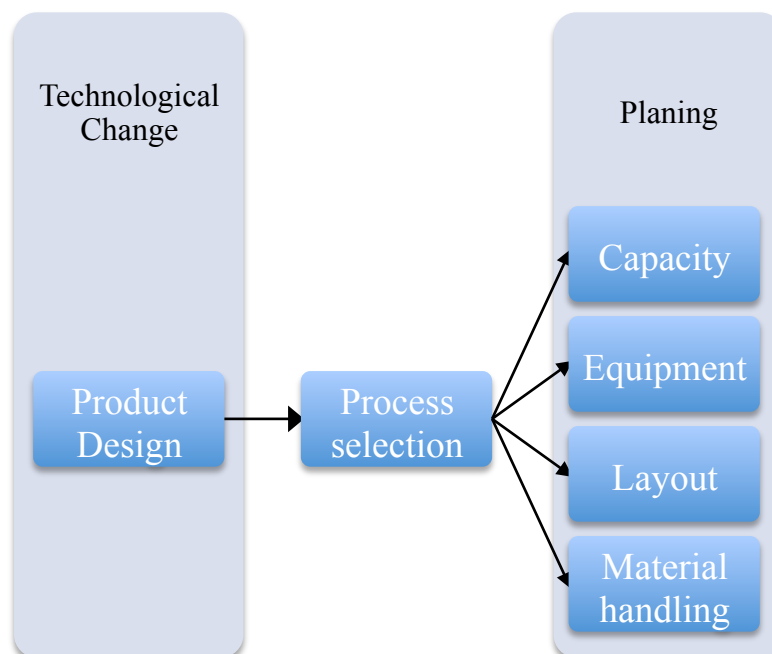
## Executive Summary

This report consists of a thorough literature review conducted on the topic of this project. It also contains the planning procedures taken in preparation of this project to enable *Modelpak* to bring their old, unkempt warehouse back into effective/efficient production. Facilities planning is much more difficult to implement than the designing process itself. The biggest challenge is going to be to sell the project to *Modelpak*, and implementing the procedures mentioned in this document.

Material handling is an important part of this project, because it represents an estimated 15% to 70% of the total cost of a manufactured product. Mechanization plays an enormous role in the material handling section.

The diagram shown below illustrates the flow pattern of the Process Selection

Fig. 1 Process Selection



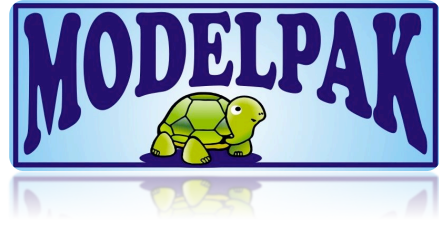
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## 1. Introduction & Background

*Modelpak* is a vegetable farm situated near Brits in the North West region. They distribute vegetables like tomatoes, corn, lettuce, spinach, peppers and many more to different markets including names like *Pick 'n Pay* and *Spar*.

*Modelpak* don't only grow the vegetables, but they also do the packaging for different markets before distribution takes place. Apart from the two major markets, namely *Pick 'n Pay* and *Spar*, which have their own packaging requirements, *Modelpak* also have their own packaging brand, which gets distributed to smaller markets.

*Modelpak* originated 12 years ago with a relatively small piece of land. Since then *Modelpak* has time-by-time expanded their premises and facilities to improve their production and service. Up to date they possess over hundreds of hectares of land and a packaging facility of an estimated 900m<sup>2</sup>.

The warehouse facility includes offices for the administrative workers, plant manager, and also the management team.

## 2. Project Aim

*Modelpak* built a new packaging warehouse five years ago to upgrade their operations into a bigger and more mechanized facility. These operations include the packaging of the following veggies: tomatoes, lettuce, corn, peppers, spinach, beans, baby marrows, patty pans, onions and butternuts. Now the old facility isn't being used anymore, and it only serves as a storage space where they stock up on excess packaging material like boxes, bubble wrap etc.

The aim of this project is to revamp the old warehouse in such a way to get it up and running again for efficient production. This means to design an effective material handling system and economic layout, which will provide a spacious workplace. Using both facilities for packaging of vegetables can upgrade the operations to a much larger scale. This will not only boost *Modelpak's* physical assets level (grounds & buildings), but also their financial status. Their reputation as well

known quality vegetable supplier will grow even further. This project includes the implementation of mechanized equipment that will introduce *Modelpak* to a more ergonomic workplace.

### 3. Project Scope

The first part of this project will consist of doing a literature review, and thoroughly planning what needs to be done in order to put this warehouse to its best possible use. Data, in terms of capacity of the warehouse, operations and processes that is going to take place must be noted. The floor plans of the facility aren't available, and I have to measure and draw the floor plan myself.

The second part of the project consists of the material handling planning which are crucial to the progress of the project. The material handling system must accommodate a typical packaging process at *Modelpak*, which consists of the vegetables being transported to the warehouse (from the land), sorted according to size/quality, batched, weighed, packaged and shipped.

Through an interview, the management of *Modelpak* made it clear that they would want to implement the newly designed facility as quickly as possible. This report includes the planning of a material handling system and the layout for primarily tomatoes, which is considered to be the biggest production line at *Modelpak*. But because tomatoes are very seasonal, the possibility arises for the new facility to be used only during the tomato season. The seasonality factor is mentioned later on to explain the decision made regarding a second vegetable type planned for the new facility.

The third part will involve making critical assumptions on the products to be handled and the volumes of each, executing a very good packinghouse design based upon the volume assumptions, and then developing a financial analysis which will include the assumptions on general and administrative expenses, as well as a certain capital structure and the related costs.



In order to narrow the scope of this project, I will only be focussing on these aspects (material handling, space requirements, layout, and equipment classification) of the facility. Simulation modeling doesn't form part of the scope.

## 4. Literature Review

### Seasonal variation

The first key problem to starting a new (second) packaging facility for *Modelpak* is that their vegetables are seasonal and they need to vary the production in order to maintain the warehouse in a productive working environment!

Tomatoes, which are *Modelpak's* most produced vegetable, are a prime example of the possible problem that could occur when implementing the new facility.

Tomatoes are highly produced during the summer & autumn seasons, and are then minimally planted during the winter season. Throughout this time the demand for tomatoes stay the same, but supply drops drastically and the price shoots sky high. This could have the effect that the new packaging facility will be very productive over the 'seasonal' months of tomatoes by supplying to the large demand. When tomatoes reach the off-peak season, the facility would most probably stand empty. Such a situation must be avoided at all cost.

Therefore, the simple solution would be to plant/produce another vegetable type that will behave exactly the opposite of tomatoes - a vegetable that reaches its peak season during the winter months.

*Modelpak* started planting onions only a year ago. Because of market uncertainty and the nature of growing onions for the first time around, *Modelpak's* onion production is still on a very small scale. This means harvesting the onions by hand and leaving it in the field to dry and also packing the onions (by hand) into bags right there on the spot. This brought me to the initiative to use the 'newly designed' warehouse to facilitate the drying and bagging of onions.

Onions are great vegetables for producing all year round. It is not very seasonal in its nature. *Modelpak's* management confirmed that this would be a great addition to their warehouse operations, and that they needed something like this to make up for their losses during the winter months.

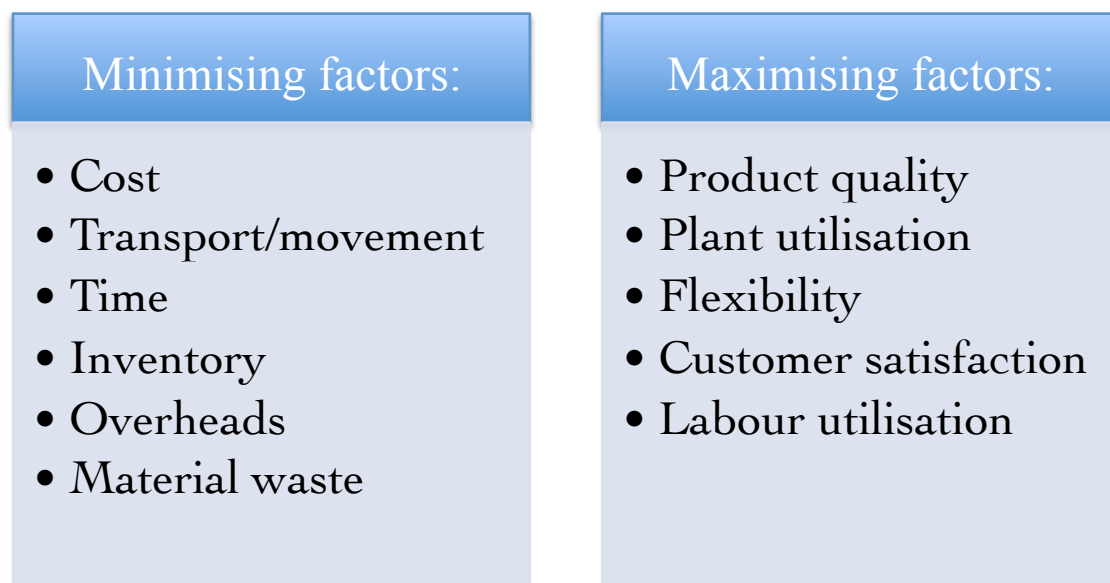
**“Ons wil baie graag ons uie produksie uitbrei tot op ‘n vlak waar ons dit aan groot markte soos ons ander groente kan versprei. Ek dink die ou pakstoor is ideaal om die verpakking van uie te fasiliteer.” – Ockert Werner (Owner)**

## Production

In developed countries, the production of vegetables is highly organized. What was once largely a manual small-scale operation has become an intensive and highly mechanized agri-business in which the areas of production are well defined and developed. As processing technologies have improved and the demand for processed products has increased, the demand for high-quality raw materials has become more important. (Arthey/Dennis. 1991)

The following figure shows exactly what factors considering production need to be minimized or maximized.

Fig. 2 Production Factors



## Layout

The quality of the plant layout plan (the blueprint) will depend upon how well I collected and analyzed the basic data. (Drury, 1981) The blueprint is the final planning step and plant layout people seem to want to start here. I must resist jumping into the layout before collecting and analyzing the basic data. Many engineering professors and industrial-consulting firms are trying to develop a

formula for plant layouts. So far, they have developed computer algorithms and simulations for parts of the analysis. The best approach is to take a systematic approach, one step at a time, adding information at each step. When completed this way, the results appear like magic.

*Modelpak's* production system layout type can be classified as a 'Product layout'. The following are key attributes to a 'Product layout':

- Machines are dedicated to particular product or a small range
- Each stage of production is distinct from the next
- Layout in specific operational sequence

## Receiving & Shipping

Receiving and shipping are two separate departments, but have very similar people, equipment and space requirements. The placement of these two departments has a big effect on the flow of material in the plant. The receiving department is the start of the material flow, while the shipping department is the end of the material flow.

When combining these two departments, the following advantages are present:

1. common equipment
2. common personnel
3. improved space utilization
4. reduced facility costs

The only disadvantage of the merged shipping and receiving docks is space congestion. Space congestion can cause injury, product damage, and lost materials. It would be a costly mistake to ship out a newly received material.

There are a few important requirements when it comes to receiving and shipping:

- Direct lines among carriers
- Continuous flow, minimizing congestion
- Concentrated area of operation, minimizes transport
- Efficient material handling

- Safe operation

These requirements must be met during the implementation of a shipping and/or receiving dock.

## Material Handling

The primary goal of material handling is to reduce unit costs of production. All other goals are subordinate to this goal. Materials handling should consider the overall flow of materials in the facility and aim to develop an integrated plan, considering interrelationships between tasks.

At *Modelpak* the primary objective is to maintain or improve product quality, reduce damage, and provide for protection of materials. General Dwight D. Eisenhower stated that the plan was nothing, but that planning was everything. The plant layout and material handling project is a plan, a drawing. What General Eisenhower was telling us is that the planning process (all the time and effort that goes into the plan) is what is important.

The Automation principle makes moves automatic. Many new systems are completely automatic. Automation is the way of the future and even the manual system must think toward the future when automation will be justified.

One of the many ways to implement automation into *Modelpak's* packaging facility is through the following highly acclaimed equipment:

### ❖ Conveyors

Conveyors are used when material has high flow rates, slow continuous movement and material is not too heavy – which all agree with the movement of vegetables.

The movement also has a fixed path and isn't obstructing any other traffic.

Conveyors are thus the best and easiest way of moving vegetables from A to B.

The question now arises: What types of conveyors?

Mechanical Conveyors can be categorized into belt or vibratory systems. The most common conveyor is for the inspections operation and consists of a rubber or plastic belt running on two drums, one of which is driven. The color of inspection belts is important and should contrast with the vegetable to prevent eyestrain. Systems used for larger vegetables include sets of driven rollers. Roller systems turn the vegetables over as they are transported and are often used for product inspection.

For the sake of the softness and perishable nature of vegetables, rubber covered/canvas and roller conveyors will be used in the *Modelpak* packaging facility.

Characteristics of an efficient material handling system are the following:

- Combine handling and processing where possible
- Automation where possible
- Minimized hand handling
- Safe
- Minimal congestion
- Economical

All of the above mentioned are part of the goal for the intended material handling system at *Modelpak*.

## Unit loading

Unit loading forms part of an effective material handling system. It is the capability to handle more items at a time, thus reducing the number of trips, handling costs and product damage. This can be implemented by:

- 1) Palletizing: accumulate on a platform
- 2) Unitization: packaging as a unit
- 3) Containerization: accumulate in a container

The main advantages of unit loading are movement of larger quantities; reduce frequency of movement; better space utilization; reducing loading/unloading times and protection from damage.

The only negative implications are high costs due to additional equipment that has to be bought. But this can be minimized according to the type/size of equipment implemented.

It is aimed for to implement Containerization (bags in crate) and Palletizing (crates on pallet) at *Modelpak*.

### **Storage and Inventory**

Within the handling system, vegetables are placed in storage from a few hours up to several days, depending on the commodity and storage conditions. Storage of a commodity serves as a means to extend the season, to delay marketing until prices rise, to provide a reserve for more uniform retail distribution, or to reduce the frequency of purchase by the consumer or food service establishment. The commodity must have sufficient shelf life to remain acceptable from harvest to consumption.

The shelf life of a fruit or vegetable during storage is dependent on its initial quality, its storage stability, the external conditions and the handling methods. Maintaining a commodity at its optimal temperature, relative humidity and environmental conditions can extend its shelf life.

Some questions that must be asked are: Quantity to be stored? Method of storage? Lost space due to aisles? Total storage requirement?

Tomatoes: Due to the fact that tomatoes are rather soft, hard plastic crates need to be used for storage purposes. Strong, non-flexible crates can be stacked on top of each other. By stacking crates up to the roof, (utilizing vertical storage) the space requirements can easily be met.

Onions: The harvest process begins with the onions being lifted from below the surface. The roots are cut and the onions are left to dry in the warm sun. The tops are then removed and the onions are windrowed to enhance drying. Once the proper curing condition is met, the harvesters carefully pick up the onions in the field and place them gently into trucks. The trucks will then transport them to the storage facility.

The onions are piled and stored in bulk in a customized storage. This facility is designed to be state of the art, employing ventilation in the floor, which continuously distributes air up and through the onions. A computer control panel monitors the environment and maintains the perfect air temperature and humidity throughout the storage season. The advanced storage facility is one more way to insure the quality of the product.

The Product Positioning Strategy used at *Modelpak* is 'Assemble-to-order'. Actually it can be renamed to 'Pack-to-order' because their assembly consists of packing the vegetables into suitable containers for shipping. This strategy concludes the following:

- Final assembly (packaging) activated in response to an actual order.
- Maintain buffer of parts (vegetables).

## **Packing**

Placement of the harvested veggies into shipping containers is one of many activities described as packing operations. Packing may occur directly in the field, or in specially designed facilities called packinghouses. Most packing operations include a means of removing foreign objects, sorting to remove substandard items, sorting into selected size categories, inspecting samples to ensure that the vegetable lot meets a specified standard of quality and packing into smaller batches and then a shipping container. Some commodities are washed to remove soil and decrease microbial load. Many commodities are pre-cooled to remove field heat and slow down physiological processes. Each operation is designed to achieve a product of uniform quality, but each handling step provides the opportunity to induce damage or disease.

As packaging season begins, onions are conveyed from the storage to the packing area. Here the onions are pre-sized, hand sorted and graded for packaging. Once the onions are packed, they are palletized and placed back in the ventilated storage to await shipment. This step maintains the chain of high quality control and guarantees higher shipping success.

## **Interaction with Quality and Cost**

When looking at the bigger picture, every decision is made with two common goals in mind – quality and cost. The centre point of the following four aspects, where they meet in the middle, will yield optimal quality and cost. (See figure on next page)

Packaging: strength, tightness, energy absorbed

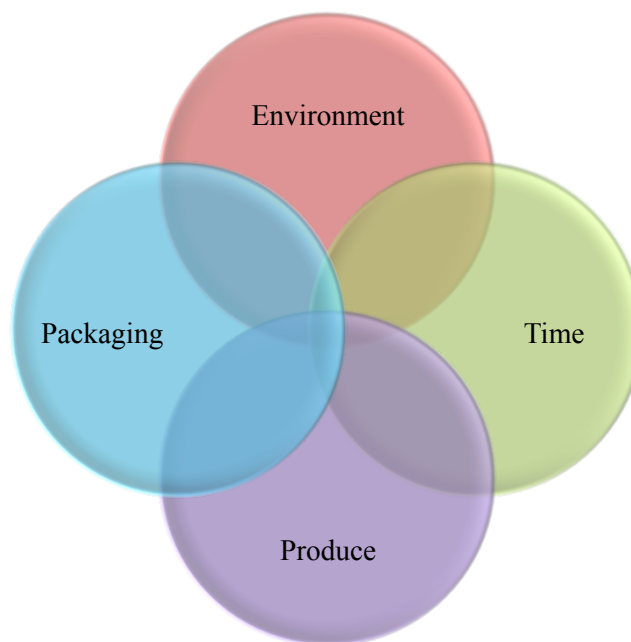
Environment: handling, transport, temperature

Time: storage, ripening

Produce: bruise resistance, shelf life, and post-harvest treatments

Thus packaging can be seen to be contributing at least a fourth (25%) towards the product's cost and quality, if not more.

Fig. 3 Interaction



## 6. Development of conceptual design/solution

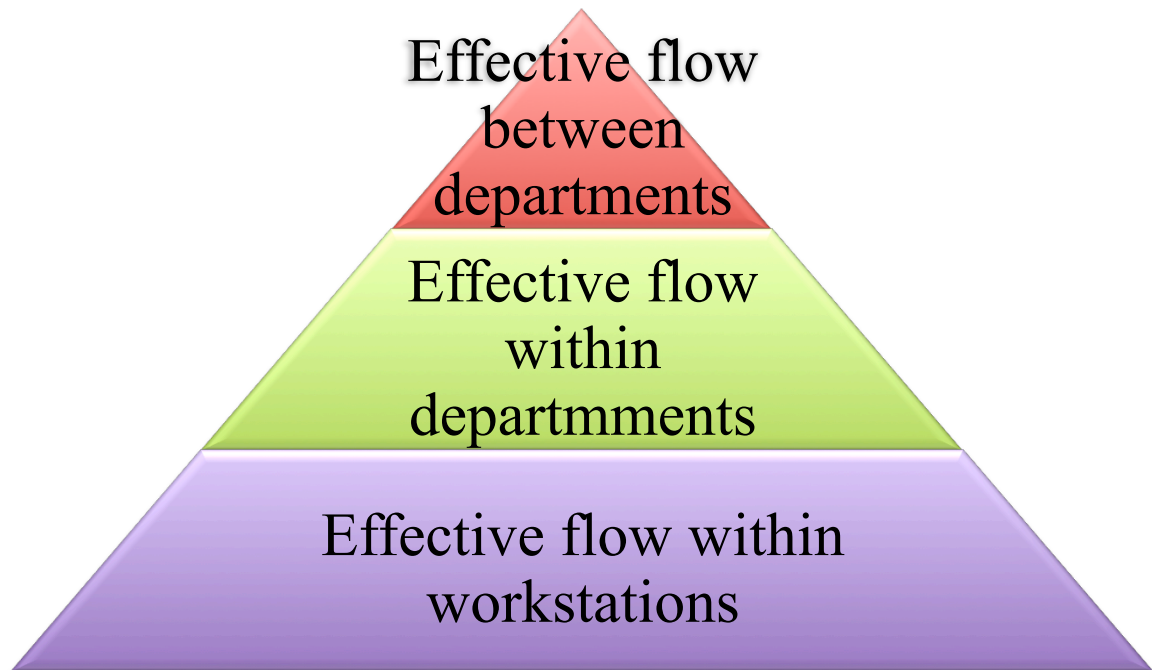
### Improve Material flow

Goods and information flow between departments and offices. Therefore each process must be placed properly in relationship to each other. Positioning of entrances and positioning of receiving and shipping areas and stores are important considerations in determining the overall flow pattern



The following figure shows how effective material flow should start from ground level, within workstations. Only when this becomes effective one can move on to material flow within departments.

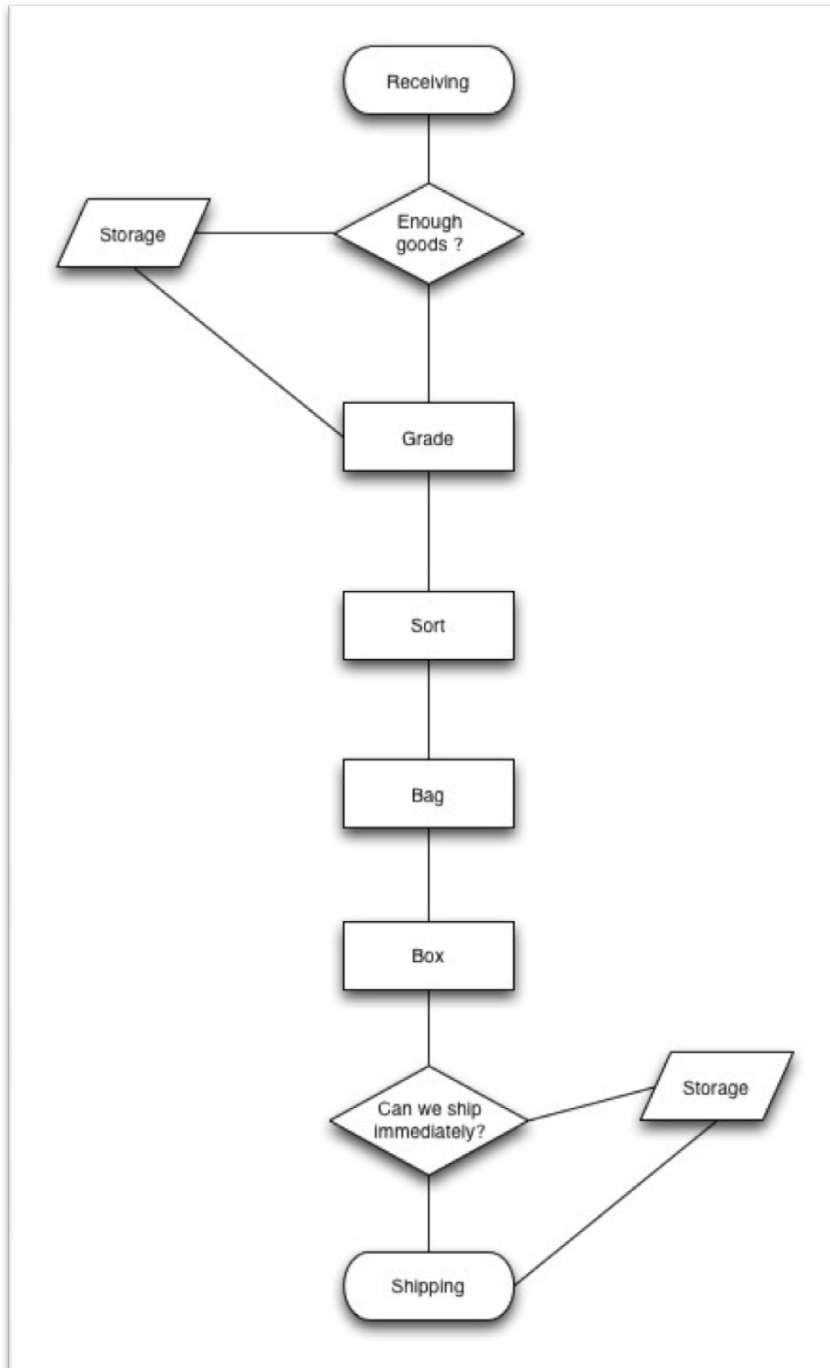
Fig. 4 Material Flow



Through the flow diagram we can see the importance of the different activities in relation to each other. It is quite necessary that the main activities directly follow each other.

The flow diagram depicts the flow of vegetables and also the decision to be made regarding storage.

Fig. 5 Flow chart



## Reduce costs of material handling

Material handling is the function of moving the right material to the right place, at the right time, in the right amount, in sequence, and in the right position or condition to minimize production costs. (Meyers. 1993)

Material handling equipment can be very expensive; so all investments should be cost justified. The cheapest cost per unit gives us the best answer. If a very expensive piece of machinery reduces unit cost, it is good to purchase. If it does not reduce unit cost, it is a bad purchase.

In the long run, the costs of material handling will definitely be reduced when an automatic bagger, for both onions and tomatoes, is purchased. At any stage of the bagging process, an average of 20 personnel/workers are busy weighing, bagging and sealing the vegetables. All these operations can be combined into one machine, which can do the weighing, bagging and sealing simultaneously. The roughly estimated savings before any deductions, is approximately R1 040 (average wage) x 20 = R 20 800 p/m

## Increase utilization of facilities, space and personnel.

Material handling equipment and operators should be used to its full capacity. Knowing what work is required, the number of moves per day, and the time required per move will help me manage the workload of *Modelpak's* people and equipment.

Due to fewer workers on site (because of possible automated machinery taking over some of the handling work), space can be fully utilized throughout the facility.

The facility, going to be revamped, has many small and segmented areas (rooms), which will make facility utilization much more complex than a normal open plan facility. After careful space requirement planning have been done, I have found that it would be much better to make physical changes to the warehouse.

By breaking down some unnecessary walls, enlarging certain rooms and closing down old entrances (doors) – the facility can accommodate operations requiring a

bigger workspace. Separated storage rooms will still be available, but opening up the main production area will lead to utilized packaging space.

### **Improve Safety**

Although mechanical machinery will be implemented which hold greater risk and safety issues, the needed safety steps must be taken to ensure no room for error.

Safety barriers for example need to be constructed around the new automated machinery, which will restrict any worker from coming into danger.

Standard PPE is not of utmost importance at the vegetable packaging facility. The focus is more set on hygiene and a clean environment. For this specific reason personnel are wearing head caps, to prevent any hair loss from coming near the food. With certain vegetables hand gloves also need to be worn.

### **Reduce Damage**

Mechanical handling, long hauling, high piling and other steps in the handling of vegetables necessarily cause many bruises. (Luh/Woodroof. 1988)

The seriousness of bruising can never be stressed enough. Dropping vegetables at any stage of handling produces bruises that cause loss of tissue juices and increase enzymatic reactions in darkening and flavor changes. The effect of rough handling of vegetables is cumulative. Several small bruises on a tomato can produce off-flavor. Bruising also stimulates the rate of ripening of products such as tomatoes and thereby shortens the holding period. Mechanical damage causes increased moisture loss.

### **Standardization**

There are many types of material handling equipment, and in every area we need to standardize on one size, type, and even brand name. The reasons are many, but if we have a special type of equipment for every move or storage, we will have too many different types and sizes to inventory and control. *Modelpak* need to choose

just one type and then stay with that brand, type, and size forever because spare parts inventory, maintenance, and operation of this equipment will be most cost efficient.

### **Procedure for Layout Design**

1. Determine space requirements for each work centre and department, summarize area and service requirements
2. Determine the relationship between work centers with From-to-chart / Relationship Chart
3. Develop a Relationship Diagram - graphical / nodal
4. Arrange the nodes (work centers) to minimize travel distances and cross flow
5. Convert the Relationship Diagram into a Space Relationship Diagram
6. Convert the Space Relationship Diagram in a Block Layout (alternatives)
7. Effectiveness calculation of proposed alternatives
8. Develop initial best layout for feasible alternatives
9. Modify the feasible alternatives and adjust according to practical limitations

These steps are necessary to follow when the actual layout is to be done.

## **8. Problem solving and results**

Mechanical harvesting of tomatoes creates a mammoth problem of grading and sorting the fruit. It is estimated that 15% of machine-harvested tomatoes are green and must be separated from the red ripe fruit. Selective shaking action and color detection, rather than size, shape, and specific gravity, seemed to be the most obvious means of separating the tomatoes. (Luh/Woodroof. 1988)

The most obvious losses after harvest are due to mechanical injury, moisture loss, decay, and aging. Losses in vitamins, sugars, texture, and color are less obvious, though they adversely affect the quality and nutritive value of the vegetable. Abusive, rough handling and holding or transport at undesirably high or low

temperature increases these losses. Losses can substantially be reduced by the use of approved packaging, transport, and handling practices.

After over maturity, the next most important cause of lowered quality in vegetables is deterioration during handling. The principal hazards are (1) bruising and other mechanical injury; (2) moisture loss and (3) mold and other microorganisms stimulated by heat of respirations.

## Layout

The layout problem is to arrange the physical spaces required for several departments in a given space provided for the departments. In practice the facility layout problem is often solved by intuition, using the artistic and spatial skills of the human designer; however, when there are quantitative considerations associated with the layout problem, the human is at a disadvantage as compared to the computer. I concentrate on mathematical procedures for solving the layout problem. There are a variety of problems regarding layout one might encounter.

I have prepared three different layouts that will each result in a different production capacity and space utilization. These alternatives are each unique in the sense that every one of them has a different flow-orientation within the given space. Although the production line is very standardized, the alternatives are designed to embrace the available space to its fullest. Unfortunately, therefore departments cannot be swapped around or exchanged to result in the ultimate best possible 'space utilization'.

Certain data is necessary to describe the layout problem.

- Number of departments,  $n$ ,
- Physical area of each department,  $A_i$  for  $i = 1 \dots n$
- Physical dimensions of the plant in which the departments are to be placed: Length,  $L$ , and Width,  $W$ .
- Product flow (measured in kg) between every pair of departments:  $f_{ij}$  for  $i = 1 \dots n$  and  $j = 1 \dots n$ .

- Material handling cost between every pair of departments measured in Rands per month:  $c_{ij}$  for  $i = 1 \dots n$  and  $j = 1 \dots n$ .

The model involves the distance from one department to another. The distance depends on the layout.

First we must prescribe the end points for the distance measurement. Here we assume that distances are measured between the centroids or centers of gravity of departments. Second, we must specify the route of travel. One possibility is that flow will follow a straight-line path. This is the Euclidean measure. More common in layout analysis, is to assume that flow travels via paths that are parallel to the axes of the layout. This is the rectilinear measure.

The centroids are specified in terms of the coordinate system as

$x(i)$  = x-coordinate of the centroid of department  $i$ , and

$y(i)$  = y-coordinate of the centroid of department  $i$ .

The centroid is the same as the center of the area when the department is rectangular.

In Fig. 7 we can see an example of the  $x$ - and  $y$ -coordinates for the 3<sup>rd</sup> layout alternative.

		Coordinates		
<b>From Department</b>		x	y	<u>Distance (units)</u>
A		7,2	2,4	10,60188662
B		7	13	4,5
C		2,5	13	4,031128874
D		2	9	3
E		2	6	1,886796226
F		3	4,4	4,675467891
G		6,5	7,5	5,14781507
H		7,2	2,4	

Figure 7. Coordinates of alternative 3

The distance between two departments by a rectilinear measure is,

$$D_{ij} = |x(i) - x(j)| + |y(i) - y(j)|$$

<i>From</i> \ <i>To</i>	<i>Receiving</i>	<i>Storage</i>	<i>Grading</i>	<i>Sorting</i>	<i>Bagging</i>	<i>Boxing</i>	<i>Storage</i>	<i>Shipping</i>
<i>Receiving</i>		45	50				22	0
<i>Storage</i>			20	25	32	35	21	44
<i>Grading</i>				10	20	33	25	45
<i>Sorting</i>					10	15	15	30
<i>Bagging</i>						5	18	25
<i>Boxing</i>							20	20
<i>Storage</i>								24
<i>Shipping</i>								

Here the vertical lines indicate absolute value. Fig. 8 show the distance between all pairs of departments on the from-to chart. Note that each measuring unit equals to 4m.

Figure 8. From-to-chart

#### Criterion for Comparison

The flow multiplied by the distance and summed over all cells of the chart. We compute the cost for the flow from  $i$  to  $j$  as the product of the material handling cost, the flow and the distance between the departments. The cost of the layout is the sum of the flow cost.



$$z = \sum_{j=1} \sum_{i=1} c_{ij} f_{ij} d_{ij}$$

The factors  $c_{ij}$  and  $f_{ij}$  are given as data, but the factor  $d_{ij}$  depends on the layout.

#### Calculation of product flow ( $f_{ij}$ ):

I analyzed the past two years' (2011 & 2012) production quantities (kg) of tomatoes at the current facility and calculated an average to determine the monthly flow of tomatoes through the facility. Note that I only used the quantities of the peak months, December up to May, so that low production during off-peak season doesn't influence the average.

This average is then multiplied with a *capacity factor*, which is incorporated to accommodate the capacity difference. The current facility has a much bigger capacity to package tomatoes, so ultimately the product flow is higher.

The *capacity factors* for the three alternatives are as follows:

Alternative 1 -	0,3
Alternative 2 -	0,3
Alternative 3 -	0,5

Thus,

$$\text{Product flow} = (\text{capacity factor} \times \text{average production capacity})$$

#### Calculation of material handling cost ( $C_{ij}$ ):

The two main aspects determining the material handling cost are 'machinery used' and 'labor cost'.

The capital cost of machinery that will be bought will be stated later in the document. So the machinery cost that affects material handling is the water & electricity consumption of everyday use.

Once again, the current facility's consumption over a period of time is analyzed to determine an average for one month. An *electricity factor* (including water) is

implemented to put the large consumption quantities into perspective for the smaller facility. *Electricity factor* = 0,3

The labor cost is a standard fixed expense, which computes to R 1 200 per worker/month. The estimated number of workers for all three alternatives is 36.

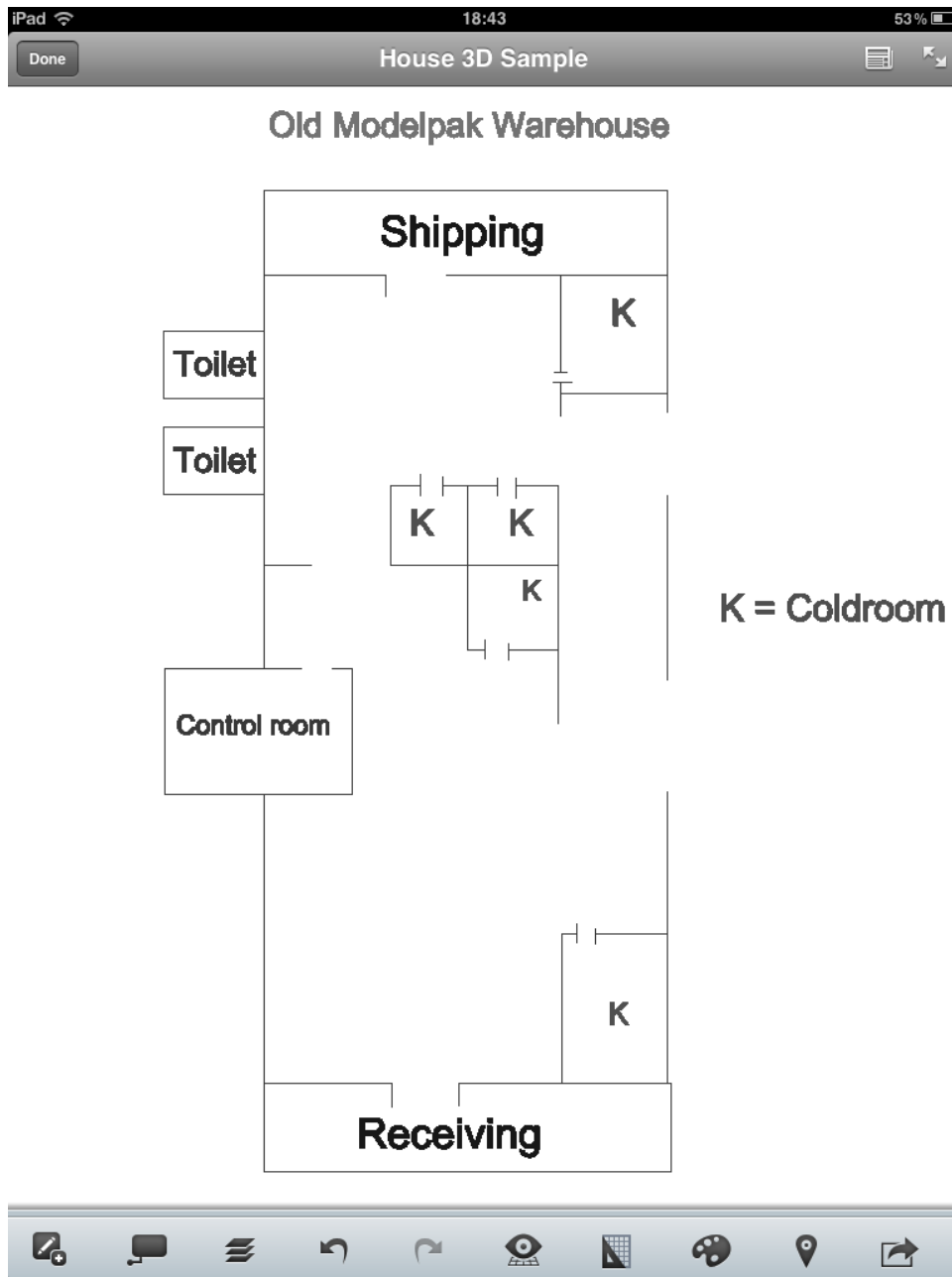
Thus,

$$\text{Material handling cost} = (\text{electricity factor} \times \text{average consumption cost}) + (\text{R1 200} \times \text{\#workers})$$

The drawings below illustrate the changes from the initial space availability of the warehouse, to the newly organized layout.

Note: In Figure 7 the top end of the image is facing north.

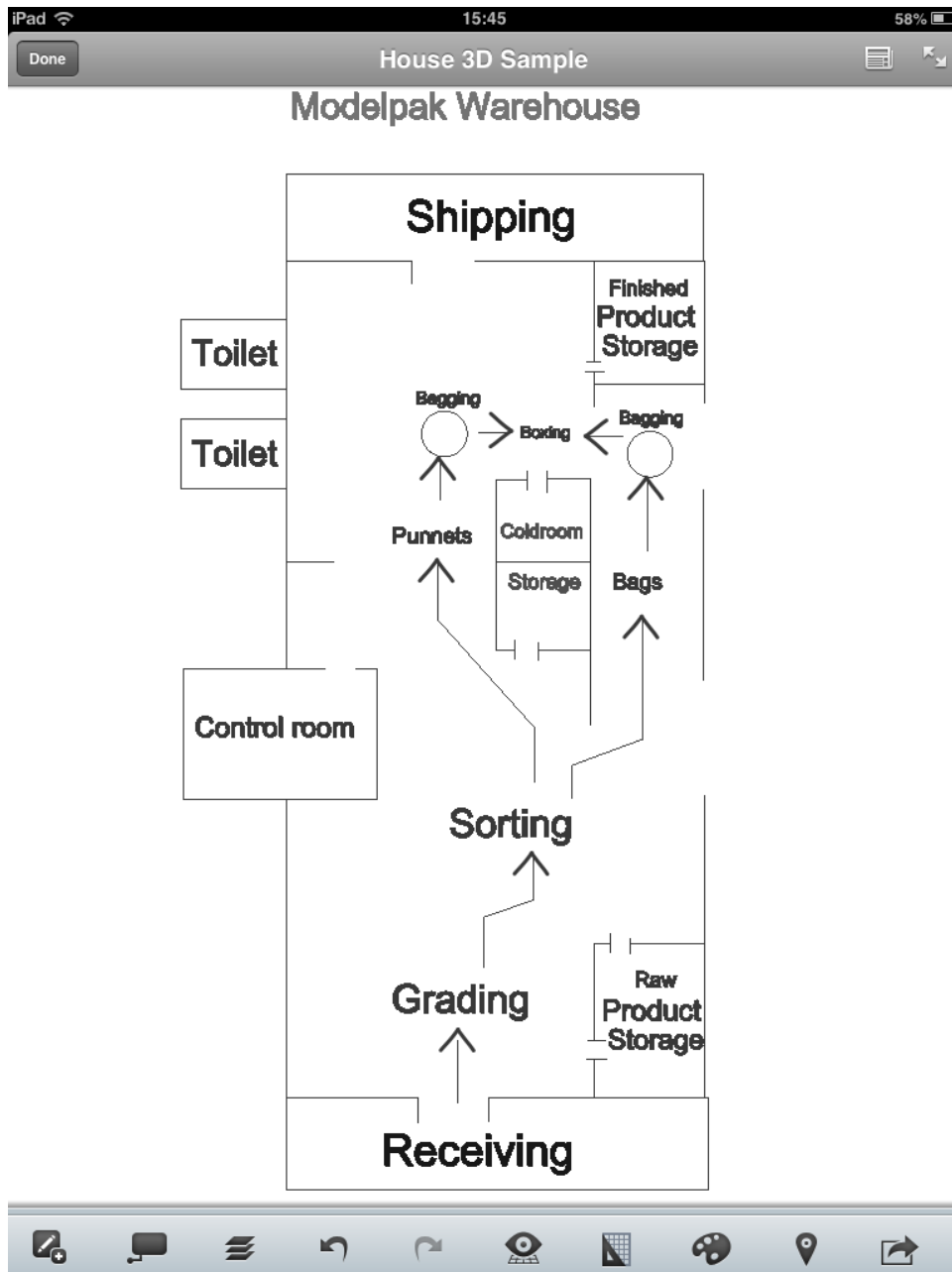
Fig. 9 Old Facility layout



### Alternative 1

The first drawing depicts the facility a lot like the initial layout. Minor changes are made to accommodate the new system. The storage coldrooms in the middle of the warehouse are reduced to make way for the 'punnet' packaging line running through that area. Punnets and plastic bags are packaged on two different lines that comes together at the end-side of the line and sharing the boxing department space.

Fig. 10 Layout Alternative 1



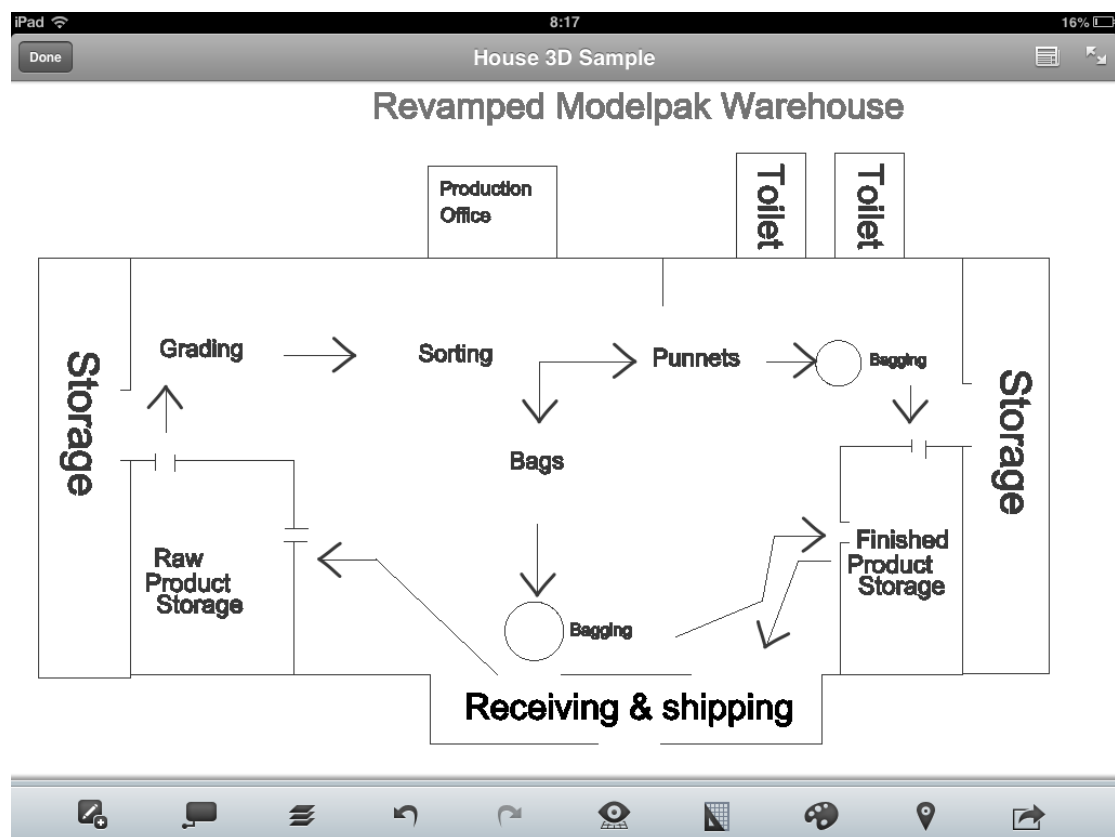
### Alternative 2:

As mentioned earlier, there are a lot of benefits through combining the receiving and shipping docks (areas). Although this is not the common method at packaging facilities in the industry, I truly believe this is an effective way to simplify the movement of material through the warehouse.

I decided to combine these two control-areas at the eastern side of the facility, rather than keeping it at one of the vertical (northern or southern) ends.

This layout option entails the total renovating and re-constructing of the cold rooms in the middle of the facility. The walls are removed to make way for packaging operations. These cold rooms are represented in the form of two bigger rooms on the two ends of the receiving en shipping station. The control room is also moved a little to the outside of the facility to free some more space for production activities. The two cold rooms will be reserved for storing the receiving and shipping vegetables respectively. Advantages of this layout option are the openness and spacious setup, accessibility to change and easier management.

Fig. 8 Layout Alternative 2



### Alternative 3:

The third layout option requires the current warehouse to undergo some changes regarding the packaging rooms and open spaces. The direction of flow of products will rather differ from the first two options.

The cooling compartments in the middle of the facility will have to be merged into one big storage room. Receiving and shipping areas are still combined as mentioned earlier, and the storage areas are still kept separate. The major advantage to this layout option is the fractional construction costs required. The different rooms are utilized as is.

Note: In Figure 8 the top end is facing south, different from the first vertical image.

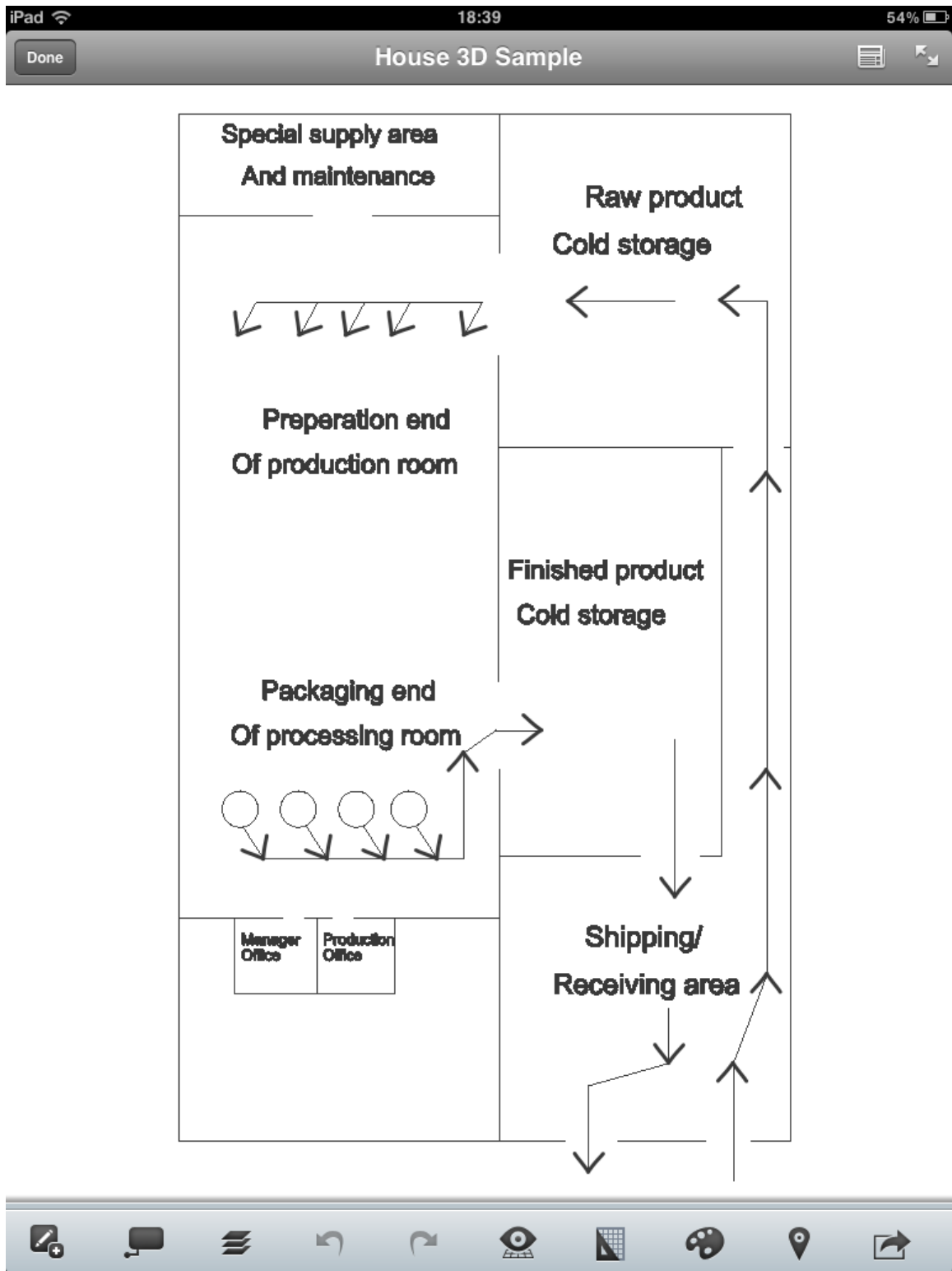
During all the scenarios, the production flow is recorded in a circular pattern. Upon receiving, all the way through to the shipping, the vegetables travel in a somewhat oval/circle way.

The layout estimates was based on calculations for the number and quantity of products to be processed and stored in the facilities, plus the length of storage needed during peak months. From this information the footprints were developed for the amount of tomatoes circulated, resulting in the space needed for receiving, processing, storing, and shipping of the product.

Alternative	Z
1	R 1 181 521,07
2	R 1 215 129,07
3	R 1 441 546,15

The above layout flow costs is purely based on the distance traveled from one department to another. To be able to make an accurate conclusion on the different alternatives, a multi-criteria analytical process is also used to rate the layouts.

Fig. 9 Layout Alternative 3



All these layouts can be used for onion packaging as well. Except for the automatic onion bagging machine, no additional equipment have to be bought. The conveyor system is already in place and can be used to its full potential.

## Decision making

Four very important criteria are identified to compare the alternatives with each other, namely: Space utilization, throughput, renovating cost and line distance.

Each criterion is weighed up against the other three criteria. The value scale is used as follow:

### Value Scale

- 1 -> Objectives  $i$  and  $j$  are **of equal** importance
- 3 -> Objective  $i$  is **weakly more** important than objective  $j$
- 5 -> Objective  $i$  is **strongly more** important than objective  $j$
- 7 -> Objective  $i$  is **very strongly more** important than objective  $j$
- 9 -> Objective  $i$  is **absolutely more** important than objective  $j$

The full pair wise comparison of the criteria can be viewed in Appendix A.

The criteria weights ended up as follow:

<u>Criteria</u>	<u>Weight</u>
Space Utilized	0.18
Throughput	0.36
Renovating cost	0.34
Line distance	0.12

### Process:

- i. After the weights have been established, each alternative is rated according to these criteria.
- ii. For each alternative, a mark out of 10 is allocated for every criterion.
- iii. The mark is then multiplied by the weight that it corresponds to.



On this basis the alternatives can be measured up against each other and a clear decision can be made.

In short, alternative 3 wins due to the fact that the renovating cost isn't the highest, and also achieves the highest score in the multi-criteria analytical process.

<b>Alternative 1</b>	<b>6,533936662</b>
<b>Alternative 2</b>	<b>5,757257104</b>
<b>Alternative 3</b>	<b>7,213742191</b>

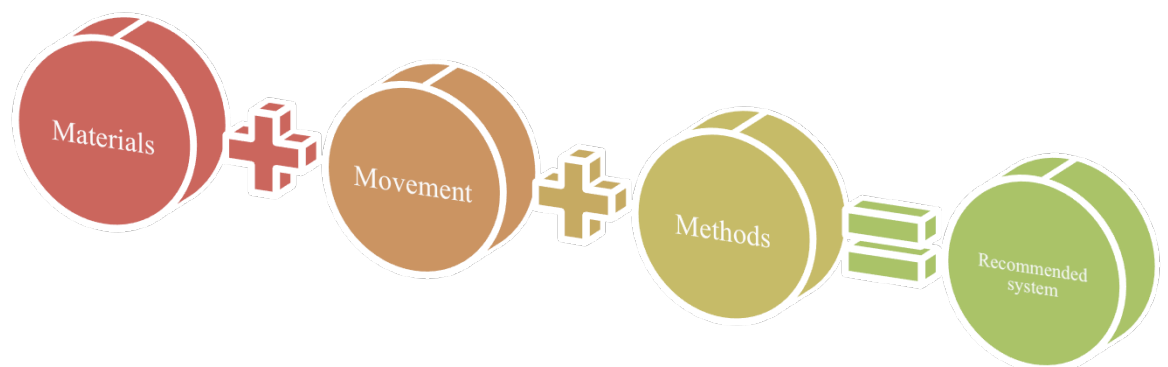
The detailed outcome of the calculations can be seen in Appendix B.

## Material Handling

The design procedure for the materials handling system is as follows:

1. Determine intended function for system and environment
2. Collect required data relating to material
3. Identify the movements
4. Design basic material handling system (and alternatives)
5. Evaluate and choose suitable alternative equipment
6. Choose suitable unit loads to accommodate properties

According to the above procedure, I propose a materials handling system that will ensure the effective movement of materials (vegetables), reduce inventory and operating costs, and increase throughput.



Here are the key rules to the recommended materials handling system:

- Vegetables are handled IN CRATES ONLY at receiving/shipping dock
- Only dock-personnel allowed handling crates at receiving/shipping. (Also applicable to all other workstations/departments)
- Movement straight to grading machine, put into grader.
- Move as fast/efficient as possible
- Do not waste any time, get the job done
- Move already bagged veggies ONLY in crates and on pallet
- Preferred Unit load size:
  - 6 bags / crate
  - 12 crates / pallet
- Additional handling equipment:
  - 2 x Forklifts
  - 10 x pallet stackers

Conveyor belts are going to be implemented to do most of the transportation work within the facility. It is estimated that the conveyor belt length at *Modelpak's* facility make up for about 65% of the total production line length of tomatoes. Slide bed belt conveyors offer the most economical form of powered belt conveying and will suit the tomato production line perfectly. This conveyor system costs approximately R3 500 per meter. Total costs are shown in the 'Capital Investment Impact' table above.

### **Multi-head Weighing for tomatoes**

The following weighing/bagging systems are listed as options for possible material handling improvement. This automated machinery from *NewTech* can be combined with a variety of weighing and grading machines to provide tailor made solutions for *Modelpak's* facility.

A. With automatic centerfold filling and sealing.



**NEWTEC**

B. With automatic polybagger.



C. With automatic punnet filler.



D. With up to 14 channels.



## Automatic bagging for onions

- Fully Automatic Net Bagging Machine



**SACLARK**

- BE 6000 Fully automatic paper bagger 1-10kg



**EMVE**  
SWEDEN

- The C-Pack 912



**C-PACK**

## 9. Financial Impact

Fig. 10 Capital Investment Impact

Capital Investment Impact					
Alternative 1	Conveyor	Grading Machine*	Automatic bagger*	Renovations	Total
	R29 073,27	R75 000,00	R250 000,00	R20 500,00	R374 573,27
Alternative 2					
	R37 002,10	R75 000,00	R250 000,00	R43 400,00	R405 402,10
Alternative 3					
	R41 457,79	R75 000,00	R250 000,00	R35 510,00	R401 967,79

(\* = Value estimation based on average between different machine types and brands.)

The following calculations are done on the selected layout alternative 3.

A capital recovery equation can be calculated to determine the annual revenue *Modelpak* should make to recover the money spent on the facility within 5 years.

### 15% MARR value

$$P = 401\,967,79$$

$$A = P [i(1+i)^n] / [(1+i)^n - 1]$$

$$= 401\,967,79 [0,15(1+0,15)^{10}] / [(1+0,15)^{10} - 1]$$

$$= R\,80\,092,08 \text{ per year}$$

### 20% MARR value

$$P = 401\,967,79$$

$$A = P [i(1+i)^n] / [(1+i)^n - 1]$$

$$= 401\,967,79 [0,2(1+0,2)^{10}] / [(1+0,2)^{10} - 1]$$

$$= R\,95\,877,36 \text{ per year}$$

### 25% MARR value

$$P = 401\,967,79$$

$$\begin{aligned}
A &= P [i(1 + i)^n] / [(1 + i)^n - 1] \\
&= 401\,967,79 [0,25 (1 + 0,25)^{10}] / [(1 + 0,25)^{10} - 1] \\
&= R\,112\,579,12 \text{ per year}
\end{aligned}$$

*Modelpak's* average monthly packaging quantity of tomatoes.

	Spar	Small markets	Pick 'n Pay	Sum
<b>Crates</b>	3692	16830	22068	42590
<b>KG/crate</b>	10,71	10	12,83	33,54
<b>Kg</b>	39541,32	168300	283132,44	490973,76

If we estimate the general price for a crate of tomatoes at R55 (making provision for peak and off-peak months), *Modelpak* can easily achieve their goal by paying the R 401 967,79 for the new facility layout.

$$R55 \times 42\,590 = R\,2\,343\,450 \text{ per month (excluding expenses)}$$

At the moment, *Modelpak* is literally throwing away tones of tomatoes some months due to incapacity of packaging space. These thrown-away tomatoes amount to anything between R 20 000 – R 50 000, according to the market price.

If the cost associated with the new layout is anything less than the amount lost with thrown-away tomatoes, this project will be feasible and worth the effort and money.

To determine the monthly cost of project over 2 years at 15% interest:

$$\begin{aligned}
F &= P (1 + i)^n \\
&= 401\,967,79 (1 + 0,15)^{0,1667} \\
&= R\,531\,602,40 && \text{Future value of project} \\
A &= F (i / (1 + i)^n - 1) \\
&= 531\,602,40 ([0,15/12] / (1 + 0,15/12)^{24} - 1) \\
&= R\,19\,130,59 && \text{Monthly payment}
\end{aligned}$$

## 10. Recommendations and Conclusion

The fact that *Modelpak* already accepted and applauded the idea of moving the onion production to the newly designed warehouse is a huge step forward for this project. This will mean that packaging of onions and tomatoes will, each during its own season; occupy the facility space and personnel.

The material handling systems for the two different vegetable types will certainly differ, but the same equipment and personnel will be used in both cases. This will consist of effective conveyor belts, mechanized weighing & bagging equipment and also pallet stackers.

It can be seen from the pictures below, that *Modelpak's* old facility is not in good use at the moment and that they're wasting the available space by storing boxes and excess packaging material. This space can be put to much better use by bringing the facility back into production.

Fig. 10,11,12 Modelpak facility



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## 12. Appendix A

### Multi-criteria decision making.

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MouseOver  
MindKey  
Background  
Applications  
Instructions

# MULTI-CRITERIA, MULTI-ALTERNATIVE DECISION MAKING

## The Analytic Hierarchy Process



Thomas L. Saaty

### Facility Layout

Space Utilized

Throughput

RenovatingCost

LineDistance

Initial

Alternative 1

Alternative 2

#### Criteria Pairwise Comparison

Throughput	is more important than	Space Utilized	3,0
Space Utilized	is more important than	Space Utilized	3,0
Space Utilized	is more important than	LineDistance	5,0
Throughput	is more important than	RenovatingCost	2,2
Throughput	is more important than	LineDistance	1,0
RenovatingCost	is more important than	LineDistance	7,0

Pairwise Comparison Matrix
Intermediate Matrix

#### Value Scale

1 -> Objectives i and j are of equal importance

3 -> Objective i is **weakly more** important than objective j

5 -> Objective i is **strongly more** important than objective j

7 -> Objective i is **very strongly more** important than objective j

9 -> Objective i is **absolutely more** important than objective j

	Space Utilized	Throughput	RenovatingCost	LineDistance					Criteria Weights
Space Utilized	1,00	0,33	0,33	5,00	0,14	0,12	0,09	0,36	<b>0,18</b>
Throughput	3,00	1,00	2,20	1,00	0,42	0,36	0,60	0,07	<b>0,36</b>
RenovatingCost	3,00	0,45	1,00	7,00	0,42	0,16	0,27	0,50	<b>0,34</b>
LineDistance	0,20	1,00	0,14	1,00	0,03	0,36	0,04	0,07	<b>0,12</b>
	7,20	2,79	3,68	14,00					<b>CI / RI = 0,4549</b>

## 13. Appendix B

### The Analytic Process

#### Alternative 1

Space utilized	5	0,18	0,882838173
Throughput	6	0,36	2,167854729
Renovating cost	7	0,34	2,365529023
Line Distance	9	0,12	1,117714736
	<u>27</u>		<b>6,533936662</b>

#### Alternative 2

Space utilized	5	0,18	0,882838173
Throughput	7	0,36	2,529163851
Renovating cost	4	0,34	1,35173087
Line Distance	8	0,12	0,99352421
	<u>24</u>		<b>5,757257104</b>

#### Alternative 3

Space utilized	7	0,18	1,235973442
Throughput	7	0,36	2,529163851
Renovating cost	8	0,34	2,703461741
Line Distance	6	0,12	0,745143158
	<u>28</u>		<b>7,213742191</b>