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A FACILITY SOLUTION REQUIRED TO INCORPORATE COLD STERILISATION IN THE SUPPLY CHAIN OF CITRUS EXPORTED TO EUROPE

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Final Project Report submitted in partial fulfilment of the requirements for the module

BPJ 420 Project

at the

Department Industrial and Systems Engineering
University of Pretoria

DECLARATION OF ORIGINALITY

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UNIVERSITY OF PRETORIA
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DEPARTEMENT BEDRYFS- EN SISTEEMINGENIEURSWESE
DEPARTMENT OF INDUSTRIAL AND SYSTEMS ENGINEERING

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Abstract [Provide an abstract of the mini-dissertation. An abstract is a short summary of the contents covered in the item.]	A facility solution that would ensure that the South African Citrus Industry meets the possible regulations imposed by the European Union (EU) for citrus fruit to undergo cold sterilisation treatment and prevent False Codling Moth (FCM) from spreading to their countries.
Category [Enter the category in which the project was done. E.g. Operations Research, Simulation, Logistics…]	Method Study, Facility Planning, Trade-off Analysis
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EXECUTIVE SUMMARY

This document describes a Final Year Project (BPJ 420) required by the University of Pretoria in partial fulfilment of Systems and Industrial Engineering. This report describes the solution to an identified problem encountered by the South African Citrus Industry with the assistance of Citrus Growers Association (CGA). This project entailed a thorough study of the citrus supply chain, facility and capacity planning of cold storages used for citrus exports through the Durban Harbour.

The South African Citrus Industry is currently facing a phytosanitary risk of False Codling Moth (FCM) that might prevent the industry gaining further global market access. FCM is only detected in Africa and stricter bio-security protocol measures imposed by the European Union (EU) can prevent further exports to their markets. South Africa exports almost fifty million citrus cartons to the EU, which approximate 40% of all citrus fruit per year at an estimated amount of R15.7 billion in 2015/2016 based on exporting prices (DAF, 2016). Current prevention measures are in place that includes: a System Approach (Moore and Hattingh, 2013) and Nuclear-based Sterile Insect Technique (SIT) (IAEA, 2017), although research has shown that cold sterilisation is the best FCM prevention measure.

The aim is to identify facility solution required that would ensure that South Africa meets the regulations imposed by the European Union (EU) to prevent FCM from spreading to their countries. Northern South African farms, packhouses, cold storages in Durban and Transnet Durban Port Terminal were visited to obtain information. The data acquired is used to adhere to cold sterilisation protocols when identifying current cold room facilities. The cold storages are divided into two types either a pre-cooling or forced air-cooling (cold sterilisation treatment) chamber. The capacity is determined with three conditions:

Prototype model 1: Current citrus production 2017

Prototype model 2: Forecasted demand for 2020

Prototype model 3: Forecasted demand for 2020 including all fruit volumes exported to the EU

Industrial Engineering (IE) techniques are used to approach, analyse and develop a possible solution. A Process Flow Diagram is drawn to illustrate key role players in the citrus supply chain. A Method Study portrays the detail of the citrus processes compiled in the Literature Review. The focus of this project would entail a thorough Facility Planning analysis of the cold storage operations in Durban. This study determined the current 38 300 pre-cooling and 13 350 forced-air cooling capacity.

The CGA provided 2020 forecasts of citrus export through Durban Harbour. The forecasts are based on tree census data, bud-wood sales, land availability, climatic conditions and historic production since 2012.

It is calculated for **Prototype Model 2** that in 2020 the demand will be 45 543 pre-cooling and 15 404 forced-air cooling pallet slots. The additional capacity required is 1085 pre-cooling and 1416 forced air-cooling facilities. This is a moderate growth expected annually.

Prototype Model 3 is calculated if the European Union imposes stricter protective measures with 45% extra volumes to undergo cold sterilisation treatment in 2020. It is calculated that the demand to cold sterilise the extra volumes will be 43 602 forced air-cooling pallet slots and pre-cooling facilities will be in excess of 21 710 pallet slots. However these facilities can be converted into forced-air cooling facilities to accommodate space restrictions in the CBD. The required 29 614 forced air-cooling pallet slots can either be transformed in current cold storages or new cold storages should be built in Elangeni, Kwa-Zulu Natal an Industrial Zoned area.

The cost involved to facilitate this forced-air cooling chambers to either convert current facilities or develop new would amount R531 129 915.00. A Trade-off Analysis is used to compare the current and additional cost per 15 kg carton to undergo cold sterilisation treatment. An increase per carton of R18.28 would accumulate to a total of R519 116 500.00 additional annually for all citrus fruit exported to the EU.

In conclusion of this Final Year Project is the result subjective to condition. The current forced air-cooling facility in Durban will not accommodate cold sterilisation treatment for extra volumes in 2020 if the European Union enforces stricter protocols. The increased overheads involved is not a viable solution and would be in the best interest of the South African Citrus Industry to prove different measures with research done to prevent False Codling Moth without imposing cold sterilisation treatment.

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ACRONYMS AND NOTATION

CGA	-	Citrus Growers Association
COT	-	Cold sterilisation treatment
CRI	-	Citrus Research International
EU	-	European Union
FCM	-	False Codling Moth
Non-COT	-	Not a cold sterilisation treatment
PPECB	-	Perishable Products Export Control Board
PRA	-	Pest Risk Assessment
SA	-	South Africa
SLA	-	Service Level Agreements
WBS	-	Work Breakdown Structure
WMS	-	Warehouse management system

1. INTRODUCTION

1.1 COMPANY BACKGROUND

Citrus Growers Association (CGA) was established in 1997 to represent the South African citrus growers. The Citrus Growers Association represents different stakeholder in the citrus industry such as the South African Government, Citrus Research International, various exporting companies, research Institutions and citrus growers (CGA, 2007). A statutory levy is initiated on every carton exported to provide funding for the CGA. The main purpose of the CGA is to provide the 1400 citrus growers research, transformation, market access, logistics and communications (CGA, 2007).

Citrus Research International (CRI) is the research channel of the CGA whom is responsible to do research and extension to provide the latest technical and research developments to ensure market access and to keep them globally competitive. The employers of CRI are responsible to travel across the globe and gather information concerning new exotic diseases, pests entering the South African borders, and new sustainable farming methods. They also deal with bio-security of phytosanitary regulations to ensure that the South African citrus producers comply with all the rules and regulations to export fruit to different countries worldwide (Citrus Research International, 2017).

1.2 PROBLEM STATEMENT

At the moment the European Union (EU) is causing considerable problems for the South African citrus industry due to a recently done Pest Risk Assessment (PRA) on False Codling Moth (FCM), *Thaumatotibia leucotreta* (Meyrick, 1913) (Lepidoptera: Tortricidae). According to this assessment FCM can establish in the European climatic conditions. As a result of this the EU may request the South African Citrus Industry to implement means to ensure that the fifty million, 160 kg cartons, exported to the EU does not pose a threat to the EU.

There are several system soil-borne approaches to deal with this threat, such as orchard sanitation (Moore and Kirman, 2008), mating disruption (Hofmeyer et al., 2005), biological control and sterile insect techniques (Hofmeyer et al., 2005). According to research done is cold treatment the most effective form of phytosanitary prevention for FCM. If the EU insist that all the cartons should be cold sterilised it will be impossible for the Southern African Citrus Industry to export with these regulations due to a lack of infrastructure and an increase in cost per carton. This implies that future capacity measures needs to be in place if the cold sterilisation is obligatory. The project determines:

1. The type of current cold room capacity at the Durban harbour.
2. The current citrus exporting volumes with the forecasted volumes for 2020 to determine the demand of cold storages required.
3. Calculating the capacity by using historic data from 2020 to 2017 and the forecasted data for 2020 to determine the type of cold room capacity required.

1.3 PROJECT AIM

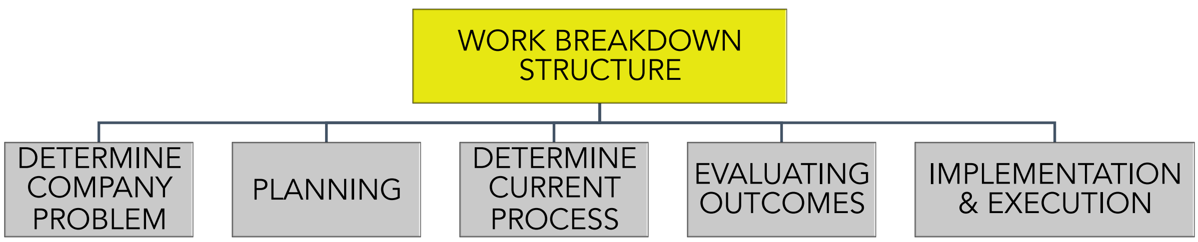
This project will propose a prototype model conducted with the historic data and forecasted data for 2020 to determine the cold room facilities necessary to meet the Service Level Agreements (SLA) of all citrus fruit going through the Durban Port that needs to undergo cold sterilisation. It would entail three proposed models:

1. Current cold room capacity for 2017 citrus production.
2. Forecasted production in 2020.
3. Forecasted production in 2020 with the extra volume of the EU.

1.4 PROJECT APPROACH

This project entails retrieving data from the CGA and CRI to determine all the capacity required to accommodate the current and forecasted exporting of citrus fruit. This project will entail to attend a road show between certain commercial farms and pack-houses with regionalisation in the Northern farm regions of South Africa. A visit to the Transnet Durban Port Terminal will be done to get an overview of the citrus supply chain and the current facilities. The gathered data will be used to determine the carton volumes allocated for niche cold sterilisation markets to determine which type of cold storage facility is required.

A Work Breakdown Structure (WBS) diagram in APPENDIX A describes the project approach that will be used to execute this project. The following diagram depicts a summary of the WBS:



1.4.1 DETERMINE THE COMPANY PROBLEM:

The environment of the citrus production will be investigated to identify a possible difficulty that requires a thorough study. The project sponsor, the CGA will be consulted about a possible problem identified that needs some thorough study. With the help of the CGA, deliverables will be identified with brainstorming to execute this project. The project sponsor signed a final project proposal and adheres to the requirements that the project entailed. A Project Topic will be submitted to this BPJ 410 module as Phase 0.

1.4.2 PLANNING

The planning phase entail to determine which Engineering technique will be suitable for the selected project. According to the nature of the project a selected supervisors will be chosen that is in their speciality fields to lead the project at the University of Pretoria (UP). Frequent meetings with both the CGA and UP mentor will be done to structure the Project Proposal with broad overview of the project in Phase 1.

1.4.3 DETERMINE CURRENT PROCESS

The current process will be done with a thorough study of the main keys in the citrus supply chain that consists of the farm, packhouse, cold storage and the Durban harbour. To have a practical overview of the whole process will help to identify problem areas and understand the whole operation. This study will be used to compose a Literature review with an in depth study of the key areas of the project to compile and submit in the Preliminary Project Report in Phase 2.

1.4.4 EVALUATE POSSIBLE OUTCOMES

Evaluation of the current tree census data, bud-wood sales, historic exports and 2020 forecasts will be used to determine the capacity demand in 2020. Analysis of the current cold storages will be done to determine the capacity of the cold storages in the Durban area. A proposed model will be calculated to determine the gap of the pre-cooling chambers, forced air-cooling and the European Protocols.

1.4.5 IMPLEMENTATION & EXECUTION

The proposed solution will be documented in a report and proposed solutions will be determined and compiled in the Final Project Report of BPJ 420 Phase 2. The implementation of the model will not take part in the duration of the project, but will be part of a substantial bigger project at the Durban harbour. The project solution will be illustrated as Phase 3 with a Poster and Oral Presentation.

1.5 PROJECT SCOPE

The importance of cold sterilisation is stated earlier that the population affected would be the citrus growers in South Africa, which will have an increase in cost per carton for the cold sterilisation treatment as well as the implementing of these facilities at the Durban, Coega, Port Elizabeth and Cape Town harbour. If the growers do choose to divert their crop to other markets, 45% of South African fruit forecasted in 2020 will be flooding other markets and ultimately influence the market price for all citrus exporters.

The SIPOC diagram (Edrawsof, 2017) is illustrated in Figure 1, which depicts the predominant steps in the process of the citrus industry's cycle; the start and end of the process from the supplier to the customer.

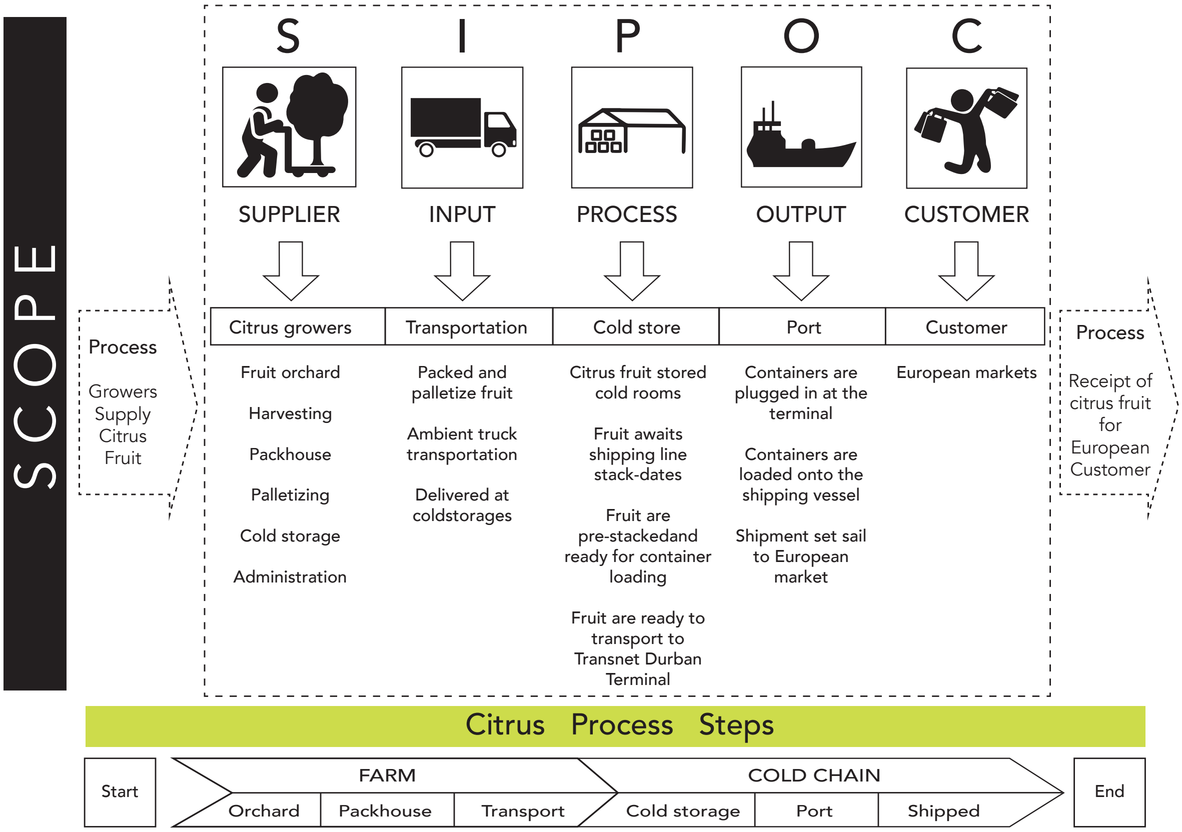


Figure 1 SIPOC diagram

The SIPOC is to illustrate an understanding of what the citrus production process entail. Data of the fundamental parts will be gathered and analysed in the Literature review.

1.6 PROJECT DELIVERABLES

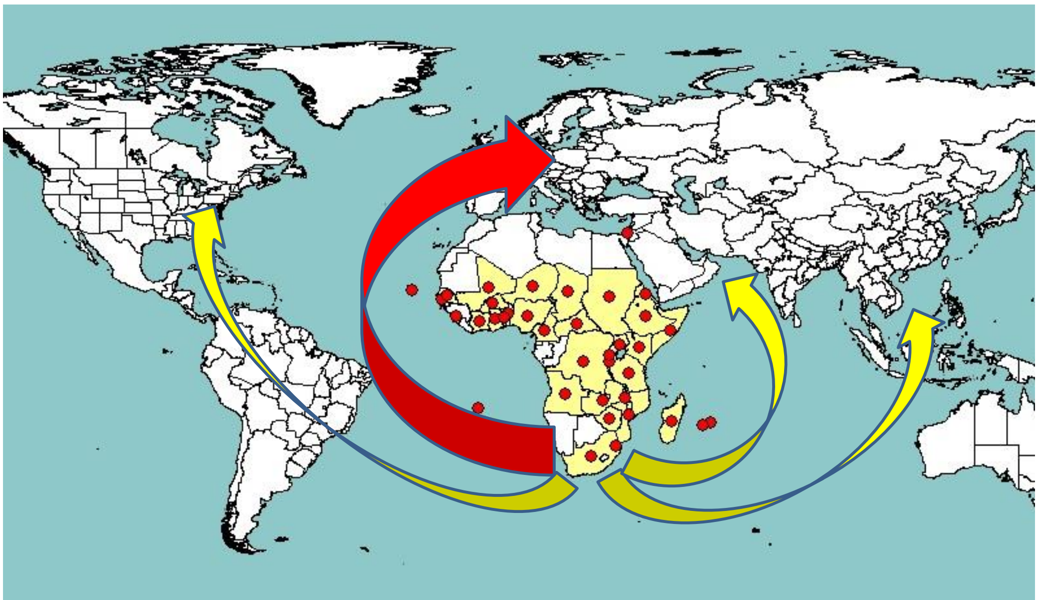
The substantial knowledge of the work will revise existing research forecasted by the Citrus Growers Association. This will include the citrus fruit expected for the next three years with the current historic data. This study would intend to improve the current cold room facilities in the Durban area with extra space to ultimately meet the Service Level Agreements (SLA) of fruit and more capacity to handle the influx of fruit projected in 2020. Research will be done to establish the best option of cold room facility to accommodate the extra fruit that needs to undergo the cold sterilisation process to meet the demand. The South African government is at the moment negotiating with the European Union to inform them that the

FCM issue can be managed by using the System Approach. This project is to determine the cost if the requirements in due future are thus initiated with severe measure to be prepared for implementation if the legislation is compulsory.

2. LITERATURE REVIEW

2.1 SIGNIFICANCE OF FALSE CODLING MOTH

False Codling Moth (*Thaumatotibia leucotreta*)(FCM)(Meyrick, 1913; Timm, A. E., et al., 2007) is a significant pest of fruit trees and field crops in portions of Africa. FCM has five generations mainly on citrus fruit except lemons and limes, but various other hybrids are also hosts with two to ten generations annually. The females place their eggs on the citrus fruit hanging in the tree or either fallen fruit, soil, bark crevice and debris were the larvae pupate. This FCM bore holes into the fruit and may cause pre-mature ripening and fruit drop. The FCM can bore a whole in green citrus fruit and choose a soft spot to bore in. FCM has a cyclic life cycle and if FCM laid eggs in the citrus fruit near the harvest period, then it changes into a pupa across the border and may establish in Europe (Gilligan, T. M., et al., 2011). Currently USA and China have very strict measures to prevent phytosanitary pest from establishing in their country due to very similar climatic condition. This means that very large consignments will be rejected if any FCM is detected in exported cartons. Europa is FCM free and at this moment it is the biggest threat for the current 40% and forecasted 45% citrus fruit of the South African Citrus Industry. The EU do everything in their means to prevent FCM from establishing in their country with strict quarantine and quality control measures when exporting citrus from South Africa. An estimation to implement cold sterilisation is calculated at an amount of R1,58 billion annually over 5 years and the increase per ha is 5%, it would escalate to an approximation of R2 billion (Moore and Manrakhan, 2017).



cri citrus research international

Figure 2 FCM detected in Africa and nearby neighbouring countries (Moore and Manrakhan, 2017)

2.1.1 FCM LIFECYCLE

The following Figure 3 depicts a description (Meyrick, 1913) of the False Codling Moth and its lifecycle:

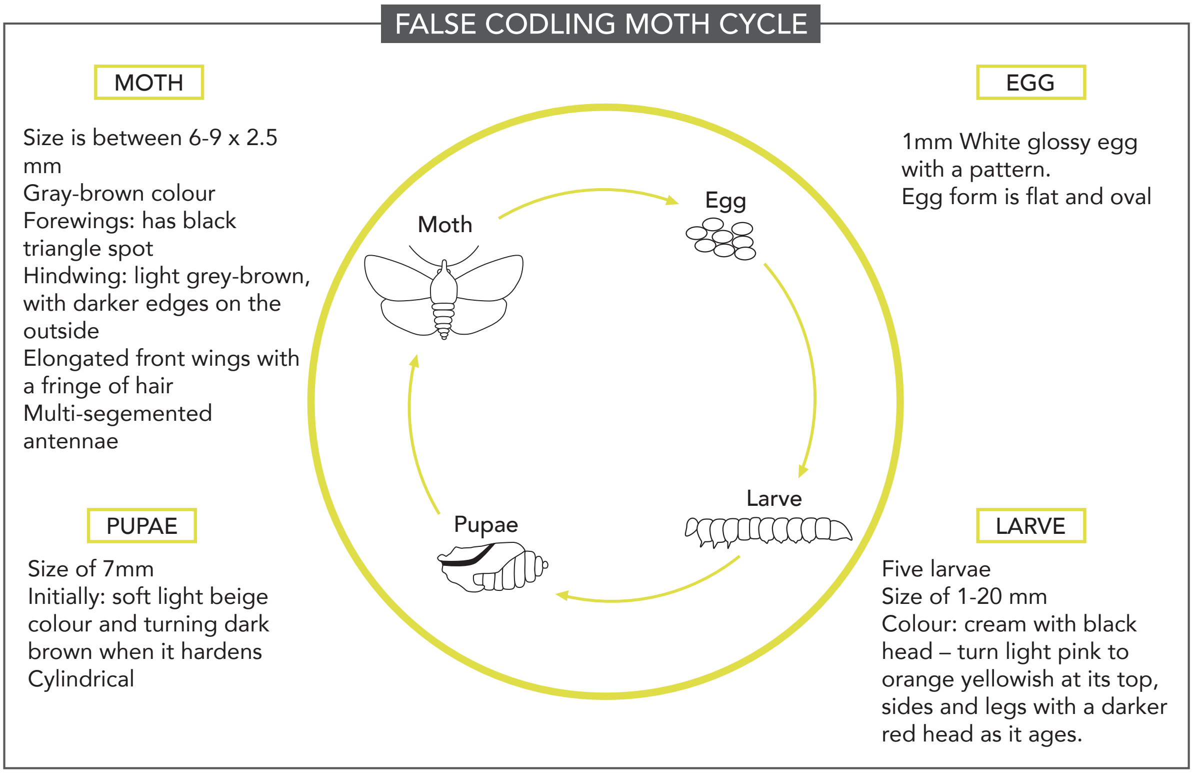


Figure 3 False Codling Moth Life Cycle (Binet-Agriculture, 2017; Citrus Pests, 2017)

In Table 1 each part of the False Codling Moth life-cycle and the function it portray:

Table 1: The False codling moth (Cabi, 2017; Citrus Pests Glossary, 2017)

	Function
Moth (Adult)	• Moth bore into fruit for consumption. • Introduce other bacteria and microorganisms. • Infested fruit drops before harvesting period. • Infested fruit near harvesting may not be detected and be packed to export.
Pupae	• The pupae appear from the cocoon just before the adult development. • The pupa is prone to cold temperature and heavy rainfall. • This stage appears to last 2-33 days.

Larvae (wasp)	• Wasp appears from the FCM eggs. • Lifecycle is 8 days. • Larvae hatch less than 3 wasps/egg. • Feed on the moth larvae in the egg. • The larvae pupate more than 4 days. • Moth eggs change black after larvae pupates.
Eggs	• The eggs are prone to cold temperature for a long period. • If the temperature is adequate, the eggs develop between 2-22 days.

2.1.2 IMPORTANCE OF COLD STERILISATION FOR FCM

The False Codling Moth nearly demolished a great amount of citrus orchards across the country and various studies had to be done to establish techniques to prevent this moth from over populating. At the moment a System Approach is in place, which is a chemical and fruit flytrap prevention measure. Since chemicals methods are not affective, new measure had to be investigated. Citrus is the second highest export commodity in SA and the second largest exporter of citrus fruit in the world at an amount of R15,7 billion in 2015/2016 based on exporting prices and R14.8 billion for local produce (DAF, 2016). The citrus industry is also responsible for providing 10% of the South African labour force.

Better measures were researched to replace older methods since they were not effective anymore. A nuclear technique called Nuclear-based Sterile Insect Technique (SIT) (IAEA, 2017) is implemented in Citrusdal, Western Cape to sterilise the moths and set it free in this high-density area. This SIT reduced a great amount of FCM and definitely helped farmers. This sterile moth is only released in high-density areas as we speak and will take a few generations to faze out. Further research is done and resulted in the effectiveness of cold sterilisation. At this moment if the EU insist on cold sterilisation sooner than we think, a possible solution needs to be determined in advance to ensure that the cold sterilisation process can be implemented if necessary.

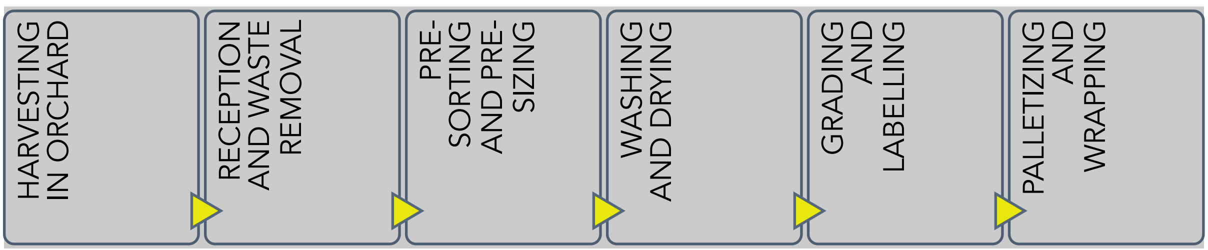
2.2 THE CITRUS PROCESS

Initial research was conducted on the current activities in the process that citrus follows from the farm to the consumer. Thereafter the current process is mapped in detail in APPENDIX B of each process in the citrus supply chain. This Citrus Process Diagram in Figure 4 gives a summary of all the stakeholders responsible in the production supply chain of citrus fruit. This supply chain begins in the orchards and end at the consumer:

Figure 4 Citrus Process

2.2.1 FARM PROCEDURE

Fruit are grown on a farm in an orchard and goes through a complete program every year with certain spray methods that needs to be implemented at an exact time during the growing period. These measurements are set in place according to the market the fruit is exported to with research and programs developed by the CRI. If fruit is harvested in the orchard it is send to a packhouse which are either located at the farm or nearby for further processing. The following diagram is a summary of the Process Diagram in APPENDIX B:



2.2.1.1 ORCHARD

Citrus fruit is grown on farms in different areas of South Africa. Producers harvest citrus fruit either to sell locally or to export their fruit in the winter seasons. The type of market the farmers cater for determine the certain technical measures the farmers have to adhere to according to local or exporting regulations. Workers use scissors to cut the stems to prevent damage to the fruit and pack the fruit into big crates until trailers collects the crates and transport it to the packhouse. To minimize poor quality of fruit, sanitation in the orchards are of utmost importance to prevent pesticides in the later stages to occur (Moore, 2008). Sanitation entails a clean area underneath the trees; no wood, no rotten fruit or fallen fruit that may have been injured.

The System Approach (Moore and Hattingh, 2013) is used to inspect fruit in the orchards with flytraps to track infested fruit earlier in the supply chain. Especially tracking False Codling Moth when picking the fruit.

The system approach entails:

- Orchard sanitation on a regular basis in Nov/Dec to harvesting.
- Place 1 trap per 4 ha or per orchard.
- Monitor the FCM infestation, one set of 5 data trees per orchard.
- Supply data in orchard to the packhouse, 12 weeks before harvest.
- Limit < 0.2 infested fruit/tree/week.
- The growers should take immediate action 4 weeks before and during harvesting season.
- Apply a final 4 weeks prior to harvest.
- Pre-sort fruit in the orchard before it is send to the pack-house.

2.2.1.2 PACKHOUSE PROCESS

A TFR Team Citrus Orientation & Grower Road Show was attended to identify all the farm and packhouse operations and facilities at the growers in the Northern South African regions. All the operations within the packing lines are subject to unique constraints and have potential hazards that will ultimately affect the quality of the fruit (Postharvest Innovation, 2017). The important steps in the packhouse are:

- **Reception and waste removal**: Mechanised tippers are used to tip the individual crates filled with fruit that are received from the orchard. Fruit enters the packing line.
- **Pre-sorting and Pre-sizing**: This operation examines the quality of each individual fruit by graders. The three factors namely quality, size and colour are brought into consideration. The inspection of any infected fruit such as FCM should be eliminated in this first step of pre-sorting. The pack-house workers should be trained to ensure that they know the differences between different types of blemish on the fruit. In more advance packhouses, electronic systems and photos are used to identify an infected fruit and is automatically eliminated, but there is no technology yet developed to identify FCM, which makes is more labour intensive to

identify it with an eye. This method is thus only 79% accurate and not reliable enough to prevent FCM from passing through to other countries

- Washing and drying: The fruit proceeds from the pre-sizing equipment on a roller conveyor where after it precedes into a washing unit. Esthetical value plays an enormous roll when it comes to marketability. Citrus fruit is also washed and cleaned from any fungicide to establish.
- Fungicide and wax application: The fruit is treated with fungicide for two specific reasons: to control the spread of post-harvest diseases and to prevent decay during storage. The purpose of a wax coating is to protect the fruit from pathogens and to give the fruit a natural shine.
- Grading and sizing: Graders inspect the colour, size, shape and weight of each fruit individually and sort them in Grades 1, 2 and 3. Modern packhouses make use of electronic sizing, since it is a very accurate method that uses cameras to determine the size of the fruit. This method is expensive to implement compared to other methods and the mechanical method is still very popular in South Africa.
- Labelling and packing: Labelling is done with a sticker on each or a few fruit in a box. This is an optional requirement due to market or exporter requirements.
- Palletizing and wrapping: This is the final operation of a typical packing line. The cartons received from the packing operation are stacked onto pallets and wrapped for protection.
- Inspection: The packhouse management notify the PPECB to inspect every pallet packed and ready to be exported.

Figure 5 Schoeman Boerdery (Edms) Bpk, Moos Rivier Farm, Groblersdal

2.2.2 PACKHOUSE

Inspected fruit is palletised, packed and dispatched from the packhouse. The packhouse is responsible to inform the transportation company of pick-up dates, packhouse location and cold storage destination that the fruit needs to be delivered at in the Durban region. The fruit is transported in ambient truckloads to its destination.

2.2.3 COLDCHAIN

The cold chain is used for temperature sensitive, perishable products along a supply chain through refrigerated packaging practices and logistical planning to protect the integrity of these products.

2.2.3.1 COLD STORAGE

The beginning of the citrus cold chain starts at the cold storage facility. Goods arrive from the packhouse at the receiving dock and are registered on the warehouse management system (WMS). Fruit are unloaded and placed in an ambient warehouse. The exporter waits for a consignment of twenty pallets from different packhouses to fill a container. If twenty pallets are selected then PPECB is notified to inspect a carton of every pallet. Products receive inspection and undergo quality control (QC) at the cold storage. Inspection takes place to determine if there is any phytosanitary risk in a consignment. At this stage a focus on FCM in a pallet prior to shipping is priority. The following protocol for FCM is shown in Table 2:

Figure 6 Ambient storage

Table 2: FCM Protocol according to pallet detection (Moore and Manrakhan, 2017)

FCM detection in a pallet	Shipping temperature	Duration
Any FCM in a pallet; or not SA compliant	Cold-steri Protocol -0.6 °C	22 days
• No FCM detected in a pallet • FCM detected in a pallet from the same consignment	1 °C 2 °C	16 days 18 day
If no FCM in every pallet in a container	4 °C	16 days

If all twenty pallets' boxes are approved then the cold storage management will inform a forklift to pre-stack the twenty pallets together in a cold room. The chosen cold room facility will be dependent on the market to either choose between pre-cooling to drop fruit temperature or forced air-cooling chamber to undergo cold sterilisation treatment. The forced air-cooling consignments are separately pre-stacked in compartments and cooled each starting at different times. These compartments consist of all twenty containers allocated for one container. If the shipping-line confirms the stack-dates then the cold storage can prepare the consignment pallets for reefer truck loading.

PRE-COOLING CHAMBERS

A pre-cooling chamber in Figure 7 is an open space or with modern racking installed with electronic pallet tracking system. Fruit normally is stacked in this pre-cooling facility for ± 8-10 days. Fruit that are not destined for special cold treatment market is placed in these pre-cooling cold rooms to drop the fruit temperature before it is pre-stacked for a container to await shipment.

FORCED-AIR COOLING CHAMBERS

The forced-air cooling chambers in Figure 8 are designed to do cold sterilisation treatment for special markets. This is a ± 12-day uninterrupted treatment that twenty pallets consignment allocated for one container go through in a separate compartment. This design ensures that the compartments operate at an uninterrupted period without being opened when fruit pallets enter and exit the entire chamber.

Figure 7 Pre-cooling storage

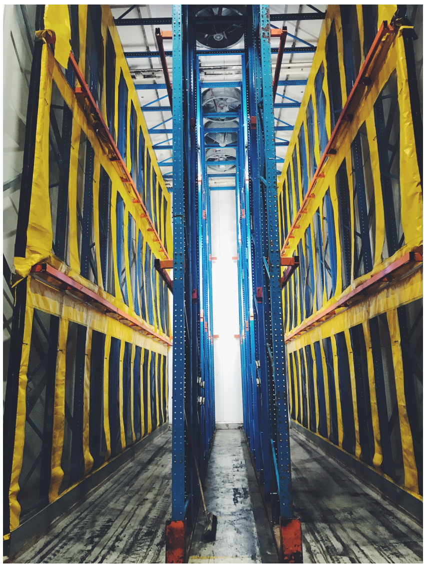


Figure 8 Forced-Air cooling storage

2.2.3.2 EXPORTERS RESPONSIBILITY

The exporter is accountable for the entire logistics occurring from the cold storage and marketing their fruit at different international markets. Every truckload and pallet received will be scanned on the WBS system with arrival. Thereafter the fruit is stacked in an ambient warehouse open space for exporters to accumulate pallets to make-up a container. A container can take 20 pallets of different farms (owners), thus the exporter needs to allocate which farms fruit is going into which container consignment. Once the pallets are allocated the exporter has the responsibility to notify PPECB to do inspection on every pallet allocated for the one container. Once the pallets are all scanned in the WBS and the PPECB approved of inspection, then the forklift is notified to come and pick-up at the different locations of the pallets and pre-stack them in the cold room facility. These facilities will either be a precooling area or a forced air-cooling cold room for cold sterilisation treatment. Certain niche markets has cold sterilisation protocols. Once the cooling process start according to protocol for the certain markets, then the exporter can create a Q67.

A Q67 is a document that states the entire description of the pallet. This will include the descriptions of the exporter, from which packhouse, to which market, variety type, dates and the PPECB inspection accreditation. If a Q67 is created then a few key partners is notified. A transport company is notified by the exported of the empty depot location to pick-up a container. PPECB is notified to inspect the empty container. A truck will load the inspected container and take it to the allocated cold storage. The truck will be weighed and then upload the selected pallets in the container. After loading the pallets the truck will be weighed again to ensure that the reefer container is at adequate weight to adhere to the shipping-line protocols. The truck will head to the Transnet Durban Port Terminal and queue in the line for a day. The fruit is transported with a continuous cooled temperature to the Durban Port to prevent temperature drop that may cause decay of fruit along the way.

2.2.3.3 TRANSNET DURBAN PORT TERMINAL

Transnet Port Terminal opens their stack-dates prior to shipment for truckloads to unload reefer containers. The trucks will queue into Durban CBD for a day to unload their consignment inside the Port Terminal. The Port Terminal has plug in ports to immediately plug the reefer container in for continuous temperature. The containers will wait for the ship to arrive and loading of the vessel will take between 3-5 days to load. The trucks will drive outside the Terminal and queue in another line to pick-up an empty container and deliver it to the empty depot.

Figure 9 Transnet Durban Port Terminal

2.2.4 SHIPPING RECCOMENDATION FOR THE EUROPEAN UNION

Currently a cold chain is used to ship citrus fruit to the EU, but a cold sterilisation process is not yet compulsory. The shipping recommendations as we speak is all fruit need to be sent at air delivery of ±2 °C, if pre-cooled it should be at 4°C, minimum shipping time of 16 days or ambient lad a minimum shipping time of 19 days (PPECB, 2017). Some fruit varieties especially lemons is prone to cold damage and need to adhere to other protocols. At this moment strict inspection needs to be in place to ensure that no FCM enter the EU to ensure that cold sterilisation facility is not necessary to implement.

South Africa exports 50 million citrus cartons to Europe (2016 historic data), which is currently 40% of citrus fruit and a high risk for the whole South African Citrus Industry. This means that if the European Union does detect FCM in the fruit exported, stricter measures or compulsory cold sterilisation will be implied. This mean that either 50 million cartons needs to be re-directed to other markets, which will flood the other markets, or the cold sterilisation process needs to be developed.

2.2.5 COLD TREATMENT

Cold treatment is used to procure fruit quality and prolong fruit decay.

2.2.5.1 RATIONAL OF THE COLD CHAIN

A cold chain for perishable foods is the uninterrupted control of the product within a cool temperature environment during the postharvest part of the value chain including harvest, fruit handling, collection, packing, processing, storage, transport and marketing until it reaches the final consumer. The uninterrupted cold chain is a critical part to prevent a perishable product to develop post-harvest fungicides, phytosanitary infection and fruit decay when it reaches the European Markets. The importance for FCM in the cold chain is stated in the problem statement.

2.2.5.2 COLD STERILISATION PROCESS

Cold sterilisation is a cold treatment process that fruit undergoes to ensure that no phytosanitary risks arise when exported to another country that is pest free. It is ultimately bio-security from pests and diseases crossing borders and infecting orchards across continents. The cold sterilisation process is a cold treatment at a specific cool temperature and duration that the country exported to determine according to research done (Postharvest Innovation, 2017).

An obstruction in the harbours will be experienced if fruit needs to receive cold sterilisation treatment, due to the increased period of cold treatment protocol. The facility needs to be sufficient to accommodate a pile up of fruit. Different methods need to be investigated to keep costs as low as possible and determine the acceptable facility to implement for the cold sterilisation process across the country.

Currently the cold sterilisation process takes place to a few main exporting markets such as the USA, Japan, South Korea, China, Israel and Thailand but these special markets increase yearly. The cold treatment container protocols are a standard set of regulation given by the PPCEB yellow card in APPENDIX C. The strict measures of the USA will be assumed to use for all citrus fruit exported to the EU markets, since the EU is still determining their requirements. Their regulations state that fruit needs to be pre-cooled for a minimum of 72 hours but for USDA the last 24 hours the product must be on protocol temperature (PPECB, 2017).

2.2.6 SUPPLY CHAIN MANAGEMENT

Supply Chain Management is the uninterrupted strategic administration of goods and products required by the part of the prior section (Christopher, 1998).

The importance for supply chain management is to experience a streamline continuous supply of goods from the producer to the consumer (Interrait, 2017). The system will need a competitive infrastructure to reduce delays and breakages while increasing profit with net value, a system with competitive infrastructure, a synchronized fruit supply to compete globally and have competitive logistic advantage in global markets.

Supply chain management is a multinational operation, which is a link between the citrus growers and European consumers responsible for the following:

- Distribution of information between key partners in the supply chain. This is between the citrus growers, the 3PL (Third-party logistics) and the European Market fruit supplied for.
- Service logistics to integrate citrus product between stakeholders.
- Reduce backlog pile-up of perishable product. The supply chain need to ensure that its system is capable to accommodate the load of perishable citrus fruit ripen at once in a season.
- Improve process integration between the growers, packhouse, Port and global markets

2.2.7 LOGISTICS

Logistics management is the process of strategically managing the procurement, movement and storage of resources as well as related information flow through the organisation and its marketing channels in such a way that the existing and future profitability are maximized through the cost-effective performance of orders (Malcolm, 2017). The citrus industry logistics have different stakeholders in the supply chain handling the fruit from the farm to the international market. Most farmers use the services of third-party logistics (3PL) companies to take responsibility of the logistics to export fruit and deal with the legal requirements of the specific markets. The logistics data of citrus fruit capacity will be obtained in certain northern areas in South Africa who supply citrus fruit to the Durban harbour to export.

The northern regions supply the Durban Port with high volumes which cause a delay in inbound transportation available trucks with long distances to transport, fruit that causes capacity limitations with high peak volumes at the Port. The infrastructure congestion occurs around the Port at Point, Maydon Wharf and Bayhead precinct in Durban and the control of the cold chain with the logistics of the containers is not managed adequately (Brooke, 2017).

2.2.8 TRANSPORTATION METHODS

Global transportation is used for transporting fruit from the farms to the markets. In SA road transportation is used to transport citrus fruit from the farm to the cold storage in Durban with ambient trucks. Interlinks with cooled standardised containers in between 20-53 foot boxes transport fruit from cold storages to the harbour. Intermodal shipment can be used in cases such as Europe or America to connect the markets inland from certain harbours. Ocean transport is the most universal shipment method of transporting bulk, container and break-bulk products across the globe. There are three types of shipments:

- Liner - A liner use consistent scheduled routes
- Charter - Different routes that are contracted services
- Private - If a company use its own logistics transporting means.

Growers use Export Management Companies (ETC) to export their fruit to Europe, America and the Far East. ETC's are familiarized with every countries specifications, government requirements and legislation. They can arrange transportation inland, they have set markets in the various countries and select the appropriate markets for certain products, do promotional campaigns and have good relations with that markets. They are also responsible to ensure movement of fruit through customs with the correct and complete documents to enter the country.

2.2.9 GLOBAL STORAGE, FACILITIES AND PACKAGING TERMINOLOGY

In-transit reefer containers: Refrigerated reefer containers are used to ensure an uninterrupted cold chain of cold treated fruit from the cold storage to the market.

Transit area at Transnet Port Terminal: At the harbour is a transit area with plug-in points to ensure that the reefer containers sustain the cool temperature. The stacked reefer containers await the shipment in this area.

Hold-on-dock: Free ambient storage available for fresh citrus pallets to be delivered

Public warehouse: This is longer periods of storage, which is not likely to be used in the case of Citrus Fruit due to a perishable product

Bonded warehouse: Is storage to re-pack products without paying import duties. This type of warehouse is not used with citrus fruit in SA. Citrus fruit is treated and packed with specific requirements in a packhouse and wrapped on pallets to take as a unit. The only re-packing that takes place is the twenty packed pallets that are re-packed according to their container consignment.

The global packaging of citrus fruit is a high insurance risk due to many facets in the supply chain handling these perishable products. There are many companies involved from the farm to the market that are difficult to determine who is liable for any occurrence that may happen during the process. USDA approved temperature data loggers are used by the PPECB with the following temperature requirement to adhere to the exporting regulations, attached in APPENDIX C (PPECB, 2017).

2.3 INDUSTRIAL ENGINEERING TECHNIQUES

Industrial engineering techniques are used to identify, plan, design, implement, manage or maintaining any type of production or service process to improve, re-design or implement more efficient means to improve efficiency and be the most cost effective. These techniques can be based on any type of industry to implement future improvements.

2.3.1 METHOD STUDY

Method study is the process of subjecting work to systematic, critical scrutiny to make it more effective and/or more efficient. It is one of the keys to accomplish productivity improvement (Textile learner, 2017). This method study is solely to use for cost reduction and refining a system to operate better with standardized methods, equipment, and working conditions. A basic methodology of Method study is illustrated in essential steps (Nraoiekc, 2012):

SELECT
- Choose an industry with economic value.
- Define a problem definition.

RECORD
- Record the job/operation detail, facts and observe the basic data of the operation.
- Record a thorough study of the current operations.
- Process charts or flow diagrams that can be used to get an understanding of what the project entails.

EXAMINE
- Determine the main purpose of the operation.
- Examine the critical purpose, place, sequence, person, means.

DEVELOP
- Create a new improved model/method/system to re-examine for selection.

EVALUATE
- Compare the new developed alternatives and choose according to all aspects and the most costly.

DEFINE
- Operation, procedure, layout, equipment, methods, instruction.

INSTALL
- Install the chosen alternative and implement the model.

MAINTAIN
- Ensure that the model is continuously improved and maintain.

2.3.1.1 PRINCIPLES OF METHODS EFFICIENCY ENGINEERING

The successful determination principles would be to define the main goal to accomplish beforehand:

The main goal to accomplish for an industrial engineering project is to increase the productivity and reduce the overall costs for an industry.

The following decision is to either focus on a single step in a process or the entire process.

With either a single step or the process, the main goal of this project should be established.

The following specific goal alternatives may be use to focus on:

Determine the key activities of the cold storage process to identify elements to improve in areas.

- Reduction in lead-time, operator delay, wastage and discomfort of an operator.
- Eliminate re-packing time of fruit pallets between hold-on-dock, inspection and the cold room facility.
- Eliminate make-ready time to pre-stack containers for stack-dates.
- Improving of the current cold storage layout, operation flows or work area to accommodate more pallet slots.

The principle of Method efficiency design has various decisions changes that can be looked into when investigating a current process. The material used, goal, sequence, product, equipment, method, hand pattern and modification of work.

2.3.1.2 APPROACH TO ANALYSIS

The approach would be to select an industry of importance such as the South African Industry with an economic value. The industry has many areas for improvement of which one problem would be identified and the keys that are valuable to investigate. This will entail a thorough recording of the entire citrus supply chain using the process flow diagram and identify the key partners in the citrus process. Examining the purpose of the operation and how the key partners connect. With the 4W1H(What? Where? Who? When? How?) method the rationale steps is identified in the process to determine the significance of the necessary steps. Examine the identified current cold storage operations in Durban to determine the current capacity. Develop a prototype model to determine the current and forecasted capacity of every week in the citrus season since 2012. Evaluate and discuss the prototype model with the CGA and UP supervisor to determine the significance of the model results. Define the calculated model that will suit the demand of the industry. Installation and maintenance will not be part of this project but suggestions to the industry will be illustrated.

2.3.2 FACILITY PLANNING

Facility Planning determines how an activity's tangible fixed assets best support achieving the activity's objectives (Slide-share, 2017). Facility planning is important to identify the current process and analyse the intention of the stakeholders. This analysis will give an objective view to advance in the facility management organisation requirements. With facility planning a pro-active approach is to evaluate the deliverables proposed by the industries strategic objectives. This IE technique will be used to obtain the current capacity at the eleven cold storages in the Durban regions. This information will be mapped and used to determine if the facility require pre-cooling or forced-air cooling chambers.

Applying a facility planning at the cold storages in and around Durban (International Facility Management Association, 2009):

1. Determine and formulate the problem

   Define the objective of the facilities at the eleven cold storages around Durban. To meet the industries requirements of capacity shortage that will possible be faced in due future with an influx of citrus volumes.

2. Investigate and evaluate the problem

   Identify the quantitative service that needs to be provided at the cold storages. Specify the primary and supportive activities that happen to achieve the objective.

   Determine the available space for cold room activities at the cold storages in the Durban region.

   Requirements for main activities include operations, equipment, employees and product (citrus pallet) flow.

3. Investigate and develop alternative solutions

   Defining the interrelationship between quantitative and qualitative relationship of the citrus process.

4. Evaluate alternate facility solutions

   Evaluate current cold room facilities at current packhouses in the Northern region to determine if it is efficient to establish cold facilities not located near Durban, but near the packhouse on the farm.

5. Choose a adequate facility design

   Select a plan by not considering cost but main considerations.

   Take the various facility solutions and draw a comparison to rank the differences.

6. Implement the chosen facility plan

   The implementation would consist of a facility layout design of the Durban area and a preceding possible construction. For this project only a layout design will be done and not an execution.

7. Regular facility improvement

   Facility design needs to be updated according to market protocol, new technology, legal requirements, cold-sterilisation treatment, energy saving measures and different flow patterns for handling equipment and containers at the cold storages. The maintenance will occur if this model is implemented only if the EU implies these strict measurements.

To determine the capacity with facility planning, data will be acquired to incorporate the maximum inflow of fruit supplied currently to use with the estimate forecasted capacity for 2020. The data of the different citrus varieties at certain times in season needs to be compiled to ensure that maximum inflow of fruit is adhered to. Due to citrus fruit that are perishable and also winter seasonal, is it important to ensure no decay of unaccompanied fruit at the independent cold storage facilities.

2.3.3 TRADE-OFF ANALYSIS

Trade-off Analysis is a decision-making technique, which stakeholders use to determine between options investigated. A trade-off is normally a trade between objects to obtain another. The strength and weaknesses are typically compared to determine a trade-off between options of chosen processes. Collaborative learning should be conducted to understand the difference between the decisions concerning the resources. The following decision trade-offs can be implemented by using a multi-criteria process:

Define the six-step planning process problems:

- Define the problems and opportunities of the problem.
- Criteria of the options identified.
- Evaluation of alternative plans.
- A comparison between the options is illustrated with a decision matrix. A value trade-off analysis can be done with the matrix. Weight and synthesis of alternative plans.
- Decision based on the comparison of the alternative options.

The following Figure 10 depicts the relation of the planning process of multi-criteria decision support:

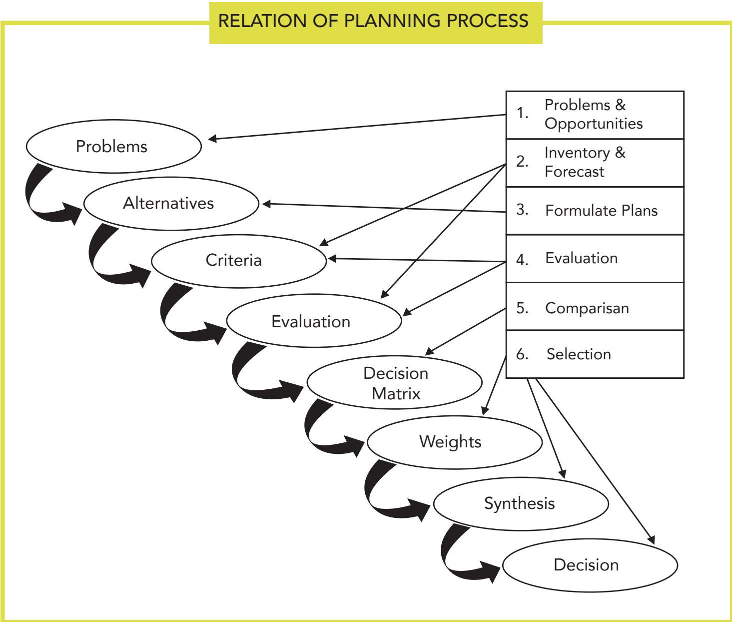


Figure 10 Relation of a Planning Process (IWR, 2007)

A trade-off analysis will be done to compare the cost per carton comparing the current normal pre-cooling (Non-COT) that European Union market is currently undertaken and the increased cost to do cold-sterilisation treatment (COT) if the protocols intend to it. This will compare the cost of DAF Phyto Inspection, Forced-air cooling compared to pre-cooling at the cold store, PPECB COT Container Inspection fee, PPECB container-shipping fee and extra Seafreight charges.

3. PROBLEM INVESTIGATION

The following data is gathered from the Industry Sponsors, the Citrus Growers Association and a visit to the Durban is used to develop a standard prototype model at the Durban Harbour. Determining the number of cold room facilities that will be necessary to send South Africa's crop into the EU, which would make use of the cold sterilisation protocol. This project is based on the farms in the Northern Regions in SA allocated in the following Figure 11:

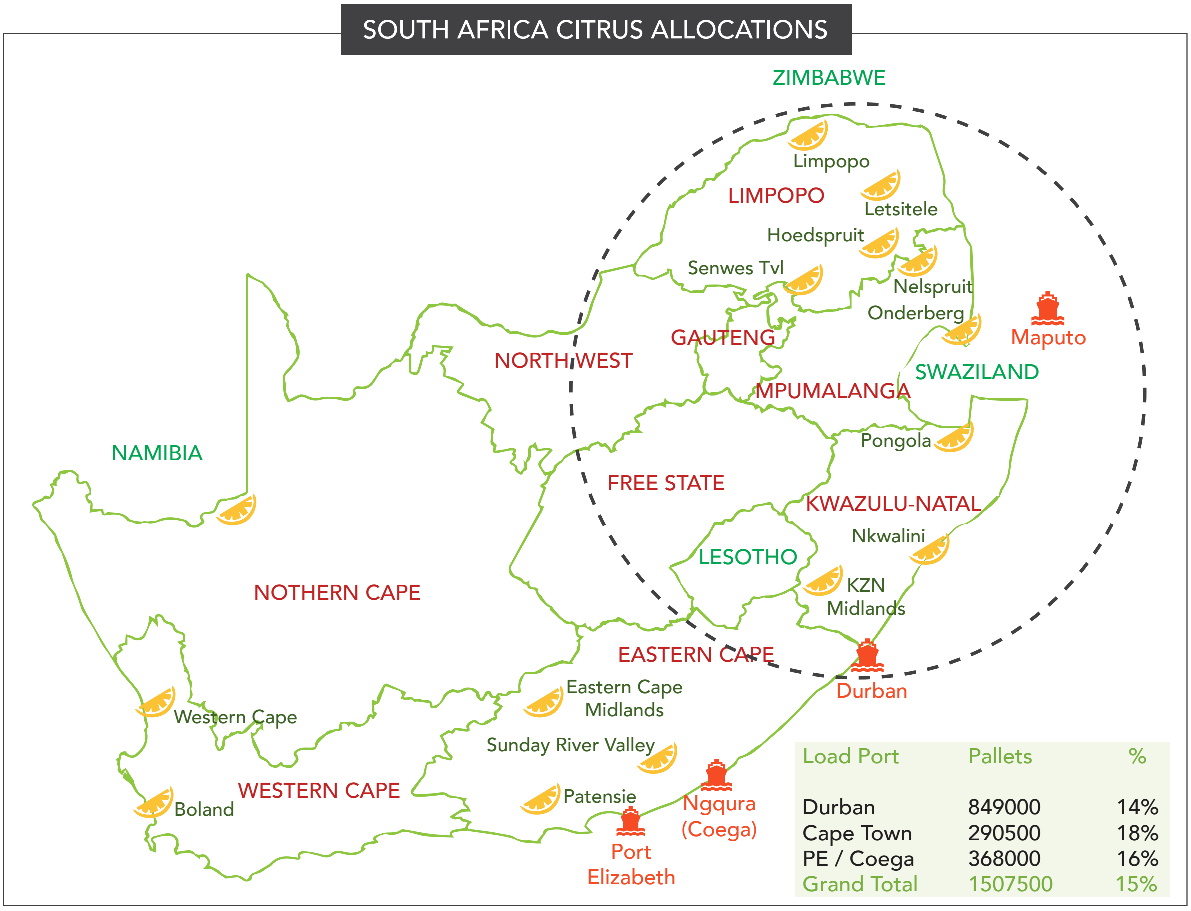


Figure 11 Northern region of Citrus allocated in South Africa

3.1 DATA ANALYSIS

Facility planning, an industrial engineering technique is used to establish the current capacity of each of these cold storages. On the 14-18th August 2017 data were gathered with a visit to the head office of the Citrus Growers Association in Hillcrests, Kwazulu-Natal to get an overview of the Durban Port operations. Data were collected with visiting five of eleven cold storages in the Durban region currently operating in the citrus season. A visit to the Transnet Durban Port Terminal took place to show the process of the reefer containers to have a better understanding of what the plug in operations entail. The loading bay was also visited to show how reefer containers were loaded onto a shipping vessel. All these visits contributed to complete this project with a better understanding of the citrus supply chain and information acquired of each section in the chain. The eleven current cold storage locations accommodating citrus fruit are allocated in the map in Figure 12:

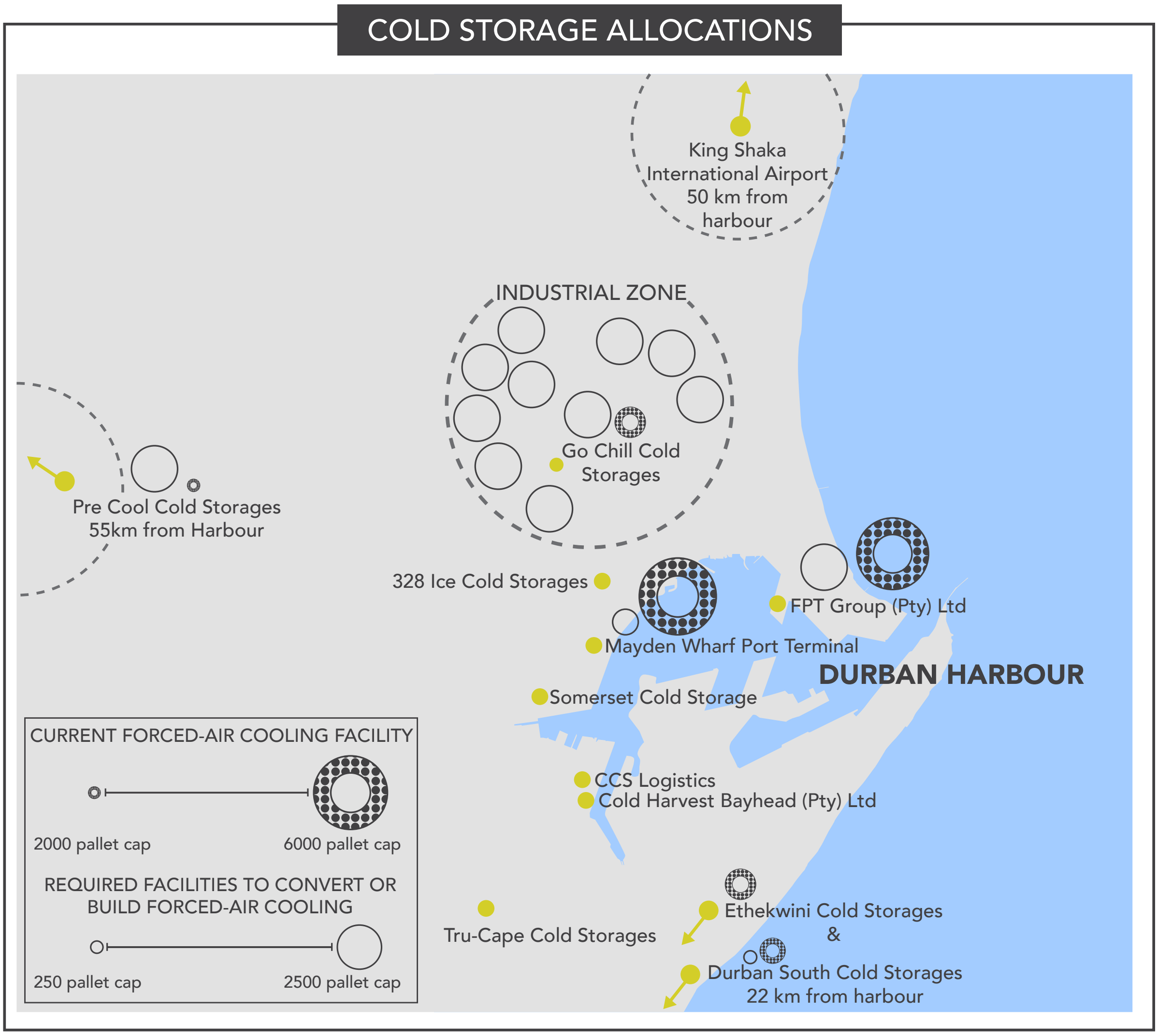


Figure 12 Cold storage allocation in KwaZulu-Natal

3.2 OBJECTIVE OF THE PROBLEM

The objective of the facility planning is to determine the current cold room facilities that are located at the Durban harbour surroundings. The purpose is to investigate the current pallet capacity to determine if it can facilitate the extra volumes and intended protocols expected in the next three years. Cold storages are divided into two types of facilities, which are pre-cooling and forced air-cooling chambers.

According to stricter protocols that may be a burden in the next few years from the EU side, measures needs to be in place to prevent bottlenecks and ensure that the right cold room facilities is chosen for the right cold treatment protocols.

3.3 CITRUS DEMAND IN SOUTH AFRICA

To following aspects needs to be incorporated when determining the demand of cold storage facilities. This include the current citrus production, the volume fruit exported from Durban harbour, the forecasts for 2020, tree census data, bud-wood sales and the EU protocols.

3.3.1 CITRUS PRODUCTION IN SOUTH AFRICA

The current South African production for export estimates in APPENDIX D is shown in Figure 13 until estimated 2020 supplied by the Northern South African regions:

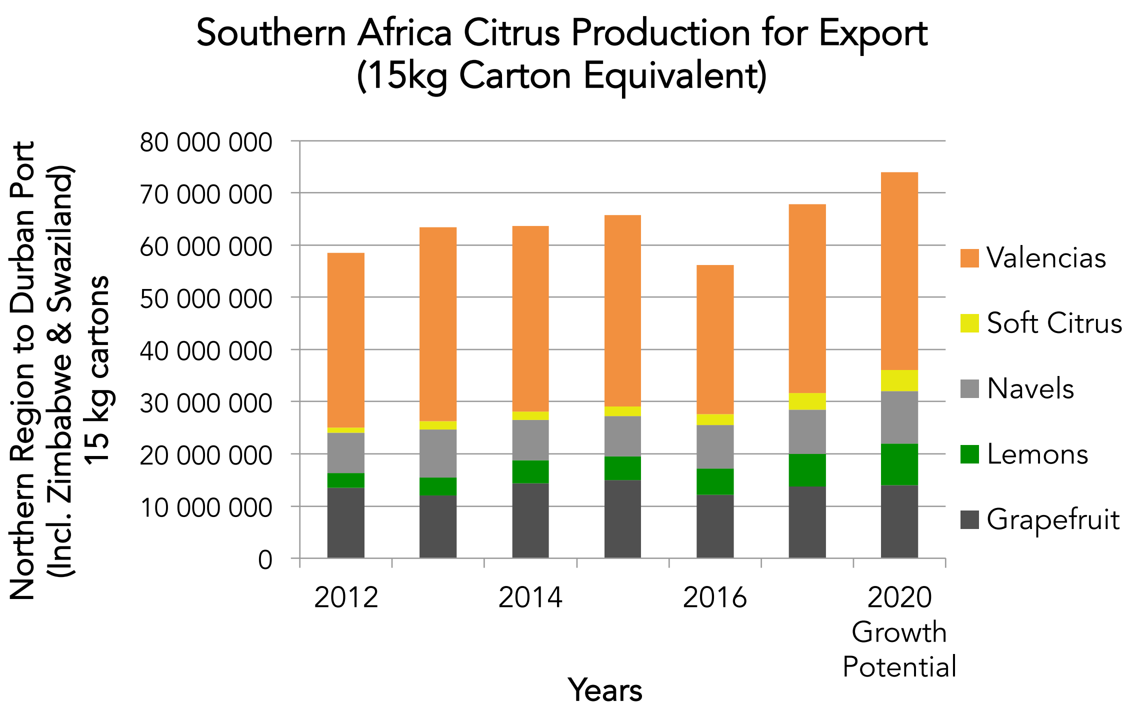


Figure 13 Graph depicts the historical and forecast production for export volumes estimates. Five main variety groups exported (per 15 kg box) through the Durban Port and the estimate growth statistics in next three years are shown.

3.3.2 DURBAN HARBOUR EXPORTS OF CITRUS FRUIT

The historical and forecast citrus export volumes by Commodity at the Load Port per pallet is illustrated in the following Table 3:

Table 3 Historical and forecast for export volumes by Commodity by load Port (Pallets) (Brooke, 2017)

Citrus Export Volume by Commodity by Load Port (Pallets)										
Exit Port	Commodity	2012	2013	2014	2015	2016	2017 Estimates rev: week 31	2020 Growth Potential	3 Year Average 2014-2016	% Growth - 3 Year ave. vs Growth Potential
DURBAN	Grapefruit	153 052	228 324	195 084	206 217	178 086	*195 000*	210 000	193 129	9%
	Lemons	36 042	43 949	54 775	55 582	62 409	*72 000*	80 000	57 589	39%
	Oranges	499 895	538 196	512 407	532 139	456 476	*550 000*	560 000	500 340	12%
	Soft Citrus	12 022	19 944	19 538	25 450	27 544	*32 000*	35 000	24 177	45%
	Total	**701 010**	**832 304**	**783 660**	**819 388**	**724 516**	***849 000***	**885 000**	**775 855**	**14%**

3.3.3 FORECASTS FOR 2020

The forecasts of the Citrus Growers Associations are used to determine the capacity of the cold storages and develop a model to accommodate in 2020. The forecasts are based on different aspects of the citrus industry in the Northern regions. The forecasts are based on the historical volumes of citrus production illustrated earlier in the report, tree-census data and bud-wood sales.

The northern regions tree census data is shown to determine the current trees in production or when it will be in production. A citrus tree on average produce in year three and is in full production in year five. The tree census data is shown in Table 4:

Table 4 South African Citrus Tree Census 2016: Estimates (Brooke, 2017)

South African Citrus Tree Census 2016 (Excludes Swaziland and Zimbabwe)					
Citrus Types	Hectares of Trees Younger than 5 Years	Hectares of Trees Younger than 5 Years as a % of Total	Hectares of Trees 6 Years to 20 Years	Hectares of Tress Older Than 20 Years	Total Hectares of Trees
MANDARINS	3 989	41%	4 910	804	9 703
LEMONS	2 944	31%	5 016	1 591	9 551
VALENCIA	2 234	9%	15 673	8 355	26 262
NAVEL	1 789	11%	8 922	5 849	16 559
CLEMENTINES	287	16%	694	836	1 818
GRAPEFRUIT	203	3%	5 317	1 748	7 269
MIDSEASON	15	12%	45	64	125
SATSUMAS	13	47%	11	3	27
Grand Total	**11 475**	**16%**	**40 589**	**19 250**	**71 314**

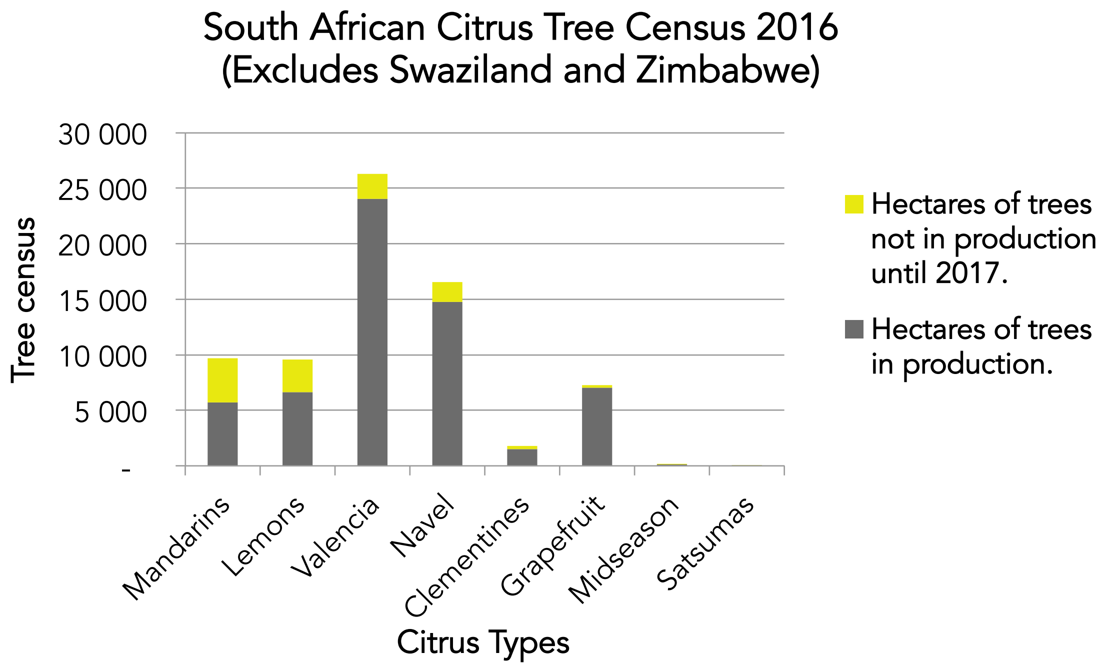


Figure 14 Graph depicts the current trees in production and the newly planted trees in yellow, which starts producing in year three and is in full production in year five.

The bud wood sales can be used to determine the amount of trees, the type and in which area it is planted. The bud-woods would not have a 100% yield, but calculations are based on the percentage yield it cultivate. In APPENDIX E a table of bud woods supplied is summarised in the different varieties planted since 2011 to 2016 in the Northern Regions. The following chart illustrates bud wood supplied peak in sales since 2016 which will be in full production in approximately 5 years time:

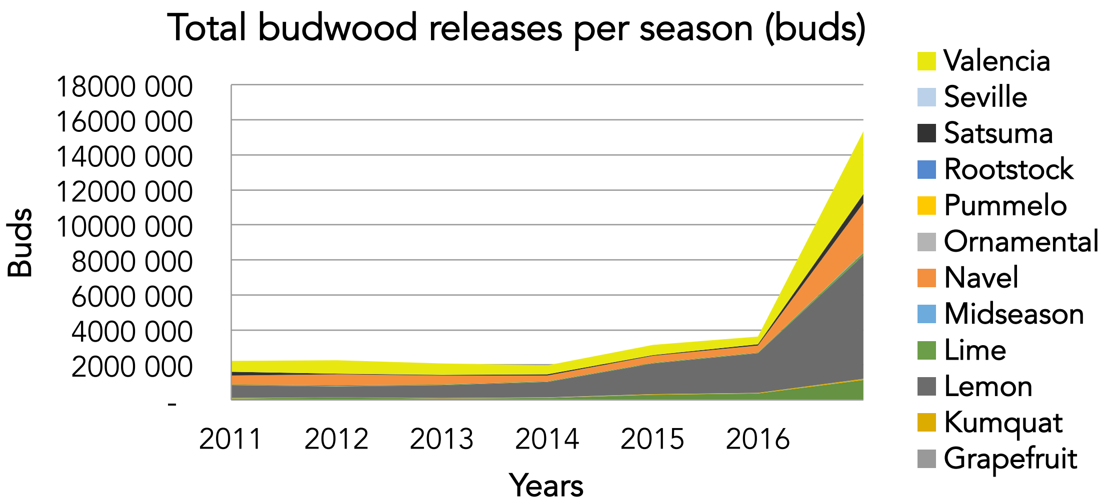


Figure 15 Graph indicates an immense increase in volumes that are expected in the next five years.

3.3.4 THE EU PROTOCOL IMPOSED FROM JANUARY 2018

The European Union delivered an amendment of the European Union's Directive on protective measures against the introduction of harmful organisms into the EU published in the Official Journal of the EU, to include FCM [Commission Directive 2017/1279]. This amendment states that FCM is now officially a controlled pest. At this moment regulated prevention methods need to be in place from 1 January 2018 with either cold treatment or the scientifically based system approach within an FCM management system (Chadwick, 2017).

To determine these volumes, current special markets needs to be established to determine the extra volumes that will increase the current cold sterilisation facilities. The following Figure 16 illustrates the projected destinations for 2020 to which country all the citrus fruit in SA is going. The market destinations are illustrated per pallet volumes in APPENDIX F. The following chart illustrated that 45% extra volumes in orange that needs to be looked at:

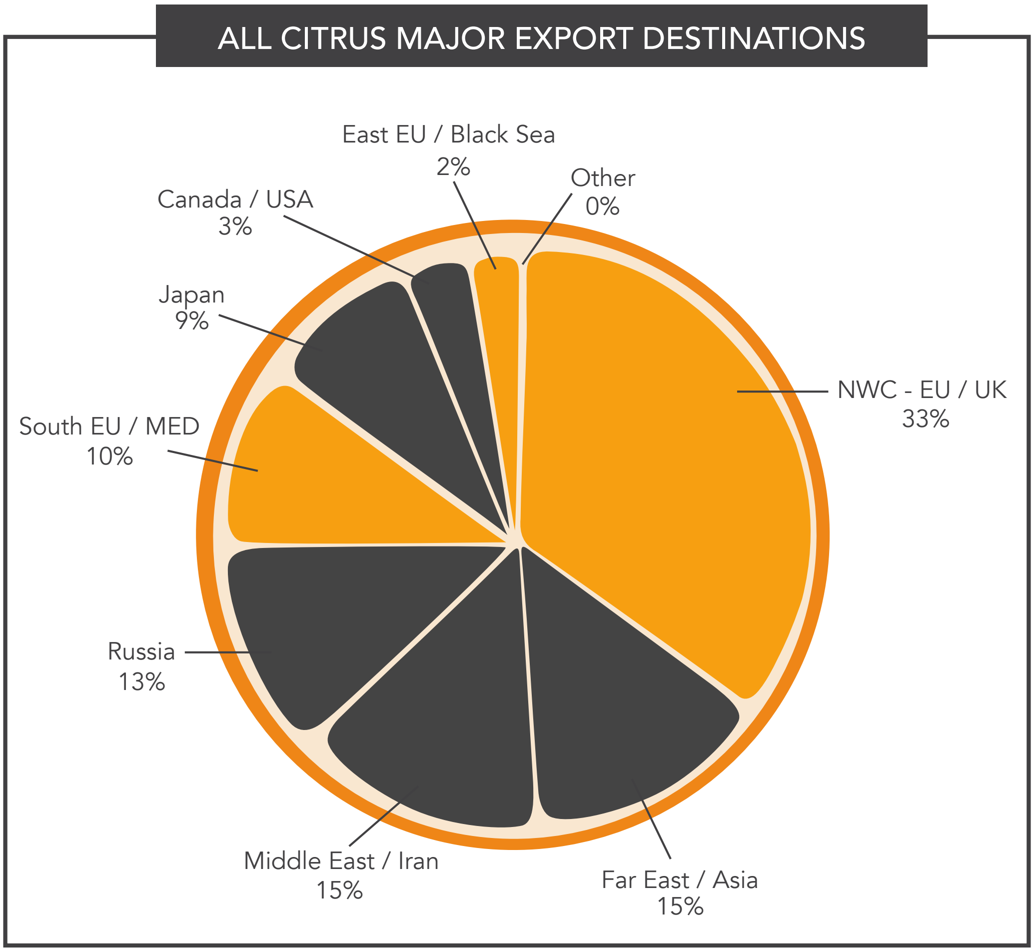


Figure 16 Pie chart of the market destination projected for 2020: Estimates (Brooke, 2017)

The significance of this project is to determine the capacity if the European Union insists to cold sterilisation protocol to have enough facilities of forced air-cooling to accommodate the forecasted 45% of citrus fruit exported to the EU.

The following calculation has been done to establish which percentage variety type is going to which market. The markets are divided between a Non-cold sterilisation markets (Non-COT) or Cold sterilisation treatment markets (COT). The estimations of volumes were incorporated to determine the estimated COT markets with the EU extra volumes if protocols do impose cold sterilisation treatment. Detailed calculations is shown in APPENDIX G of the summary of the following graph depicting the extra COT volumes per variety expected in 2020:

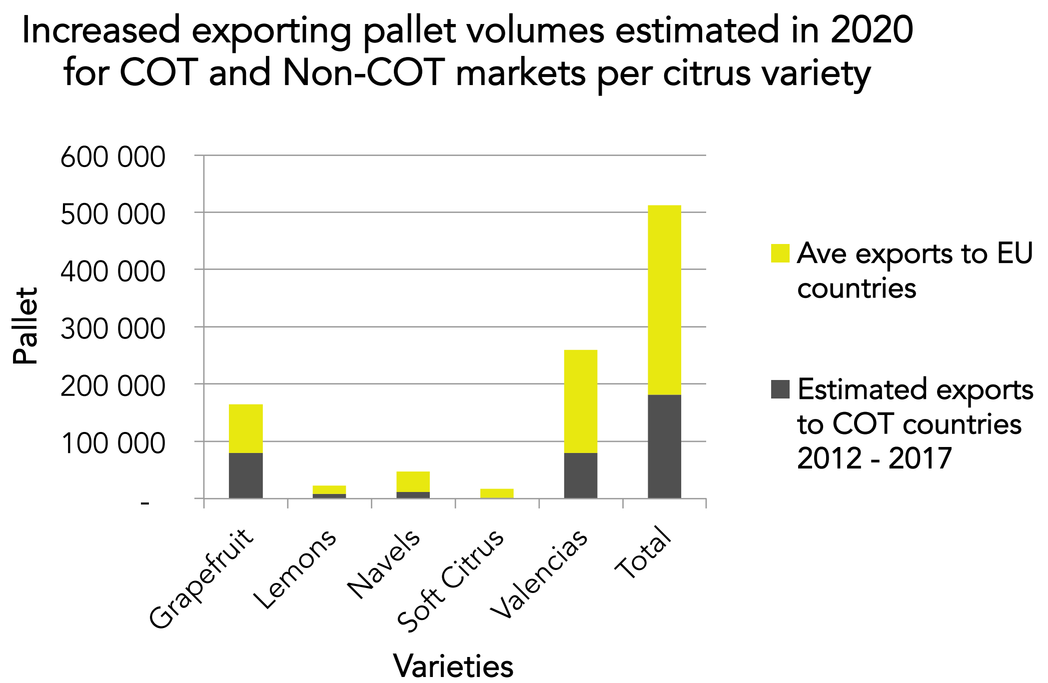


Figure 17 Graph illustrates the cold treatment volumes in yellow per variety type of the European Union exports pallets that will increase

3.4 METHOD STUDY TO DETERMINE CURRENT CAPACITY

The implementation of a method study was applied with each cold room visit. This was to identify the operations and capacities of six cold storages of which five was operated currently as citrus cold stores. The cold storage operations are in retrospect very similar just with different layouts, technology and systems of management preference, but the main operations is comparable.

3.4.1 FACILITY PLANNING CASE STUDIES

3.4.1.1 IDUBE COLD STORAGE

This cold storage facility is situated in the industrial zoned area next to King Shaka International Airport in Kwa-Zulu Natal. This cold storage is fairly new in operation since May 2017 with state of the art equipment but it only cater for imported frozen meats and goods at this moment. The facility has the capacity and ability to accommodate citrus fruits of South Africa, although with the small loading bay, not adequate truck queuing space and offloading flow is it almost impossible to facilitate citrus fruit due to the truck-load volumes that arrive from the pack-houses daily at some volumes of 80 per day.

Figure 18 iDube Cold storage facility

3.4.1.2 FPT

This is the largest cold room facility that is located at the Durban Port next to a loading bay with uncommon large floor space available. They have 17 000 pallet capacity of which 10 000 pallets is precooling capacity, 5000 forced air-cooling for cold sterilisation and 2000 ambient storage pallet capacity. They have ample space for trucks to deliver their fruit from the farm and load the reefer containers. The design of the facility has a great flow of truck turning area and do have land space available to convert their warehouse into more cold room facilities. FPT is also close by to the Port Terminal and have access to load non-perishable cargo next to their warehouse.

Figure 19 FPT Durban Cold storage facility

3.4.1.3 PRECOOL COLD STORAGE

Precool Cold Storage is situated in an industrial area on the outskirts of Durban approximately 55km from Durban harbour. This cold-room facility is newly build with new equipment and only takes in Zimbabwe fruit to quarantine them from the South African fruit. Zimbabwe has a phytosanitary difficulty and is not accredited as a bactrocera-free zone to export fruit from. This cold room facility has ample space available. They can accommodate 1750 pallet slots of which 1300 is for precooling pallets, 200 are forced air-cooling pallets and 250 are ambient storage pallet capacity. They have enough space for trucks to queue, offload, load and turn to get around. They average about two truckloads turnaround into the Port Terminal and are under construction for expansions of extra cold room facilities for different uses.

Figure 20 Precool Cold Storage facility

3.4.1.4 MAYDEN WHARF PORT TERMINAL (MFT)

This cold-room facility is situated at the Durban harbour next to a loading bay. It has two facilities that can accommodate 11500 pallets of which 4500 is precooling, 6000 are forced air-cooling and 1000 is ambient storage pallet capacity. It has an open environment cold store where fruit is unloaded from the farm trucks. MFT has an ideal location with close proximity to Transnet Port Terminal.

Figure 21 Mayden Wharf Port Terminal (MFT) facility

3.4.1.5 ETHEKWINI

Ethekwini cold storage is nearby the Durban Port between many other industrial operated buildings doing exporting type of consignments. The facility has 7980 pallet capacity of which 7000 is precooling and 980 forced air-cooling pallet capacity to accommodate different citrus fruit varieties. The flow of trucks in and out is not as ideal as it should be and if the truckloads are received in its peak time, the congestion they make in Durban's traffic is an immense problem. This facility is also restricted with space and don't have surrounded area to expand their current cold room facilities.

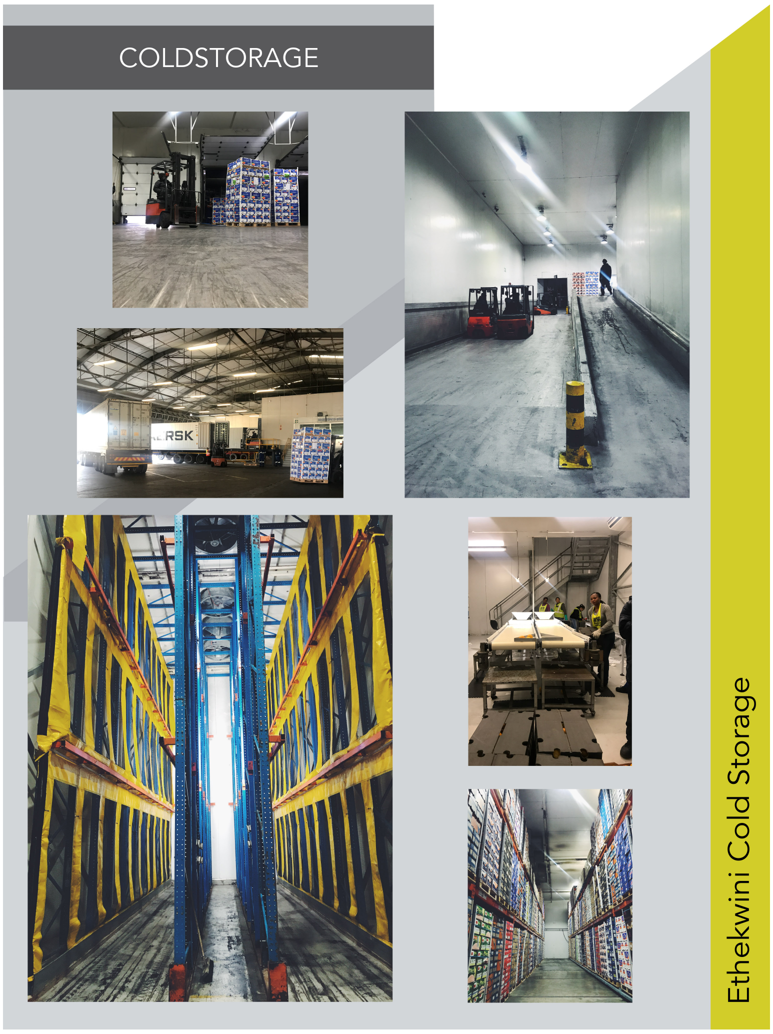


Figure 22 Ethekwini Cold Storage facility

3.4.1.6 GO CHILL COLD STORAGE

This storage facility is on the outskirts about 22km from Durban Port in a newly developed industrial area with no congestion of the inner city (Go Global Group, 2017). They have a new modern facility with up to date storage equipment such as a modern racking and electronic pallet tracking system. The facility has 6420 pallet slots that are 4500 precooling pallet, 920 forced air-cooling and 1000 ambient storage pallet capacity available. The surrounding area is a newly developed industrial zone and improvements with the landscape are recommended to emphasize the dust driven in by the truckloads with every deliver. The facility itself is in impeccable condition with up to date equipment for operation. The surrounding area is adequate to develop further into any cold-room type of facilities, ample space. The truck load and off-loading is happening smoothly, although such as any of the other storages if the farm trucks arrive at peak-time it do develop a congestion in the traffic of the industrial area with one entrance.

Figure 23 Go Chill Cold Storage

4. EVALUATE THE CAPACITY

The following data has been gathered by the case studies and the data of the CGA to determine the current eleven cold storage capacities of ambient, pre-cooling and forced-air cooling facilities inTable 5. These data is used with each cold storage and dwell time to calculate the weekly pallet throughput and annual container pallet packing rate that are shown in **APPENDIX H**:

Table 5 Summary of cold storage pallet capacity in Durban region (Brooke, 2017).

DURBAN SOUTH COLD STORAGE CAPACITY					
	COLDSTORAGES	PRECOOLING PALLET CAPACITY	FORCED AIR COOLING PALLET CAPACITY	AMBIENT STORAGE PALLET CAPACITY	TOTAL PALLET CAPACITY
1	FPT DURBAN	10 000	5 000	2 000	17 000
2	MW FRUIT TERMINAL	4 500	6 000	1 000	11 500
3	SOMERSET COLD STORAGE	2 500	-	-	2 500
4	BAYHEAD COLD STORAGE	1 000	-	-	1 000
5	CCS LOGISTICS COLD STORAGE	1 000	-	-	1 000
6	DURBAN SOUTH COLD STORAGE	4 000	250	-	4 250
7	ETHEKWINI COLD STORAGE	7 000	980	-	7 980
8	GO CHILL COLD STORAGE	4 500	920	1 000	6 420
9	PRECOOL COLD STORAGE	1 300	200	250	1 750
10	TRUCAPE COLD STORAGE	500	-	-	500
11	328ICE COLD STORAGE	2 000	-	250	2 250
	SUBTOTAL CAPACITY	38 300	13 350	4 500	56 150

4.1.1 DETERMINE REQUIRED CAPACITY

A basic model is developed to determine the capacity on a weekly basis of 48 weeks to ensure that the maximum inflow of pallets is adhered to in peak season. Three scenarios are determined with the same model to compare. Each model has two types of data of which is a COT or Non-COT market. **Model 1** is done with the current citrus exports of 2017, **Model 2** is determining the estimated volumes for 2020 and **Model 3** is determining the estimated 2020 volumes plus the extra European Union volumes if it also needs to undergo cold treatment. The data used illustrated in **APPENDIX I** is the total Grapefruit, Lemons, Navels, Soft Citrus and Valencia volumes of each variety per percentage going to a certain market in each week.

4.1.1.1 PROTOTYPE MODEL 1: CURRENT PRODUCTION VOLUMES 2017

The current production volumes for 2017 total that the maximum capacity for Non-COT stock balance is 44 485 and for the total COT stock balance 13 988 pallet slots were used. The following graph show per week the capacity used this year of 2017 in either pre-cooling chambers (Non-COT) or forced air-cooling chambers (COT).

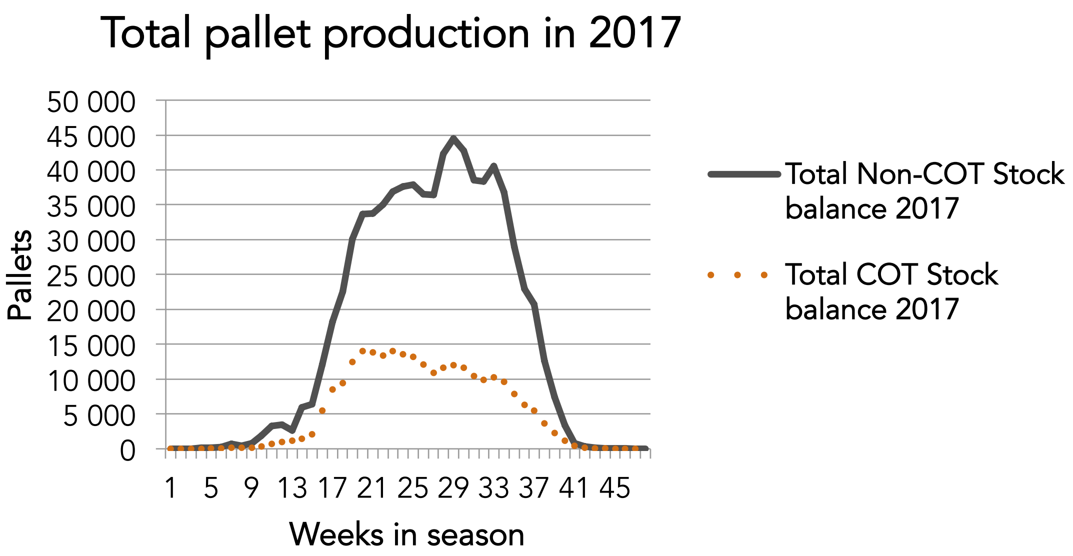


Figure 24 Line graph depicts the total pallets produced in each week according to Non-COT and COT markets. Only a small portion of the export markets currently requires cold treatment.

4.1.1.2 PROTOTYPE MODEL 2: FORCED AIR-COOLING CHAMBERS

The current production estimated for 2020 has a maximum capacity for Non-COT stock balance of 45 543 and for the total COT stock balance 15 404 pallet slots. The following graph show per week the capacity that will be required for the estimated volumes in 2020 in either pre-cooling chambers (Non-COT) or forced air-cooling chambers (COT).

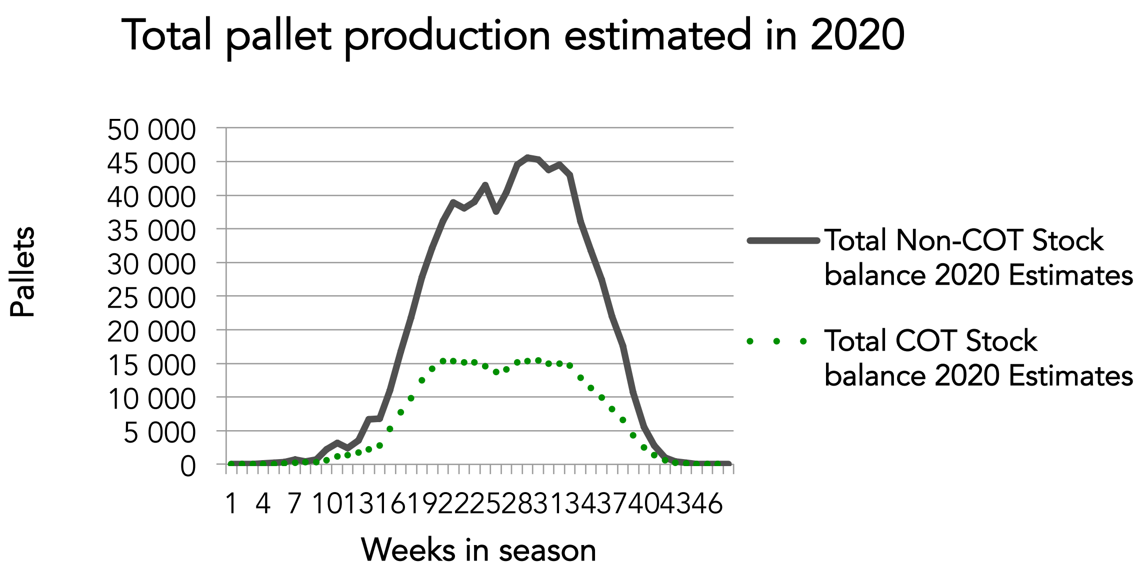


Figure 25 Graph depicts the estimates for 2020 season that is increasing with a normal tendency.

4.1.1.3 PROTOTYPE MODEL 3: EU PROTOCOLS IMPLEMENTED

The current production estimated for 2020 plus the European Union market extra volumes has a maximum capacity for Non-COT stock balance of 22 775 and for the total COT stock balance 43 602 pallet slots. This illustrates the big gap of forced air-cooling chambers that needs to be implemented extra if the EU imposes stricter means.

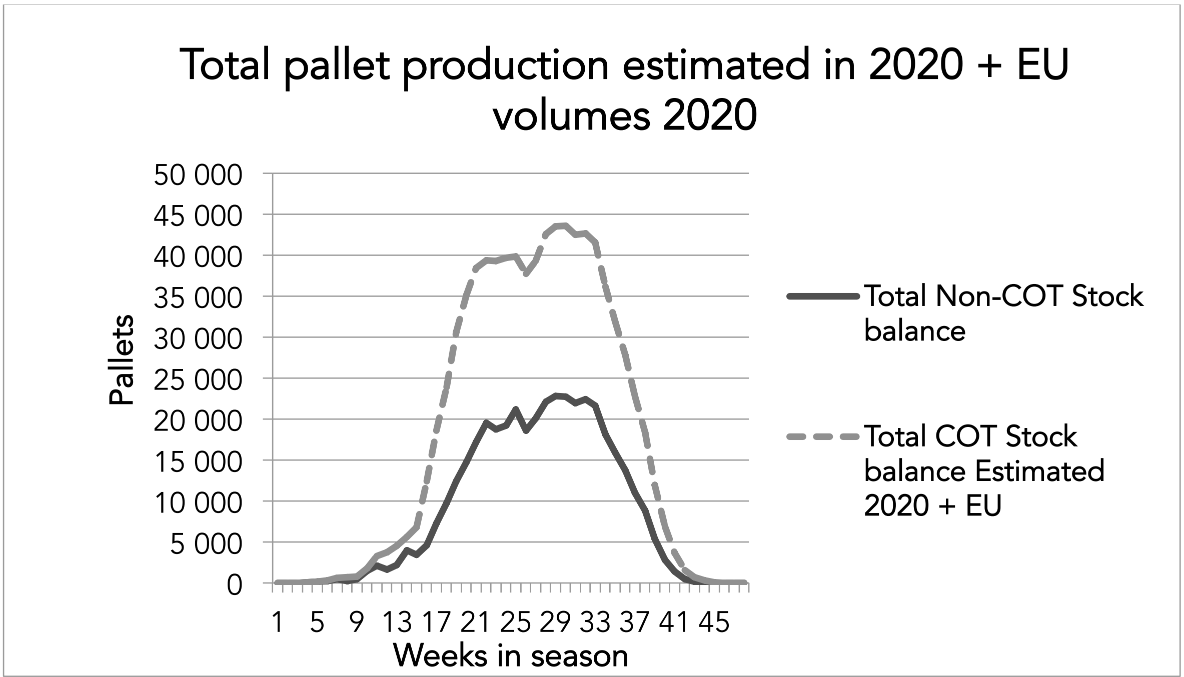


Figure 26 Graph show per week the capacity used that will be required for the estimated volumes in 2020 with the peak of the extra EU volumes for forced air-cooling chambers (COT).

According to the data the forecast for 2020 from this years production is as expected with a moderate degree of growth in next following years. However shown in the following graph is a steep peak in volumes if the European Union exports is also added to the 2020 forecasts. This imply that if the EU volumes needs to undergo cold treatment, the gap will increase from 15 000 pallets to 45 000 pallets cold treatment slots.

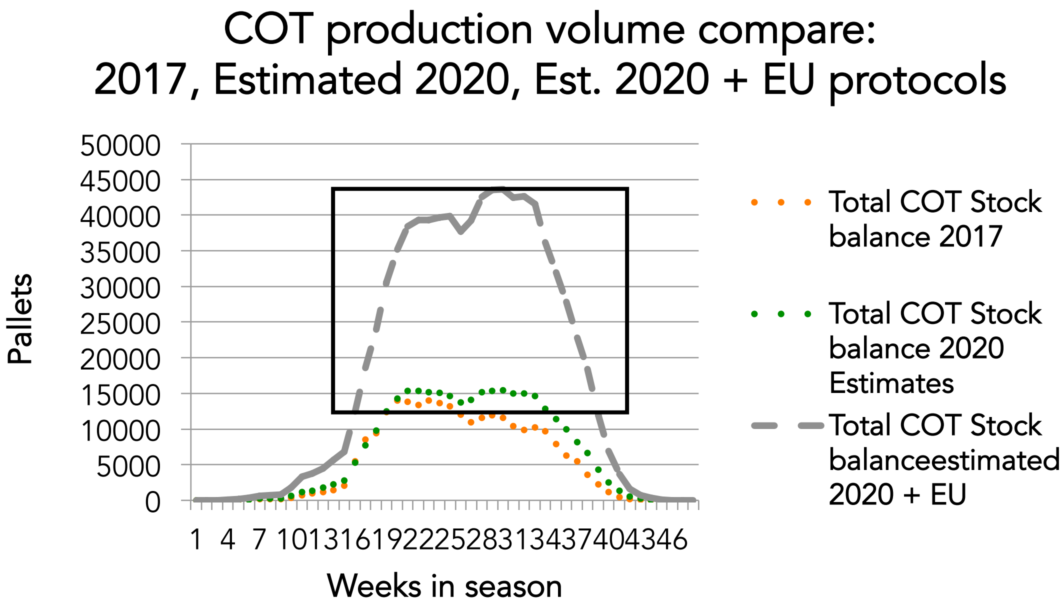


Figure 27 Graph depicts the comparison of the three Models to show the increase in the estimates for the 2020 volumes with the European volumes added. The black block indicates that the Durban Port Terminal will require 30 000 extra pallet slots of forced air cooling plug-in points to accommodate this peak volumes.

According to this values of the capacity calculations the following pallet slots are determined if the European Union's extra volumes needs to undergo special cold sterilisation treatment. This would be extra volumes and increase the capacity for forced air-cooling chambers shown in Table 6:

Table 6 Maximum citrus produced per pallets (weekly)

MAXIMUM PALLET CAPACITY PER WEEK						
	DEMAND Current pallet capacity	MAX capacity cold storages could accommodated in 2017	DEMAND MAX capacity Estimated in 2020	GAP Required capacity for 2020	DEMAND MAX Estimated in 2020 + EU volumes	GAP Required capacity 2020 + EU
Pre-cooling (Non-COT)	38300	44485	45543	1085	22775	- 21710

Forced air-cooling (COT)	13350	13988	15404	1416	43602	29614

The first column shows the current capacity in operation in this citrus season of 2017. Comparing this column with second column, the maximum capacity accommodated in this season of 2017 is shown that the cold storage already operate at more than full capacity with 24 hour shifts and extra management to accommodate the extra volumes from this year only. The required capacity in 2020 is normal growth with a gap of the size on average of one cold storage. However the gap calculated with the extra European Union volumes in 2020 is something to reckon with. The tendency of any new cold storage construction would be to focus on implementing forced air-cooling pallet capacity to be prepared in advance if any regulations may be implemented by the EU. The demand for forced-air cooling facilities is calculated about 29 614 pallet slots.

4.2 COST

The cost evaluated would be to determine the cost to implement forced-air cooling facilities by either converting current cold rooms or build new cold storages. The cost per carton is also calculated to establish the extra cost involved if all the European Union's fruit need to undergo cold-sterilisation treatment.

4.2.1 EVALUATING THE FACILITY COST REQUIRED

The costs are calculated with the use of the current capacity noted earlier of these two different facilities types available. To keep costs as low as possible, current facilities should convert their pre-cooling or extra ambient space in facility to forced-air cooling facilities. This however will eliminate the pre-cooling chambers and be added to the forced-air cooling capacity. An approximate cost in the industry for forced-air cooling has been used to convert these facilities at ±R12000/slot or build new forced-air cooling facilities at ±R17500/slot. All these current facilities are not able to expand due to congestion in the Durban CBD and no available land space. According to calculations a lot more needs to be build outside Durban in an Industrial zoned area according to the required pallet slots. To incorporate the capacity of all eleven cold storages and eliminating the type of facility they will use for conversion is a summary shown in the following Table 7. A thorough calculation between conversion and building facilities is shown in APPENDIX J. It is evaluated that it will cost R39 000 000.00 to covert facilities and R87 500 000.00 to build new facilities at current facilities with available space. With the demand of 43 602 pallets and a gap of 23 122 pallet slots extra needs to be implemented at new allocated zoned areas. To build these new cold-sterilisation facilities it is calculated that it will cost R404 629 915.00. In totality if the EU imposes stricter means it will cost the South African Industry a great amount of R531 129 915.00 to accommodate the expected citrus fruit in 2020.

Table 7 The cost involved to implement extra forced-air cooling facilities

SUMMARY OF DURBAN COLD STORAGE FACILITIES	PALLETS	COST
Cost of forced air cooling conversion (±R12,000 / slot) at current facilities.	3250	R39 000 000
Cost of forced air cooling new build (±R17,500 / slot) at current facilities.	5000	R87 500 000
Total cost of converting or building forced air cooling at current facilities		R126 500 000
Current forced air and ability to convert in total to forced air pallet capacity	20480	
DEMAND REQUIRED COT FORCED AIR COOLING CAPACITY IN DURBAN FOR COT SHIPPING TO EU + OTHER COUNTRIES	43 602	
GAP REQUIRED NEW FORCED AIR COOLING PALLET CAPACITY (~R17,500 / SLOT)	23 122	R404 629 915
TOTAL COST OF REQUIRED FACILITIES IN DURBAN TO BE ABLE TO DO COT SHIPMENTS TO EU IN ADDITION TO OTHER COT SHIPMENTS		R531 129 915

4.2.2 TRADE-OFF ANALYSIS: COST PER CARTON

A trade-off between the cost per carton for Non-COT and COT market is calculated. The cost is illustrated in Table 8 that will accumulate if fruit needs to undergo cold sterilisation treatment. The cost extra will involve an extra DAF Phyto Inspection, more than double the increase for forced-air pre-cooling at the cold store, additional PPECB COT Container Inspection fee, an increase in PPECB container shipping fee and extra Seafreight charges. This will accumulate to an increase of R29 246.00 per container that will be an extra R18.28 per carton. According to the forecasted pallets of 355 000 a total additional estimated cost for the Northern Regions to ship COT to EU will estimate about R519 116 500.00 per annum.

Table 8 Depicts the increase per carton for all export to the European Union

TRADE-OFF ANLYSIS ESTIMATED LOGISTIC EXPORT COSTS FOR CITRUS FROM NORTHERN REGIONS TO EU AS COLD TREATMENT (COT)			
Cost per Container (20 Pallets per Container)	Cost Structure for NON COT Shipment to EU / UK	Cost Structure for COT Shipment to EU / UK	Notes
DAFF Phyto Inspection Fee	N/A	R1 000	Cost based on DAFF charge per consignment for phyto inspections
Cold Store Pre Cooling (COT to -0.6degC)	R6 000	R13 500	Cost based on comparison of non COT shipments and COT shipments
PPECB COT Container Inspection Fee		R81	PPECB additional charge for COT probe calibration
PPECB Container Shipping Fee	R451	R866	PPECB charge per container shipped in port
Seafreight Charge (ZAR13.50/USD)	R67 500	R87 750	Cost based on USD5,000 plus USD1,500 additional for COT shipment per container
Total Cost Comparison (Cost per Container)	R73 951	R103 197	Total cost of differential
Total Cost Comparison (Cost per Container*)	R29 246,00		
Total Cost Comparison (Cost per Pallet)	R1 462,30		
Total Cost Comparison (Cost per Carton)	**R18,28**		
No. of Pallets Forecast to be Exported from the Northern Region to EU in 2020	355 000		
Total Add. Estimated Cost to Ship COT to EU/annum	**R519 116 500**		

According to calculation a trade-off between an additional R18, 28 per carton to export to COT markets if the price in the EU will be sufficient to accommodate this increase. If the market price don't adapt, other Non-COT markets needs to be investigated, which are few due to phytosanitary risk across borders. If the price will not adapt to the EU protocols of the imposed, fruit will be send to current COT markets such as Japan, China and the USA with current increased prices per carton to accommodate cold sterilisation treatment overheads. This however may cause an oversupply of fruit at these niche markets, which will ultimately flood the market and generate a drop in price.

5. SOLUTION

The purpose of this solution is to determine the cost involved if the European Union does impose stricter measure to do cold sterilisation treatment for the estimated 45% of the South African industries fruit forecasted in 2020. It is concluded that the capacity required for the EU fruit with the current 2020 estimated forecasts that only the Durban Harbour needs 29 614 pallets capacity of forced-air cooling chambers. The cost involved to implement these facilities will be R519 116 500.00 to convert some of the current or construct new cold storages. The following Figure 28 depicts the scales of the current pre-cooling facilities with doughnut shapes and the open empty circles illustrate the extra nine cold storages predicted. This would be the size of approximately 2500 pallet spaces each (±size of a cold storage) that will most probably suite the Industrial Zone at Elangeni, Kwa-Zulu Natal that has space for new industrial development en route to the harbour.

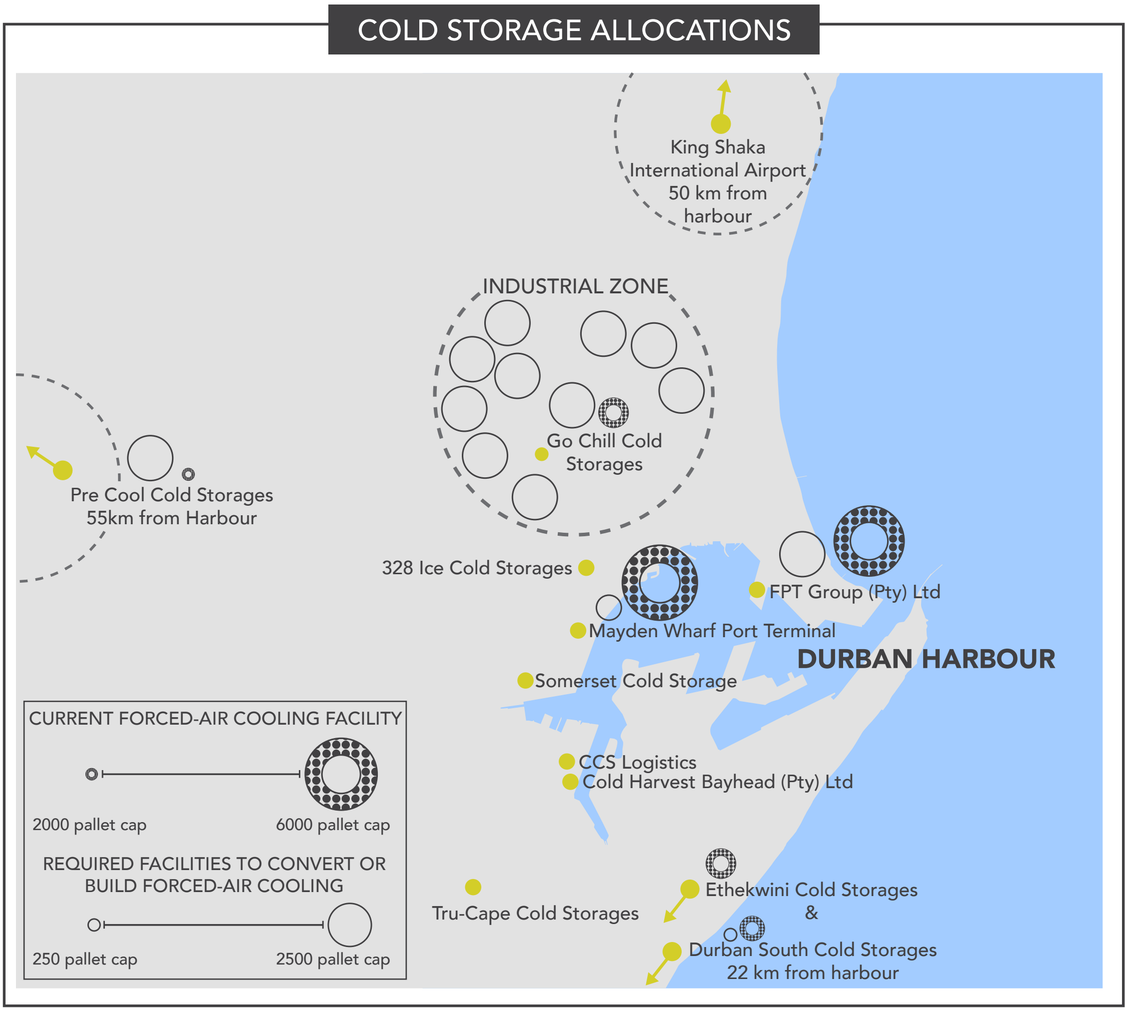


Figure 28 Depicts according to scale the forced-air cooling facilities currently with doughnut shaped circles and the open circles all the facilities that has the capacity to convert to forced-air cooling and the approximate amount that needs to be build extra at the Industrial zoned area outside Durban.

6. SOLUTION VALIDATION

The solution validation to implement these cold storages will be very costly. To get investment for about R519 116 500.00 only for the Durban Harbour will take a lot of discussion towards the Citrus Industry. It will take an investor comfortable with the citrus industry to be ensured of pallet volumes to invest. Currently the cold storage is at a sufficient size and could operate at the peak times, but if the EU protocols will be implemented then these calculations need to be investigated to eliminate the overheads involved. The validation of the demand to implement these forced-air cooling 43 602 pallet slots will not be a viable option to implement due to immense costs involved, although if the European Union do impose cold sterilisation treatment then there is no choice.

7. PROPOSED IMPLEMENTATION

The adequate facility would be to start developing extra cold-room facilities one by one with a focus on forced air-cooling chambers. The markets tend to change all to cold sterilisation protocols and in due future it will be a problem sooner than later. To start building more cold storages slowly but surely will in the long run decrease the gap of facilities that needs to be build extra at once to ensure no extra volume of citrus cartons bottlenecking the whole exporting supply chain.

The implementation and maintenance of these recommended facilities would solely be the responsibility of identified investor to invest in cold storages. This model would need to be updated yearly according to the new planting volumes and the market price of which market the citrus fruit are aiming. Implementing this type of facilities is very costly and private investors needs to be capable to carry the construction and implementation costs to cover a ten/twenty-year lease of most industrial zoned areas.

The maintenance and implementation of this model would need to be used and updated by more accurate forecasts done annually by the Citrus Growers Association to adhere to all the international citrus markets protocols to export to.

8. RECOMMENDATIONS

A recommended option would be for farmers to build their own cold storage facilities on their farm near their packhouse. Inspection of fruit can be done by PPECB on the farm and the cold treatment process can start in reefer containers from the packhouse to go directly to the Durban Port Terminal when the shipping line stack-dates open. The most of the farmers have land space, which is either already paid or inherited. This will ultimately reduce the cost of buying land outside Durban area and have a lease contract of ten to twenty years. This could decrease the cost of implementing these facilities per pallet slot. A possible option could also be to form a partnership with more than one farm/packhouse to build a cold storage together to lessen the burden of the expense on a single entity. To have all these operations close by will make the management easier to control and ensure that fruit consignments cool handling are taken care off as required.

Another possible solution would be to investigate the option to build cold storages near or next to the Tambo-Springs Container Terminal project which invested R118bn until 2012 and aiming for investments of about R300bn for 2019. The project is intended to improve the railway system and eliminate land transport (Stafford, 2017). Congestion is already happening in Durban CBD with trucks arriving daily at a great amount, thus already developing a traffic blockage in the normal Durban roads. Not only are the traffic blocked, but also the turnaround time for trucks to load containers at the empty depot, loading of fruit at the cold-rooms, unloading the containers at the Durban Port Terminal and queuing again for the empty container pick-up. This will be reduced by using rail and the cold sterilisation treatment can start in Springs which will extend the days of treatment if markets is to close by for the amount days the Shipping vessel sail for instance to Europe in 16 days and the USA cold sterilisation protocol states 22 days.

9. CONCLUSION

It is concluded in the duration of this project that the importance of the European Union protocols coming in place and forcing for compulsory measurements is becoming stricter and cold treatment will be the next step. The cold storage capacity will become a problem that the South African citrus industry will be facing. Proper cost analysis needs to be done of zoned areas around Durban and the implementation cost of both pre-cooling and forced air-cooling chambers. The focus would be for forced air-cooling chambers since more markets require cold sterilisation treatment and according to calculations 43 602 pallets slots is demanded by forecasts of 2020 with the European Union extra volumes. This will have an impact of R519 116 500.00 on the South African Citrus Industry to implement more forced-air cooling facilities near Durban Harbour. This would ultimately be the responsibility of the CGA to enlighten the idea to the farmers and it will be a tear point for the farmers to pay for the implementation of these facilities, which will incur extra levies per carton with increased expenditures per carton due to cold sterilisation treatment. A possible solution would be to identify investors to build these facilities on the behalf of the citrus growers, difficulty that might be faced in due future.

The European Union will most certainly implement protocol for cold sterilisation and more markets will start to require these protocols in a matter of time. To a conclusion the best option is to befriend the European Union and ensure them with research done by the Citrus Research International to prevent False Codling Moth of establishing in the EU without the costly cold sterilisation treatment.

This project will ensure that the Citrus Growers Association is prepared in advance if these measures are set in place. If the South African Citrus Industry keeps improving their systems one cold storage at a time to sustain competitive advantage across the globe for many years to come.

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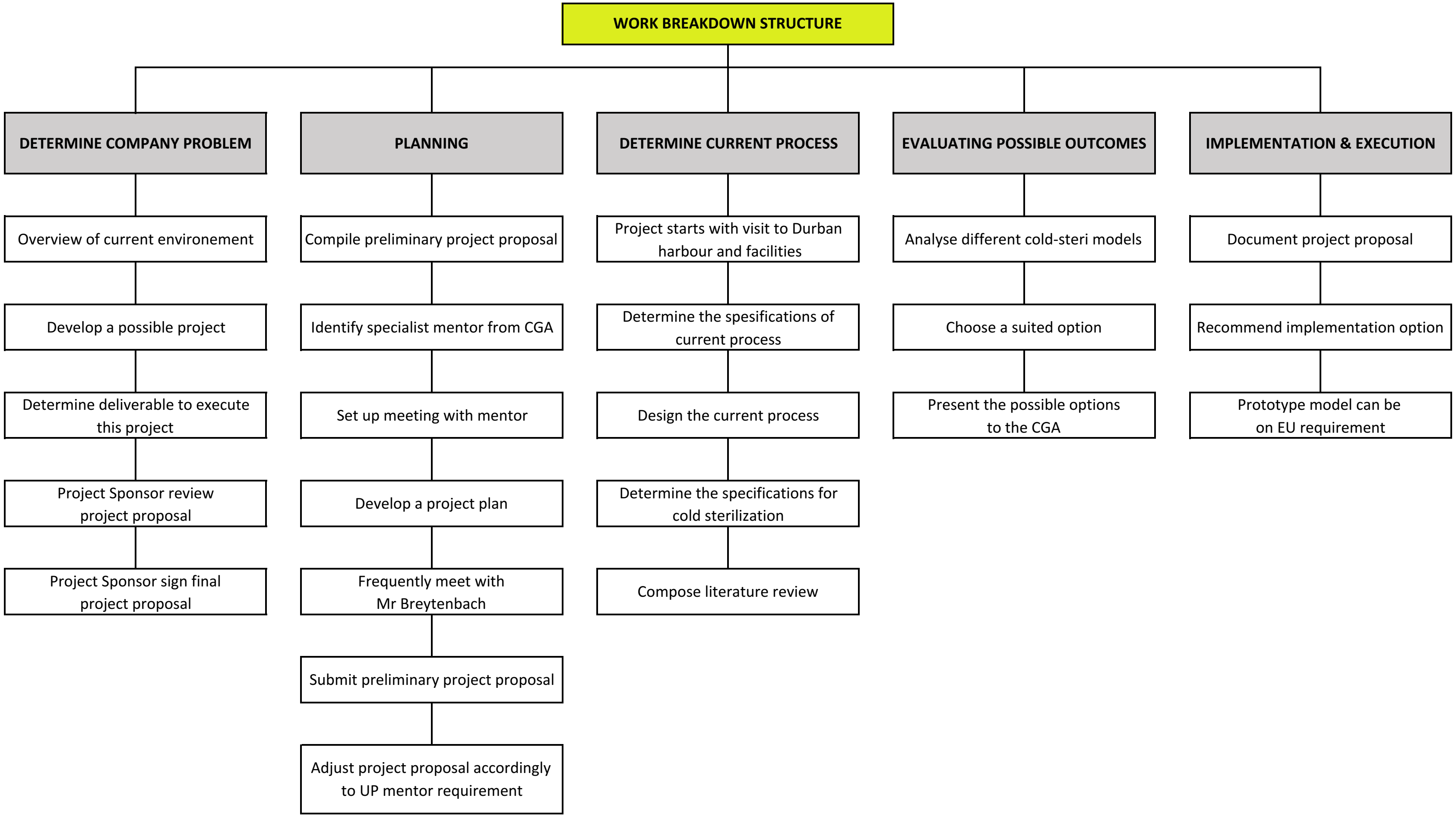
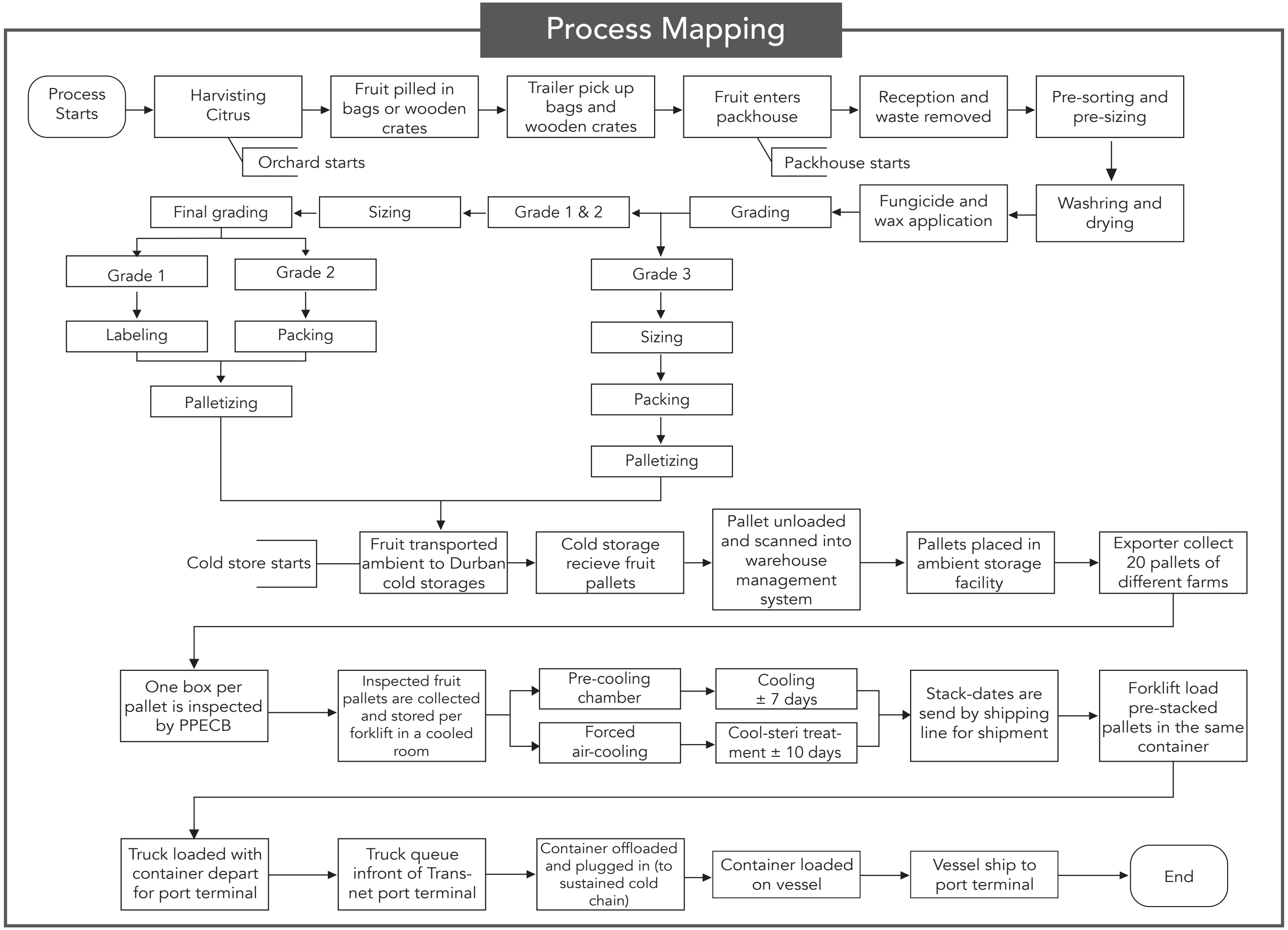
11. APPENDICES

11.1 APPENDIX A – Work Breakdown Structure



11.2 APPENDIX B - Citrus Process Mapping



11.3 APPENDIX C – PPECB: Cold Treatment Container Protocols (Yellow card) (PPECB, 2017)

PPECB — COLD TREATMENT CONTAINER PROTOCOLS

Rev: 64
Date: 12-01-2017

1: Sample fruit to be supplied to the container Depot by Exporter for calibration of empty containers.
2: Landbase- or intransit cold treament, refer import Permit.
3. Different set point temperature regime codes can be selected from the Handling Protocol HP22/PP04.04-17.

- # In the case of Sri Lanka shipments the import permit number must be indicated on the export notification at time of booking.
- # Fruit pre-cooled to target temperature - guide line, assessors can request up to a 12 hour printout.
- # Genset requirrement - Less than 2 hours travel time, shipping line recommendation.
- # Ensure that the ventilation is set correct for Plums, Persimmons and mixed (ventilated and non ventilated) commodities. Use the "**SDV**" code.
- # Recommended cold store delivery air not colder than -1.5°C, and pulp temperature for pome fruit not colder than -1.5°C, the rest -1.2°C.
- # **AMENDMENTS TO PERMITS DURING THE SEASON WILL OVERRIDE THE COLD TREATMENT YELLOW CARD**
  PLEASE ADVISE DAFF and PPECB WITH REGARDS TO ANY AMENDMENTS
- # ***In the case of Permit countries with different protocol options, the required protocol must be indicate on the export notification at time of booking, if not indicated, the coldest protocol will be used as a default.***

COUNTRY	FRUIT	RECOMENDATION SET POINT (°C) 3	PROBES	VENT SETTING	PROTOCOL	DAYS	COLD STORE TARGET TEMP.
ALL FRUIT MUST BE PRE-COOLED FOR A MINIMUM OF 72 HOURS BUT FOR USDA THE LAST 24 HOURS THE PRODUCT MUST BE ON PROTOCOL TEMPERATURE							
USA	T107-a Apples, Pears	-1.3(SD3)	3 Onboard	CLOSED	1.1	14	-0.5
"	T107-e Table Grapes, Nectarines, Peaches & Plums	-1.5(SD1)	"	CLOSED	-0.55	22	-0.6
"	T107-e Citrus	-1.5(SC1)	"	15	-0.55	22	-0.6
"	*T107-e Citrus - Houston Texas*	-1.5(SC1)	"	15	-0.55	22	-0.6
ALL FRUIT MUST BE PRE-COOLED FOR 72 HOURS TO THE TARGET TEMPERATURE							
JAPAN	Oranges, Grapefruit & Lemons	-1.5(SC1)	3 Onboard	15	0.0	12	-0.6
"	Clementine		"		0.0	14	
"	Table Grapes (Barlinka)	-0.5(SD2)	"	Closed	0.8	16	-0.5
S / KOREA	Oranges, Grapefruit & Lemons	-1.5(SC1)	3 Onboard	15	-0.6 ± 0.6	24	-0.6
CHINA	Oranges, Grapefruit, Lemons & Mandarins	-1.5(SC1)	3 Onboard	15	-0.6	24	-0.6
"	Table Grapes	-1.0(SD4)	"	CLOSED	0.8	20	-0.5
"	Apples	-0.5(SD2)	"		1.0	16	-0.5
1. ISRAEL	Table Grapes	-1.5(SD1)	3 Onboard	CLOSED	-0.6	22	-0.6
"	Persimons	-1.0(SDV4)	"	15			
THAILAND	Oranges, Grapefruit, Lemons & Mandrins	-1.5(SC1)	3 Onboard	15	-0.55	24	-0.6
"	Table Grapes	-1.5(SD1)	"	CLOSED		22	
ALL FRUIT MUST BE PRE-COOLED TO THE TARGET TEMPERATURE							
INDIA	Plums	-0,50(SL1)	Landbased: 3x probes in Cold Store	15	0.0 0.55 1.1	10 11 12	Apply the same cold store method as for Nigeria
"	Apples, Pears and Table Grapes	"	"	CLOSED	"	"	"
"	Oranges, Grapefruit, Lemons & Mandarins	"	"	15	"	"	"
INDONESIA	Table Grapes	-0.5(SD2)	3 Onboard	CLOSED	2 3	14 16	0.0
"	Apples, Pears, Peaches, Plums & Apricots	-0.5(SD2)	"	CLOSED	2 3	16 20	"
"	Oranges, Grapefruit, Lemons & Mandarins	-0.5(SC2)	"	15	2 3	16 18	"
TAIWAN	Apples & Table Grapes	-1.0(SD4)	3 Portable-spear or 3 Onboard	CLOSED	0.0 1.67 3.33	12 14 18	-0.5
"	Oranges, Grapefruit, Lemons & Mandarins	-0.5(SC2)	"	15	0.0 1.67 3.33	12 14 18	"
SRI LANKA	Apples, Pears & Table Grapes	-1.0(SD4)	2 Portables	CLOSED	0.0 0.55 1.1 2.2	14 18 20 22	-0.5
"	Oranges	-0.5(SC2)	"	15	0.0 0.55 1.1 2.2	14 18 20 22	"
BANGLADESH	Apples & Pears	-1.0(SD4)	2 Portables	CLOSED	0.0	14	-0.5
2 NIGERIA	Apples & Pears	-0.5(SL1), -1.0(SD4)	Landbased: 3x probes in Cold Store or en-route: 3 x portable-spears	CLOSED	-0.5 -0.5	2 5	Cold store temperatures to be in line with required protocol in the case of landbase treatment (SL)
"	Table Grapes	"	"	CLOSED	-0.5	2	"
"	Apples, Pears & Table Grapes	-0.5(SL1), -1.0(SD4)	"	CLOSED	-0.5	3	"
"	Apples, Pears & Table Grapes	-0.5(SL1/SD2)	"	CLOSED	0.0	2	"
"	Apples, Pears & Table Grapes	-0.5(SL1/SD2) -0.5(SL1/SD2) -0.5(SL1/SD2)	"	CLOSED	0.0 2 3	5 10 14	"
"	Lemons	-0.5(SL1) -1.0(SC4) -0.5(SL1/SC2)	"	15	-0.5 -0.5 -0.5 -0.5 0.0	2 5 2 5 2	"
"	Oranges, Grapefruit, Lemons & Mandarins	-0.5(SL1/SC2)	"	15	0.0 2 3	5 10 14	"
MAURITIUS	Apples, Pears & Table Grapes Fruit from BD infected areas	-1.0(SD4)	3 Onboard	CLOSED	0.0 0.56 1.11 1.67 2.2	13 14 18 20 22	-0.5
"	Oranges, Grapefruit, Lemons & Mandarins Fruit from BD infected areas	-1.0(SC4)	"	15	0.0 0.56 1.11 1.67 2.2	13 14 18 20 22	"
JORDAN	Apples & Table Grapes	-0.5(SD2)	2 Portables	CLOSED	1.5	14	0.0
"	Plums & Persimmons	-0.5(SDV2)	"	15	1.5	14	"
"	Pears	-0.5(SD2)	"	CLOSED	1.5	40	"
"	Oranges, Lemons & Mandarins	0.5(SC5)	"	15	2.0	14	"
GHANA	Apples & Pears	-0.5(SD2)	3 Portable-spear or 3 Onboard	CLOSED	1.11 2.22	14 18	0.0
SUDAN	Oranges	-0.5(SC2)	3 Portable-spear or 3 Onboard	15	1.6	5	0.0
ZAMBIA	Apples & Pears	-0.5(D05)	3 Probes in Cold Store		0.0	12 RRMT	-0.5
Cold treatment is not compulsory - refer to import permit							
MADAGASCAR	Apples, Pears & Table Grapes	-1.0(SD4)	2 Portables	CLOSED	0.0	5 land + 15 en-route	-0.5
"	Oranges, Lemons, Kiwifruit	-1.0(SC4)	"	15	"	"	"

11.4 APPENDIX D – Citrus Production of South Africa in the Northern Regions

Southern Africa Citrus Production for Export (15kg Carton Equivalent)											
Supplier Region	Product	2012	2013	2014	2015	2016	2017 Estimates rev: week 31	2020 Growth Potential	3 Year Average 2014-2016	% Growth - 3 Year ave. vs Growth Potential
Northern Region to Durban Port (Incl. Zimbabwe & Swaziland)	Grapefruit	13 500 000	12 000 000	14 400 000	15 000 000	12 150 000	13 700 000	14 000 000	13 850 000	1%
	Lemons	2 806 932	3 456 017	4 381 776	4 505 160	5 040 460	6 300 000	8 000 000	4 642 465	72%
	Navels	7 721 863	9 182 069	7 736 184	7 668 799	8 299 139	8 500 000	10 000 000	7 901 374	27%
	Soft Citrus	1 020 412	1 618 432	1 567 189	1 893 509	2 131 174	3 100 000	4 000 000	1 863 957	115%
	Valencias	33 500 000	37 200 000	35 600 000	36 700 000	28 500 000	36 200 000	38 000 000	33 600 000	13%
	Total	**58 549 207**	**63 456 518**	**63 685 149**	**65 767 468**	**56 120 773**	**67 800 000**	**74 000 000**	**61 857 797**	**20%**

2) Northern Regions Citrus Exports from Durban Port (Incl. Zimbabwe & Swaziland) (Pallets)	Product Category	2012	2013	2014	2015	2016	*2017 Estimates*	2020 Growth Potential	3 Year Average 2014-2016	% Growth - 3 Year ave. vs Growth Potential
	Grapefruit	153 052	228 324	195 084	206 217	178 086	*185 000*	188 000	193 129	-3%
	Lemons	36 042	43 949	54 775	55 582	62 409	*85 000*	95 000	57 589	65%
	Oranges	499 895	538 196	512 407	532 139	456 476	*540 000*	600 000	500 340	20%
	Soft Citrus	12 022	19 944	19 538	25 450	27 544	*42 000*	50 000	24 177	107%
	Total	**701 010**	**832 304**	**783 660**	**819 388**	**724 516**	***852 000***	**933 000**	**775 855**	**20%**

11.5 APPENDIX E – Bud wood varieties supplied

Total Budwood releases per season (buds)

Year	Mandarin Hybrid	a Experimental Quantities Supplied	Experimental Quantities Supplied	Clementine	Diverse	Grape-fruit	Kumquat	Lemon	Lime	Mid-season	Navel	Orna-mental	Pummelo	Root-stock	Satsuma	Seville	Valencia
2011	657903		5176	86310		58190	10850	741933	25300		533226	1860	650		218060	1000	604920
2012	852311		12222	145154		30320	10100	625580	50020	6185	610327	700	700		58584		751220
2013	1105227	13425		94102	6650	162065	7210	743076	20505	2941	516306		665		47300		646613
2014	1764027			127295	3350	73390	13300	886576	27040	4987	326812		5600		53798		539115
2015	1771657			288775	7055	50440	25210	1767306	13943	5768	406848		4420	240	53197		583487
2016	1983109			379025	3410	90580	12115	2279752	16615	9947	404906		15	586	60317		449852
Grand Total	8134234	13425	17398	1120661	20465	464985	78785	7044223	153423	29828	2798425	2560	12050	826	491256	1000	3575207

11.6 APPENDIX F – Market destinations 2020

Market Destination	2012	2013	2014	2015	2016	2017	Projection 2020
NWC - EU / UK	231 367	276 809	208 369	240 831	237 782	245 000	255 000
Far East/Asia	107 609	110 438	140 186	170 556	153 404	180 000	200 000
Middle East / Iran	106 889	144 598	150 289	166 949	123 409	170 000	180 000
Russia	89 857	122 313	118 787	88 354	77 082	100 000	120 000
South EU / MED	67 462	68 552	60 651	56 086	59 282	70 000	72 000
Japan	60 853	62 597	60 558	55 474	39 183	46 285	47 500
Canada / USA	18 966	28 725	25 008	24 204	17 667	30 000	36 000
East EU/Black Sea	14 129	12 818	13 499	11 385	12 006	12 000	15 000
Other	3 878	5 455	6 313	5 870	4 819	5 000	7 500
Grand Total	**701 010**	**832 304**	**783 660**	**819 709**	**724 634**	**858 285**	**933 000**

11.7 APPENDIX G – Carton volumes exported to COT and Non-COT markets

Commodity	Total avg exports 2012 - 2017	Estimated exports to COT countries	% Exported to COT countries	Ave exports to EU countries	% Exported to EU	Ave exports to COT markets + EU countries	% Ave exports to COT markets + EU countries
Grapefruit	200000	80000	0,4	85000	0,425	165000	0,825
Lemons	70000	8000	0,114285714	15000	0,214285714	23000	0,328571429
Navels	100000	12000	0,12	35000	0,35	47000	0,47
Soft Citrus	30000	2000	0,066666667	15000	0,5	17000	0,566666667
Valencia	420000	80000	0,19047619	180000	0,428571429	260000	0,619047619
Total	820000	182000	0,22195122	330000	0,402439024	512000	0,624390244

Commodity	Estimated 2020	Ave exports to COT countries	Estimated % Exported to COT countries	Estimated Ave exports to EU countries	Estimated % Exported to EU	Estimated Ave exports to COT markets + EU countries	Estimated % Ave exports to COT markets + EU countries
Grapefruit	200000	90000	0,45	85000	0,425	175000	0,875
Lemons	95000	16000	0,168421053	25000	0,263157895	41000	0,431578947
Navels	125000	15000	0,12	37500	0,3	52500	0,42
Soft Citrus	50000	5000	0,1	25000	0,5	30000	0,6
Valencias	460000	100000	0,217391304	182500	0,39673913	282500	0,614130435
Total	930000	226000	0,243010753	355000	0,38172043	581000	0,624731183

11.8 APPENDIX H – Durban Cold Storage Capacity

	DURBAN SOUTH COLD STORAGE CAPACITY							
	COLDSTORAGES	PRECOOLING PALLET CAPACITY	FORCED AIR COOLING PALLET CAPACITY	AMBIENT STORAGE PALLET CAPACITY	TOTAL PALLET CAPACITY	WEEKLY PRECOOLING PALLET THROUGHPUT (10 DAY DWELL)	WEEKLY FORCED AIR COOLING PALLET THROUGHPUT (14 DAY DWELL)	TOTAL WEEKLY PALLET THROUGHPUT
1	FPT DURBAN	10 000	5 000	2 000	17 000	7 000	2 500	9 500
2	MW FRUIT TERMINAL	4 500	6 000	1 000	11 500	3 150	3 000	6 150
3	SOMERSET COLD STORAGE	2 500	-	-	2 500	1 750	-	1 750
4	BAYHEAD COLD STORAGE	1 000	-	-	1 000	700	-	700
5	CCS LOGISTICS COLD STORAGE	1 000	-	-	1 000	700	-	700
6	DURBAN SOUTH COLD STORAGE	4 000	250	-	4 250	2 800	125	2 925
7	ETHEKWINI COLD STORAGE	7 000	980	-	7 980	4 900	490	5 390
8	GO CHILL COLD STORAGE	4 500	920	1 000	6 420	3 150	460	3 610
9	PRECOOL COLD STORAGE	1 300	200	250	1 750	910	100	1 010
10	TRUCAPE COLD STORAGE	500	-	-	500	350	-	350
11	328ICE COLD STORAGE	2 000	-	250	2 250	1 400	-	1 400
	SUBTOTAL CAPACITY	38 300	13 350	4 500	56 150	26 810	6 675	33 485

DURBAN SOUTH COLD STORAGE CAPACITY

	COLDSTORAGES	ANNUAL ESTIMATED PRECOOLING PALLET VOLUME (10 DAY DWELL)	ANNUAL ESTIMATED FORCED AIR COOLING PALLET HANDLING (14 DAY DWELL)	TOTAL ESTIMATED ANNUAL PALLET HANDLING	DAILY CONTAINER PACKING RATE	DAILY CONTAINER PALLET PACKING RATE	WEEKLY CONTAINER PALLET PACKING RATE	ANNUAL CONTAINER PALLET PACKING RATE
1	FPT DURBAN	168 000	50 000	218 000	80	1 600	11 200	224 000
2	MW FRUIT TERMINAL	77 000	60 000	137 000	60	1 200	8 400	168 000
3	SOMERSET COLD STORAGE	35 000	-	35 000	30	600	4 200	84 000
4	BAYHEAD COLD STORAGE	14 000	-	14 000	20	400	2 800	56 000
5	CCS LOGISTICS COLD STORAGE	14 000	-	14 000	20	400	2 800	56 000
6	DURBAN SOUTH COLD STORAGE	56 000	2 500	58 500	50	1 000	7 000	140 000
7	ETHEKWINI COLD STORAGE	98 000	9 800	107 800	60	1 200	8 400	168 000
8	GO CHILL COLD STORAGE	77 000	9 200	86 200	60	1 200	8 400	168 000
9	PRECOOL COLD STORAGE	21 700	2 000	23 700	50	1 000	7 000	140 000
10	TRUCAPE COLD STORAGE	7 000	-	7 000	20	400	2 800	56 000
11	328ICE COLD STORAGE	31 500	-	31 500	20	400	2 800	56 000
	SUBTOTAL CAPACITY	599 200	133 500	732 700	470	9 400	65 800	1 316 000

11.9 APPENDIX I – Prototype Models forecasted per week

Weeks	MODEL 1		MODEL 2		MODEL 3	
	Total Non-COT Stock balance 2017	Total COT Stock balance 2017	Total Non-COT Stock balance 2020 Estimates	Total COT Stock balance 2020 Estimates	Total Non-COT Stock balance	Total COT Stock balance Estimated 2020 + EU
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	121	15	30	26	86	65
5	190	41	103	71	139	181
6	269	66	190	128	235	323
7	714	137	367	251	507	634
8	440	173	537	288	269	728
9	766	193	628	301	488	772
10	1 860	360	991	656	1 491	1 778
11	3 303	693	1 890	1 208	2 126	3 277
12	3 444	965	2 900	1 379	1 604	3 748
13	2 652	1 155	3 421	1 751	2 209	4 527
14	5 902	1 470	3 768	2 217	3 968	5 616
15	6 392	2 080	4 438	2 782	3 445	6 804
16	12 103	5 456	8 268	5 287	4 590	12 443
17	18 252	8 514	14 117	7 724	7 287	18 551
18	22 517	9 425	18 055	9 790	9 732	23 925
19	30 059	12 414	22 806	12 473	12 389	30 577
20	33 670	13 976	27 606	14 230	14 739	35 169
21	33 747	13 814	29 374	15 323	17 183	38 387
22	35 056	13 408	29 676	15 339	19 490	39 341
23	36 850	13 988	30 901	15 180	18 766	39 285
24	37 574	13 599	31 877	15 113	19 243	39 652
25	37 882	13 187	32 310	14 616	21 133	39 821
26	36 517	12 066	31 800	13 698	18 602	37 722
27	36 391	10 924	30 691	14 112	20 097	39 268

28	42 333	11 592	32 221	15 183	22 110	42 571
29	44 485	11 964	34 875	15 316	22 775	43 503
30	42 783	11 591	35 567	15 404	22 741	43 602
31	38 550	10 436	33 710	15 002	21 928	42 495
32	38 392	9 898	32 099	14 977	22 379	42 611
33	40 553	10 273	32 664	14 646	21 622	41 570
34	36 761	9 655	32 082	12 835	18 140	36 157
35	28 961	7 872	27 966	11 399	15 967	31 966
36	22 929	6 268	22 694	9 972	13 740	27 823
37	20 709	5 466	19 216	8 191	11 037	22 810
38	12 638	3 627	14 699	6 605	8 826	18 382
39	7 426	2 242	9 496	4 274	5 428	11 944
40	3 403	1 159	5 435	2 468	2 808	6 883
41	809	424	2 460	1 330	1 401	3 701
42	295	161	907	576	491	1 601
43	119	61	342	246	191	684
44	96	32	146	118	102	327
45	68	17	76	35	13	98
46	26	9	39	11	2	29
47	3	3	17	3	0	9
48	0	1	5	1	0	3
49						
MAX CAP-ACITY	**44 485**	**13 988**	**35 567**	**15 404**	**22 775**	**43 602**
AVG CAP-ACITY	16 209	5 226	13 822	6 511	8 573	17 528
STDEV	16842,174	5452,3885	14042,525	6446,72	8793,2	17524

11.10 APPENDIX J – Determining the capacity and cost involved

DURBAN COLD STORAGE COLD STORAGE FACILITIES	PRECOOLING PALLET CAPACITY	FORCED AIR COOLING PALLET CAPACITY	AMENDED PRECOOLING PALLET CAPACITY	ABILITY TO CONVERT IN TOTAL TO FORCED AIR PALLET CAPACITY	CAPACITY TO IMPLEMENT	COST OF FORCED AIR COOLING CONVERSION (~R12,000 / Slot)	COST OF FORCED AIR COOLING NEW BUILD (~R17,500 / Slot)
FPT DURBAN	10 000	5 000	2 500	7 500	2500	R30 000 000	
MW FRUIT TERMINAL	4 500	6 000	4 000	6 500	500	R6 000 000	
SOMERSET COLD STORAGE	2 500	-	2 500				
BAYHEAD COLD STORAGE	1 000	-	1 000				
CCS LOGISTICS COLD STORAGE	1 000	-	1 000				

DURBAN SOUTH COLD STORAGE	4 000	250	3 500	500	250	R3 000 000	
ETHEKWINI COLD STORAGE	7 000	980	7 000	980			
GO CHILL COLD STORAGE	4 500	920	4 500	2 500	2500		R43 750 000
PRECOOL COLD STORAGE	1 300	200	1 500	2 500	2500		R43 750 000
TRUCAPE COLD STORAGE	500	-	500				
328ICE COLD STORAGE	2 000	-	2 000				
SUBTOTAL CAPACITY	38 300	13 350	30000	20480		R126 500 000	
DEMAND REQUIRED COT FORCED AIR COOLING CAPACITY IN DURBAN				43 602 PALLET SLOTS			

FOR COT SHIPPING TO EU + OTHER COUNTRIES		
GAP REQUIRED NEW FORCED AIR COOLING PALLET CAPACITY (~R17,500 / SLOT)	23 122 PALLET SLOTS	R404 629 915
TOTAL COST OF REQUIRED FACILITIES IN DURBAN TO BE ABLE TO DO COT SHIPMENTS TO EU IN ADDITION TO OTHER COT SHIPMENTS	R531 129 915	

11.11 APPENDIX K - Identification and Responsibility of Project Sponsors

Department of Industrial & Systems Engineering
Final Year Projects
Identification and Responsibility of Project Sponsors

All Final Year Projects are published by the University of Pretoria on *UPSpace* and thus freely available on the Internet. These publications portray the quality of education at the University and have the potential of exposing sensitive company information. It is important that both students and company representatives or sponsors are aware of such implications.

Key responsibilities of Project Sponsors:

A project sponsor is the key contact person within the company. This person should thus be able to provide the best guidance to the student on the project. The sponsor is also very likely to gain from the success of the project. The project sponsor has the following important responsibilities:

1. Confirm his/her role as project sponsor, duly authorised by the company. Multiple sponsors can be appointed, but this is not advised. The duly completed form will considered as acceptance of sponsor role.
2. Review and approve the Project Proposal, ensuring that it clearly defines the problem to be investigated by the student and that the project aim, scope, deliverables and approach is acceptable from the company's perspective.
3. Review the Final Project Report (delivered during the second semester), ensuring that information is accurate and that the solution addresses the problems and/or design requirements of the defined project.
4. Acknowledges the intended publication of the Project Report on UP Space.
5. Ensures that any sensitive, confidential information or intellectual property of the company is not disclosed in the Final Project Report.

Project Sponsor Details:

Company:	Citrus Growers Association
Project Description:	Determine a facility solution required to incorporate cold sterilisation in the supply chain of the citrus exported to Europe.
Student Name:	Hesti le Roux
Student number:	10089625
Student Signature:	[signature]
Sponsor Name:	Justin Chadwick, Mitchell Brooke
Designation:	Chief Executive Officer, Logistics Development Manager
E-mail:	mitchell@cga.co.za
Tel No:	+27 82 892 9455
Cell No:	+27 31 765 2514
Fax No:	+27 31 765 8029
Sponsor Signature:	[signature]

11.12 APPENDIX L – TFR Team Citrus Orientation & Grower Road Show

Citrus Growers' Association OF SOUTHERN AFRICA

4th May 2017

<u>Transnet Freight Rail (TFR) Team Citrus Orientation & Grower Road Show 2017</u>

Dear Limpopo Province Citrus Producers and Interested Stakeholders,

Fruit South Africa (FSA) has presented to TFR a rail transport strategy for the fruit export industry. FSA has partnered with TFR to undergo an operational analysis of the strategy to determine the feasibility and viability of the presented strategy. The operational analysis has been categorized into a short term, medium term and long term analysis. The short term analysis has identified that citrus produced in the Limpopo province offers immediate opportunities to increase the transportation of citrus for export by rail.

The CGA has proposed to TFR that we embark on a roadshow for the purpose of providing orientation to the project team as well as to inform producers of the short term, medium term and long term prospects. The CGA will accompany the TFR team on a roadshow from Tuesday 16th May to Thursday 18th May 2017. The following roadshows have been arranged for the CGA and TFR team to present to producers the present and future potential to transport citrus destined for export to ports by rail –

1. Die Raasblaar, Marble Hall at 12:30pm on Tuesday 16th May
   - Directions – https://media.wix.com/ugd/5d6ffa_a18eb54204f74f60a2b87b4ba299b89e.pdf
2. The Tzaneen Country Lodge, Letsitele at 08:30am on Wednesday 17th May
   - Directions – 20Km between Tzaneen CBD and Letsitele on R71.
3. The Musina Hotel and Conference Centre at 10:00am on Thursday 18th May
   - Directions – Corner N1 and Willem Smit Street, Musina.

For more information contact Mitchell Brooke email: mitchell@cga.co.za or cell: 082 892 9455.