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MDES 2015

Rethinking Refrigerated Containment

– a new vision of refrigerated exports

Rethinking Refrigerated
a new vision of refrigera

WILLIAM NICHOLSON MDES

ABSTRACT

This project presents a vision o
New Zealand could work smar
to capitalise on a lucrative glob
opportunity, by offering an alte
to the current logistics and tra
infrastructure of refrigerated e

With the aid of a world-first FTA *(Free-Trade Agreement) (Barber, 2014)*, New Zealand frozen lamb exports to China are rapidly growing *(Meat Industry Association of New Zealand, 2013)*. However, the current transportation and logistical systems used to export this product were developed over 37 years ago *(Chua, 1978)*. With significant growth in the

new, lucrative Chinese mark
in this project comprises a f
shipping container system w
packing modules. The flat-p
increases space efficiency w
and improves security when
product. Internal packing m

Thank you to the Ken & Elizabe
Powell Bursary, Massey's Maste
Scholarship and Tulia Moss for
financial support. Thanks to my
supervisors Tulia Moss, Patricia
and Matthijs Siljee for your fee
support and invaluable insight
a broad range of fields and pe
A special thank you to James A
and Sam McCafferty for your s
time, advice and design exper
Finally, Lauren Wepa for your s

ACKNOWLEDGEMENTS

LIST OF FIGURES (SOURCED)

3. pg.18 Consistent safety systems ensure quality assurance.
odCap. (n.d.). *About FoodCap*. Retrieved from http://www.foodcap.com/about-foodcap/

5. pg.20 Capsules are unloaded directly at domestic supermarket.
odCap. (n.d.). *FoodMove System*. Retrieved from http://www.foodcap.com/foodmove/foodmove-tem/

9. pg. 26 Shipping and its supply chain practices are a EMEX annual exhibition targeting nufactures and exporters.
O Exhibitions. (2014). *XPO Exhibitions*. Retrieved from https://plus.google.com/+XpoCoNz/out

0. pg.28 Minimising future errors changes the thinking to prevention, rather than acceptance of tus quo.
ole. (2015). *Port of Hong Kong, Hong Kong*. Retrieved from http://www.ship-technology.com/jects/portofhongkong/

3. pg. 38 In-efficient use of space in a 40ft reefer.
ersk Line. (2013). *Energy requirement for reefer shipments drops*. Retrieved from http://www.erskline.com/ar-bh/expert-blogs/henrik-lindhardt/energy-requirement-for-reefer-shipments-ps

3. pg.39 Conveyor system lacks innovation solving issues of ergonomics in manual loading tasks.
atExportNZ. (2013). *We have the technology*. Retrieved from http://meatexportnz.co.nz/tag/

5. pg.40 Consequence of unpacking a poorly stabilised shipping container.
nley Insurance. (2014). *Why every business needs a robust BCP*. Retrieved from http://leyinsurance.weebly.com/blog/previous/2

6. pg.40 Product left precariously while 3 workers can take up to 2 hours to unload.
ntic Pacific Fishing (PTY) Ltd. (2013). *Fishing Area & Operations*. Retrieved from http://www.shing.com/fishing-area-operations/

7. pg.41 27.2 kg shipping carton are manually handled and packed.
ntic Pacific Fishing PTY Ltd. (2013). *Fishing Area & Operations*. Retrieved from http://www.shing.com/fishing-area-operations/

8. pg.48 An attempt at stabilising cartons with unsustainable materials.
otain Förster GmbH. (2015). *Refrigerated Containers / Reefer Ships*. Retrieved from http://www.tainfoerster.de/services/refrigerated-containers-reefer-ships/

Figure 31. pg.50 An estimated 10, 000 shipping containers are lost at sea p
Australia Meat & Quality Foods Pty Ltd. (N.D.). *Australia Continues Rob*
Retrieved from http://amqf.com.au/australia-continue-robust-meat-exp

Figure 32. pg.51 20ft container being removed from an inter-modal truck.
Hookers Pacific. (2013). *Shipping Containers*. Retrieved from http://ww
services/containers/.

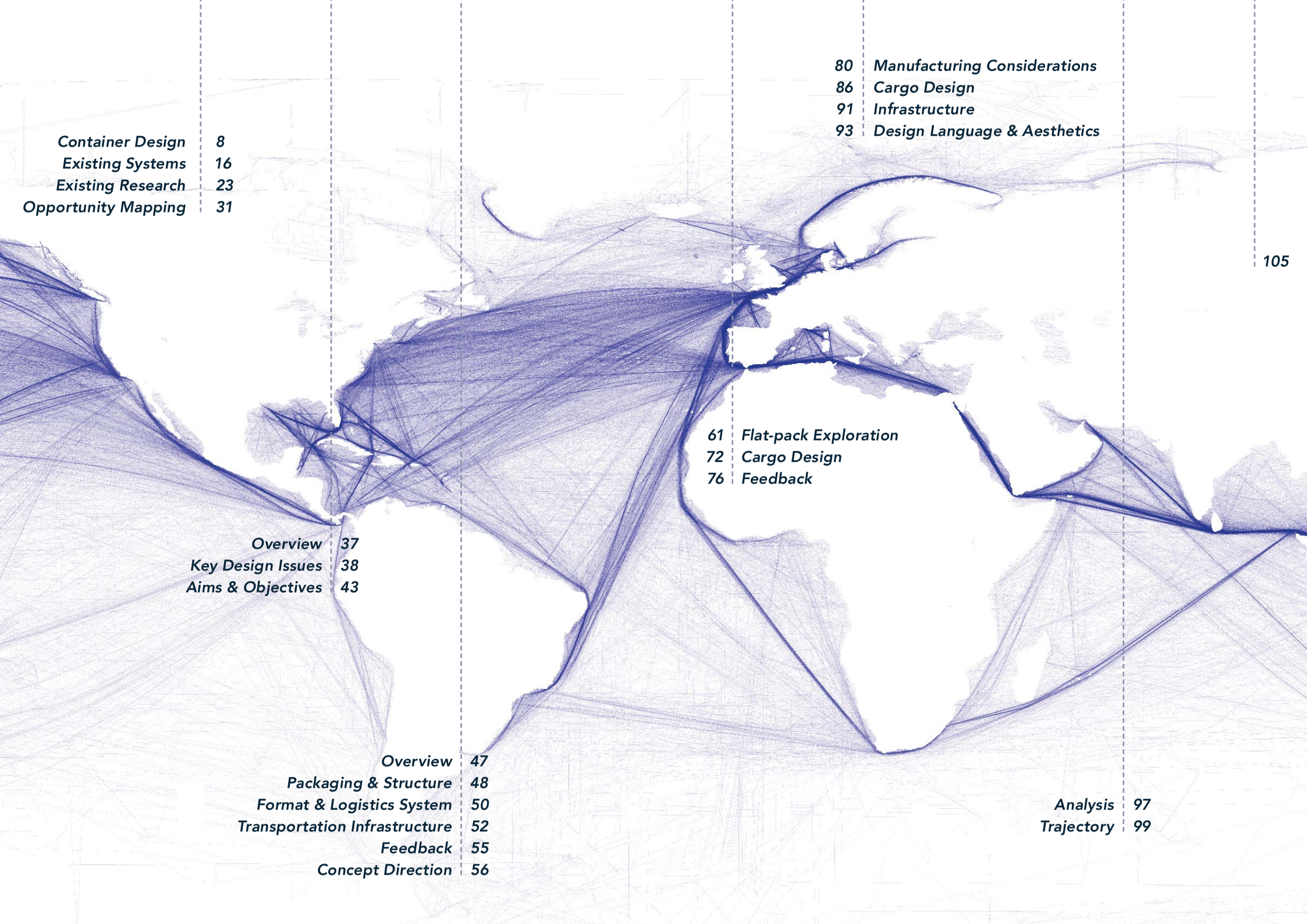
Figure 33. pg.51 Multiple forms of transportation including truck, rail and s
design challenges.
Marine Vessel Traffic. (2015). *Shanghai container terminal*. Retrieved fro
marinevesseltraffic.com/2013/12/shanghai-container-terminal.html

Figure 34. pg.52 Design specific research vessel in use.
Petroleum Geo-Services. (2014). *Ramform Titan Class*. Retrieved from h
Geophysical-Services/Towed-Streamer-Seismic/Ramform-Titan-Class/

Figure 35. pg.53 Ulstein X bow concept claims to directly enhance profitabi
new bow design.
Ulstein. (2007). *Merchant ULSTEIN X-BOW applications*. Retrieved from
/Kunder/ulstein/cms66.nsf/pages/newslista.htm?open&disp_key=bc0c
38b30c&dato_start=294

Figure 36. pg.53 There are many forms of transportation involved with expo
Port of Dover. (2006) *Dover cargo terminal*. Retrieved from http://farm
com/2912/14456104663_2d1ca0b405_m.jpg

LIST OF FIGURES (AUTHORED)



This project is a practice-led d
enquiry, facilitated through site
making, testing, iteration, pres
and engineering consideration
an industrial designer I am a cr
problem-solver who believes t
almost everything can be impr
and refined with a creative pro
solving, design ethos.

The holistic research and creative problem-solving approach that I used was based off three design theories to build a big picture, concept-building design ethos. Firstly, Mark Haffey and Alex Duffy's theory of knowledge discovery in a design environment. Secondly, Jayachandra M. Reddy, Susan Finger, Suresh Konda and Eswaran Subrahmanian Artifact Theory and thirdly, IDEO's design thinking theory.

Understanding the current knowledge available within the industry of global trade is pivotal to a

reflection of a designed obj
M, 2000). IDEO president a
refers to this process as des
centred approach to innova
the designer's toolkit' to br
desirable from a human poi
what is technologically feas
viable' *(IDEO, n.d.)*. I believe
occurs by gathering togeth
number of different but inte

ct I did not intend
to the existing system
evelop a vision of
ion systems used to
rnational markets.
ce carefully visionary
ocols. I chose to
container as it is central
e and a key element
ping container is at the
l and inter-modal
ot in what it is, but in
hly automated
oods anywhere with
ion (Levinson, 2006,
an turned the concept
bal phenomenon

which drastically cut down transportation costs and started the boom of global trade *(Levinson, 2006)*.

New Zealand signed a world-first FTA with China in 2008 *(New Zealand Ministry of Foreign Affairs & Trade, hereafter, MFaT, 2012)*. This has been a remarkable success, increasing New Zealand exports to China from $2.2 billion *(NZD)* in 2008 to $8.6 billion *(NZD)* in 2012 *(Barber, 2014)*. The Chinese economy is increasing at 9.5 percent per annum, the 'fastest-growing' major economy in the world. 'China's middle class is now estimated to be more than 100 million people and growing' *(MFaT, 2004)*. This consumer has more disposable income and is increasingly conscious of high-quality, imported Western food products *(Barber, 2014)*. This is fueling the demand for New Zealand's export food products, especially lamb. Lamb is 'a popular choice' for the middle-class Chinese

d not intend to make
all improvements to the existing
tem but rather re-consider
l develop a vision of the future

HUI

Lamb is 'a popular choice' for
class Chinese consumer as it
New Zealand-produced food
fresh and of high quality

consumer as it considers New Zealand-produced food to be both fresh and of high quality *(Hui, 2014)*. Barber argues that 'preferential access', such as a FTA, to this market has the potential to deliver significant, additional gains to our New Zealand exporters *(2014)*.

Hui identified New Zealand as a country situated a long way from its markets. New Zealand has fierce competition with other food-producing and exporting countries which are less geographically isolated. But isolation is not its only global-trade problem. On 17 November 2014 Australia signed an FTA with China, aiming to 'unlock substantial new benefits for Australians for years to come' *(Australian Government Department of Foreign Affairs and Trade, 2014)*. It is unclear at this stage how this FTA will affect New Zealand's export industry, however it has put New Zealand into direct competition with Australia with tariffs on export meat equal to New Zealand *(HSBC, 2014;& Aussies claim they have better China FTA, 2014)*. Beyond this are many other issues of concern to a small exporter such as New Zealand.

Pricewater Cooper's Global Agribusiness Leader Craig Armitage notes that both our government and our global clients constantly face shifts in regulatory regimes, occasional scarcity of resources and incidences of 'food fraud'. The cost pressures that these produce increase risk along the entire supply chain. Food safety for local and imported food is of

2014). COFCO, China's bigg
and agriculture supplier cha
New Zealand has a respons
China can trust its food safe
among the issues that sugg
needs to be the efficiency l
the supply chain to create a
edge *(Hui, 2014)*. Now is the
at ways of addressing some
New Zealand meeting the c
export market.

Throughout this projec
current research and design
often took the form of site
designs are; TEUN, an auto
for unloading shipping cont
collapsible, space efficient s
Pivotal to these designs are
within. These are the meat
the international shipping p
research contributing to the
designs and systems, such a
institute based in New Zeal
shipping logistics and auton
all these designs, systems a
in some way. My research h
problems in the present shi
and its supporting infrastru

xisting
esigns,
ystems

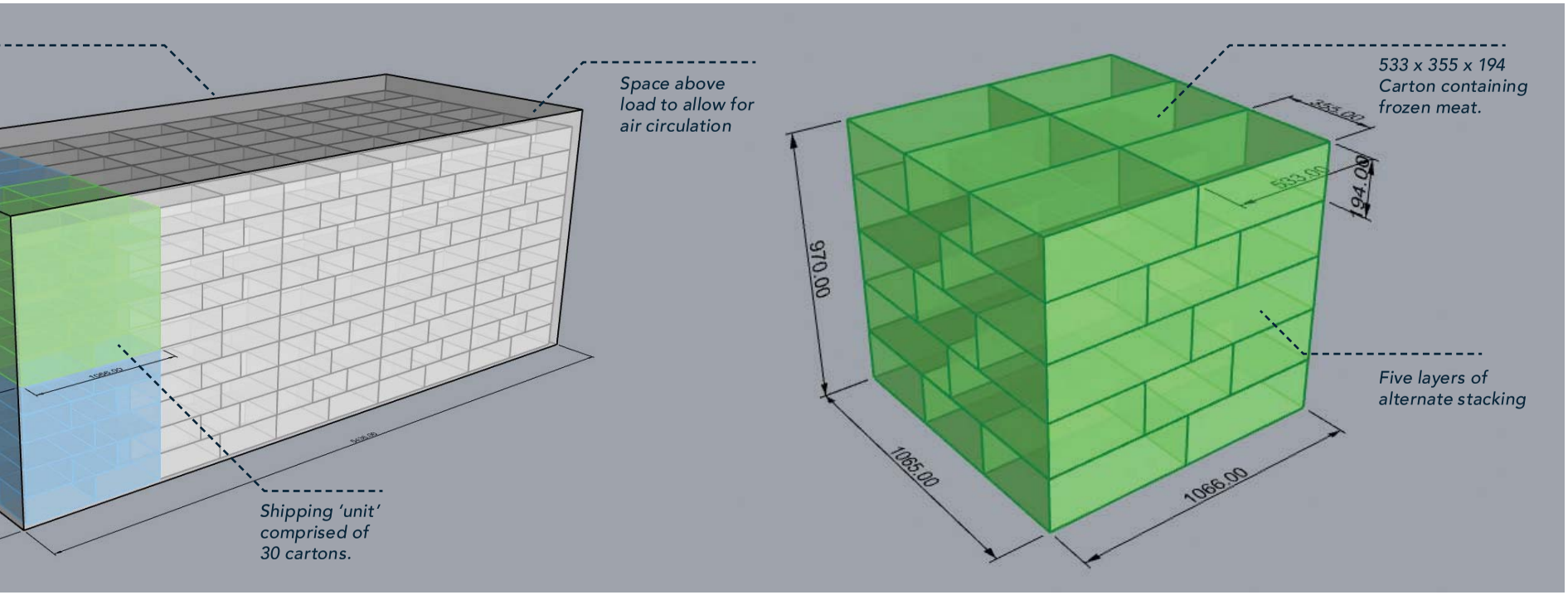
Figure 2. Current issues of space efficiency and ability to clean are evident in the floor design

Figure 3. Air circulation aroun

s chapter outlines the existing designs,
tems and research currently contributing
he development of export systems in

There are a number of container options used for export transportation. When transporting frozen export product standard refrigerated shipping container, commonly referred to as a reefer container, are industry standard. The most common sizes are

ature controlled environment during transit. Ventilation for the cargo
led via an aluminium extruded 'T' slot floor which allows the
be placed on top while providing a chamber for cold air to travel
container and around the cargo. The design of these containers
o consideration a large variation of cargo. For this project I am
on providing a very specific transportation system for frozen export
rgeting a singular cargo type allows me to design the shipping
r specifically for its cargo.
orters use cardboard shipping cartons to transport frozen primal
t. These cartons measure 533mm L x 355mm W x 194mm H and are
as shown in fig. 4.



ed loading systems manually stack 600 cartons in a 20ft reefer

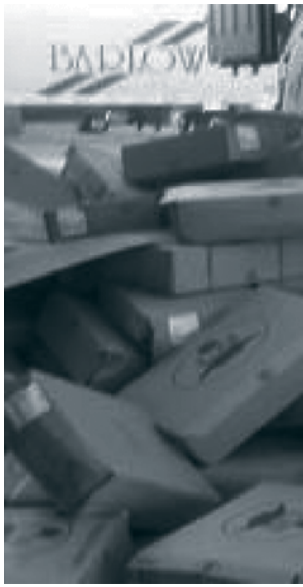


Figure 5. During transit carton
moisture or move during trans
doors the cartons can fall resu

The cardboard shipping carton design has
37 years *(Chua, 1978)*. This presents some issues
and stability. Cardboard cartons are a single-us
of when unpacked. During transit the cartons ca
from moisture or move during transit, scuffing t
information which results in product rejection. W
container doors are opened at the destination,

these containers are only suitable for cargo not requiring temperature sensitive environment. CakeBoxx, takes an innovative approach to dry shipping container configuration which eliminates the need for doors and securely fastens the walls and roof to the floor with a locking pin system. This offers three main advantages. The first is increased security as it requires specialised machinery to lift the 'lid' of the container. The second advantage is increased time efficiency when loading and unloading cargo as the design allows machine access from all sides. The third advantage allows more efficient customs clearance as the cargo can be inspected without unloading it. However, there are disadvantages to the CakeBoxx system. Firstly it can only be used for non-refrigerated

Figure 7. In storage, off port, opening containers is an non-automated process

cargo, as this configuration and construction would not allow for the inclusion of a refrigeration unit. Secondly when the container is empty it occupies the same amount of space.

Another example of dry shipping container design is Staxxon. The design collapses and stacks together providing a space saving advantage. Five Staxxon shipping containers can be collapsed to fill the same space as one ISO shipping container. However, this design would not work for refrigerated shipping containers as insulation and air tight seals

Figure 8. Without a refrigeration unit Staxxon can flat-pack efficiently

are needed to keep the refrigerated product in a controlled and isol environment. Components such as the refrigeration unit and compre take up significant space and would reduce the collapsed footprint.

Collapsible dry storage shipping containers are not a new idea there are many different designs readily available. However, I have yet to find a collapsible refrigerated shipping container which incorp aspects of space efficiency, damage and rejection prevention, impro

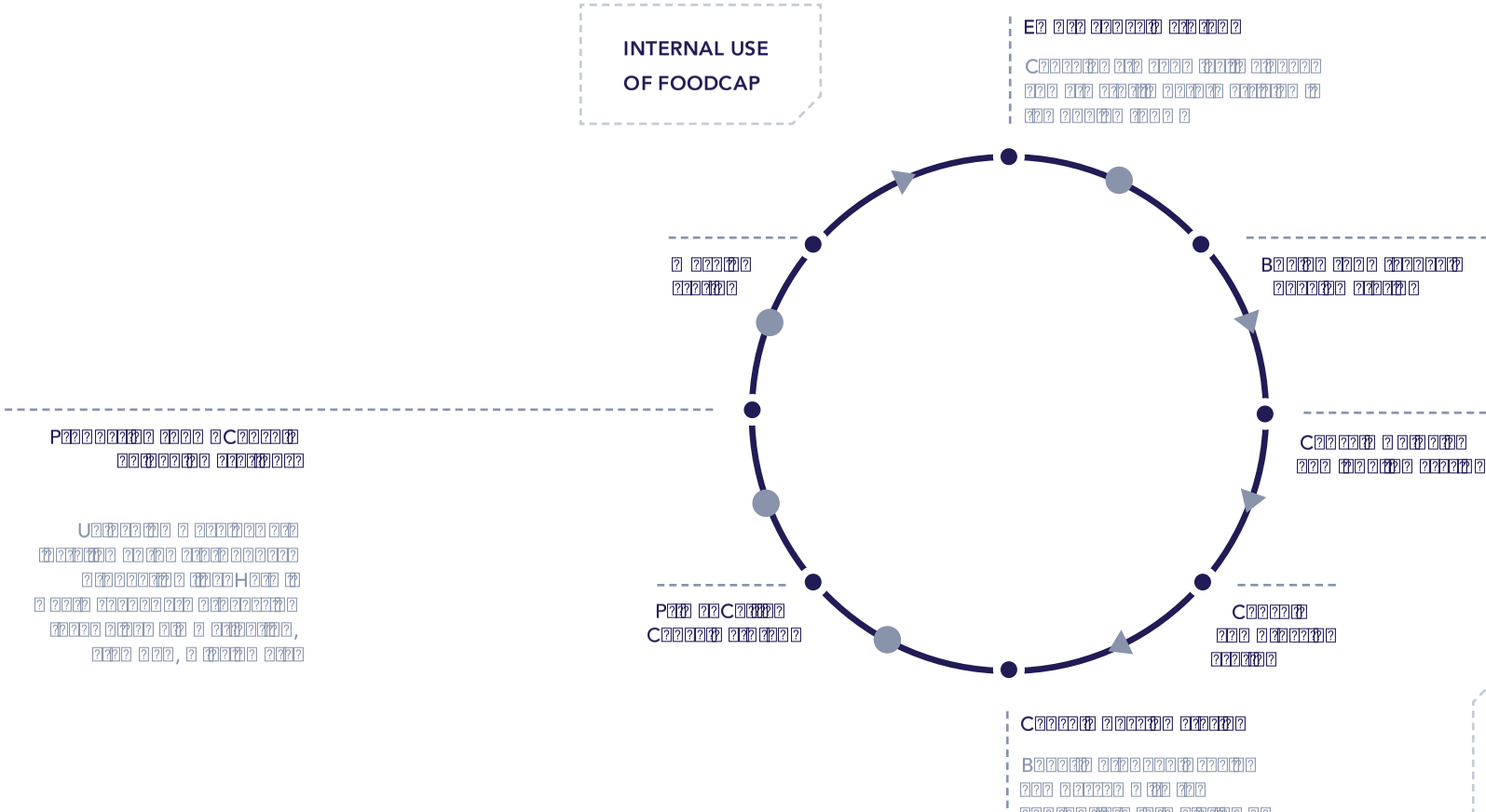
conceptual design for
ture. TEUN is a company
o have developed an
ding shipping containers.
'TEU', which is a commonly
ustry as a Twenty-foot
ping container would be
to TEUN is that it is an
ing the human component
This increasing security,
luces costs and eliminates

the risk of human error and injury. I believe TEUN to be a 'band-aid' solution as it only solves these problems after they have happened. Rather than preventing these issues at the source, TEUN recovers the damage further down the supply chain. The thinking approach for this concept is short term, with acceptance of the status quo of problems within the supply chain. This reveals a clear gap in the market, and in comparison with TEUN, my project addresses problems before they happen, at the beginning of the supply chain.

following site visits and research
lings have had a significant impact
ping and informing this project.
h offers a different, but connected,
ect of the current supply chain of
igerated meats.

FoodCap meat processing system in Otahuhu, Auckland, serves Countdown and Food Stuffs supermarkets in the North Island. It is an integrated central processing and distribution facility which handles beef, pork, lamb and chicken.The FoodCap system uses a re-usable capsule system, eliminating waste packaging when transporting product making it ideal for the national market. However this system is not suitable for the international market as the packing capsules would be inefficient to return to the plant.

Meat product is handl
primal meat packaging stat
chain. This stage of the sup
are processed into primal c
from the carcass) which are
capsules. Capsules are tran
of the plant for further proc
sausages or crumbed and n
transporting the capsules t
and cycled again forming a
This is shown in the diagra



es are used to transfer
odCap's Processing
rimal cuts are compressed
sing food safety, quality
cy. The design of the
e frozen core which fits
maintain a consistent
to uncontrolled
Fig. 14 demonstrates
sules externally between
located throughout

offers a safer, faster and

more cost effective, automated system for meat processors. The benefits are reducing manual labour, multiple product handling and packaging waste. This also results in fewer occupational health and safety incidents due to a significant reduction in bending, lifting and carrying *(FoodCap, n.d.)*

The FoodCap system was designed specifically to cater for the national market and works well. However, this system would not be effective for the international export market as there are two major issues. The first is space efficiency. The space and cost factors of empty capsules are the same as full ones, returning them to the processing plant

les

Figure 13. Consistent safety systems ensure quality assurance

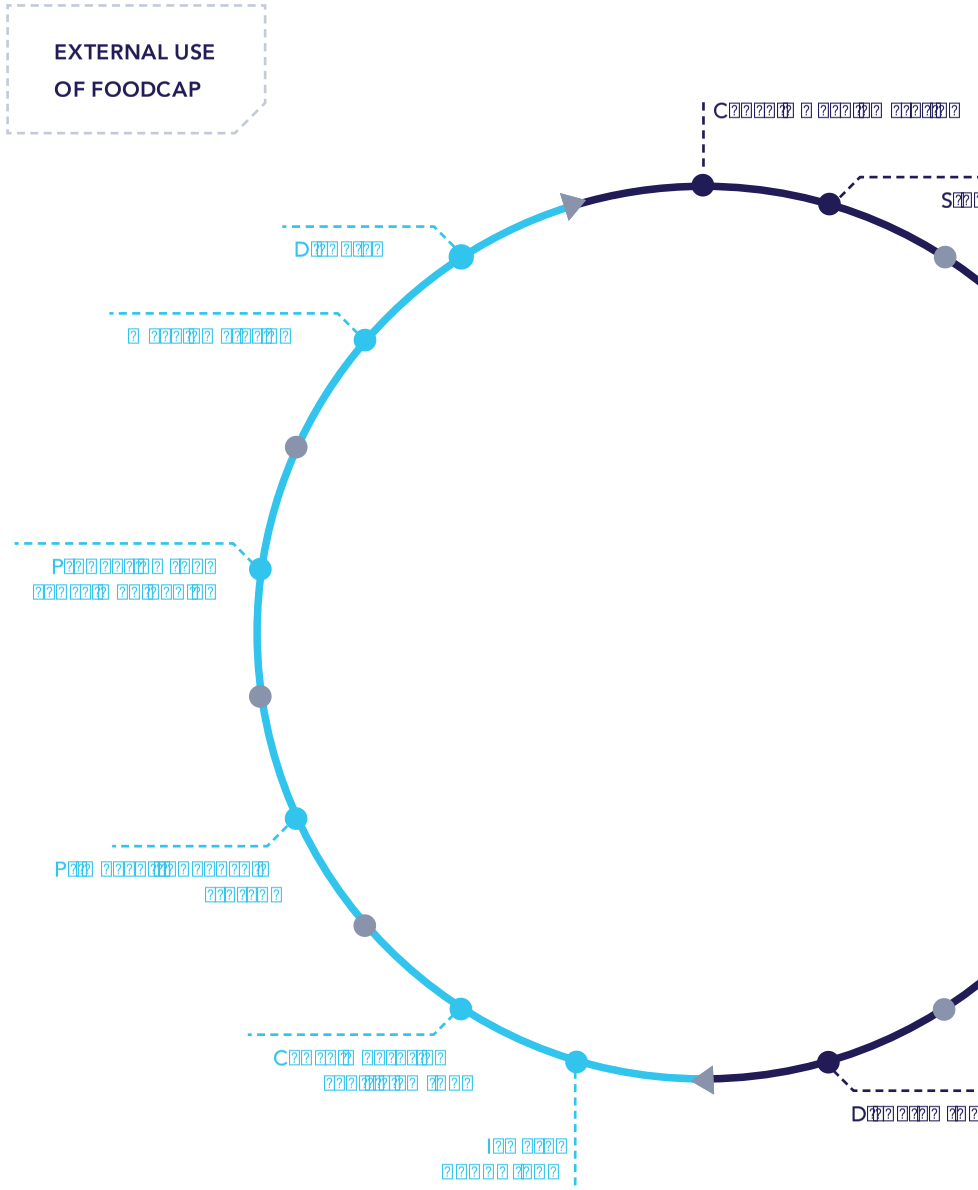
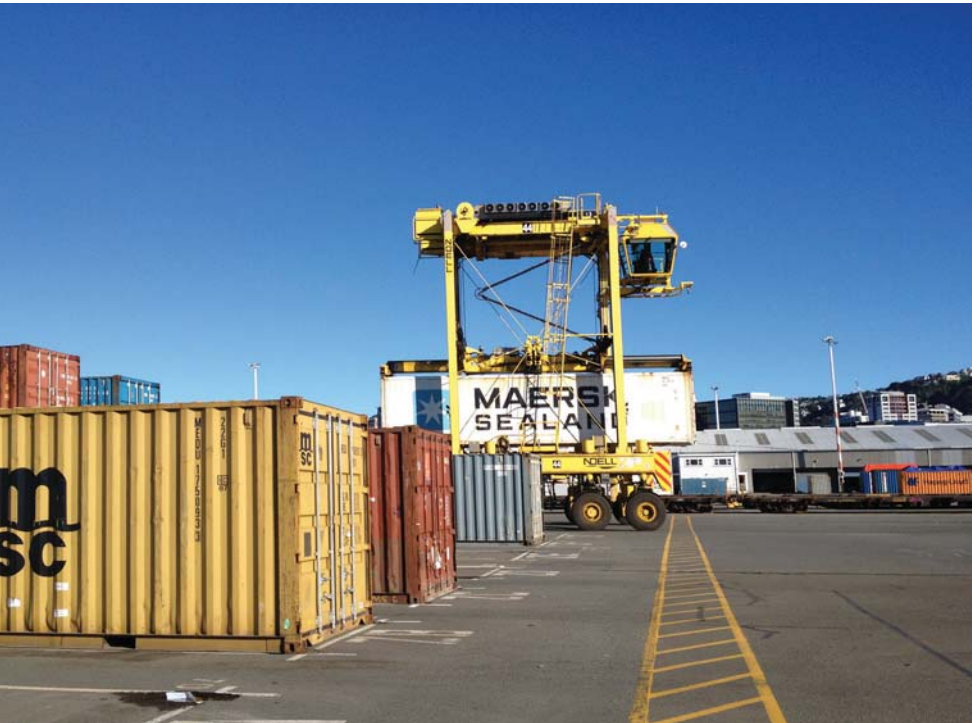


Figure 14. Demonstrates the use of the FoodCap capsules externally between FoodCap and supermarkets located throughout the North Island

ed directly at

would prove financially prohibitive. The second problem is integration into global transportation systems. The capsules are optimised specifically for use in refrigerated transport trucks which are dimensionally different from standardised shipping containers. The wheels located on the bottom of the capsules improve efficiency within the processing plant, but would consume too much space inside a shipping container. Considering space efficiency and the use of a capsule design for a international market, shipping containers offer a different dimensional configuration.

The majority of export product passes through a shipping port such as Wellington's Centre Port. My visit to Centre Port was undertaken to identify opportunities for design intervention. I looked specifically for areas which could benefit from development, refinement or even a complete re-design.



Centre Port uses digital software which aid in the organisation of loading and unloading container ships. These systems are vital in the day-to-day running of the port as they ensure all containers are accounted for and the dock workers are informed of all the necessary details regarding their cargo, origin and destination. The containers themselves are positioned and stored on the docks while they await loading onto container ships, or pick up by truck or rail.

The systems in place at Centre Port works, however I believe there are areas for improvement in the operation as there are a number of disadvantages. Firstly the lack of upgrading technology. MAERSK containers, the world's leading shipping container company *(MAERSK, n.d.)* feature a wireless digital temperature log of the internal temperature of the container. Centre Port does not have the funds to upgrade its equipment to utilise this technology feature on the shipping container design. Therefore temperature is manually logged, increasing the risk for human error. The second being space efficiency. There is a large percentage of empty reefers coming into Centre Port for the use of export. Around 43% of all imported reefer containers arriving Wellington's Centre Port in June 2014 were empty.

Figure 17. A coloured safety b
that ensures the cargo has not

New Zealand's large export of reefers does not match our relat
we need to import empty reefers for the export of frozen meat prod
security could be increased. A coloured safety bolt is the only securi
cargo has not been tampered with on arrival. The bolt's colour is spe
origin and is an international standardised system. I believe this is a v
assurance given the consequence of compromised food safety, addr

In addition to giving me first-hand experience of the global ship
Centre Port confirmed some of the assumptions I had made regardi
used at shipping ports.

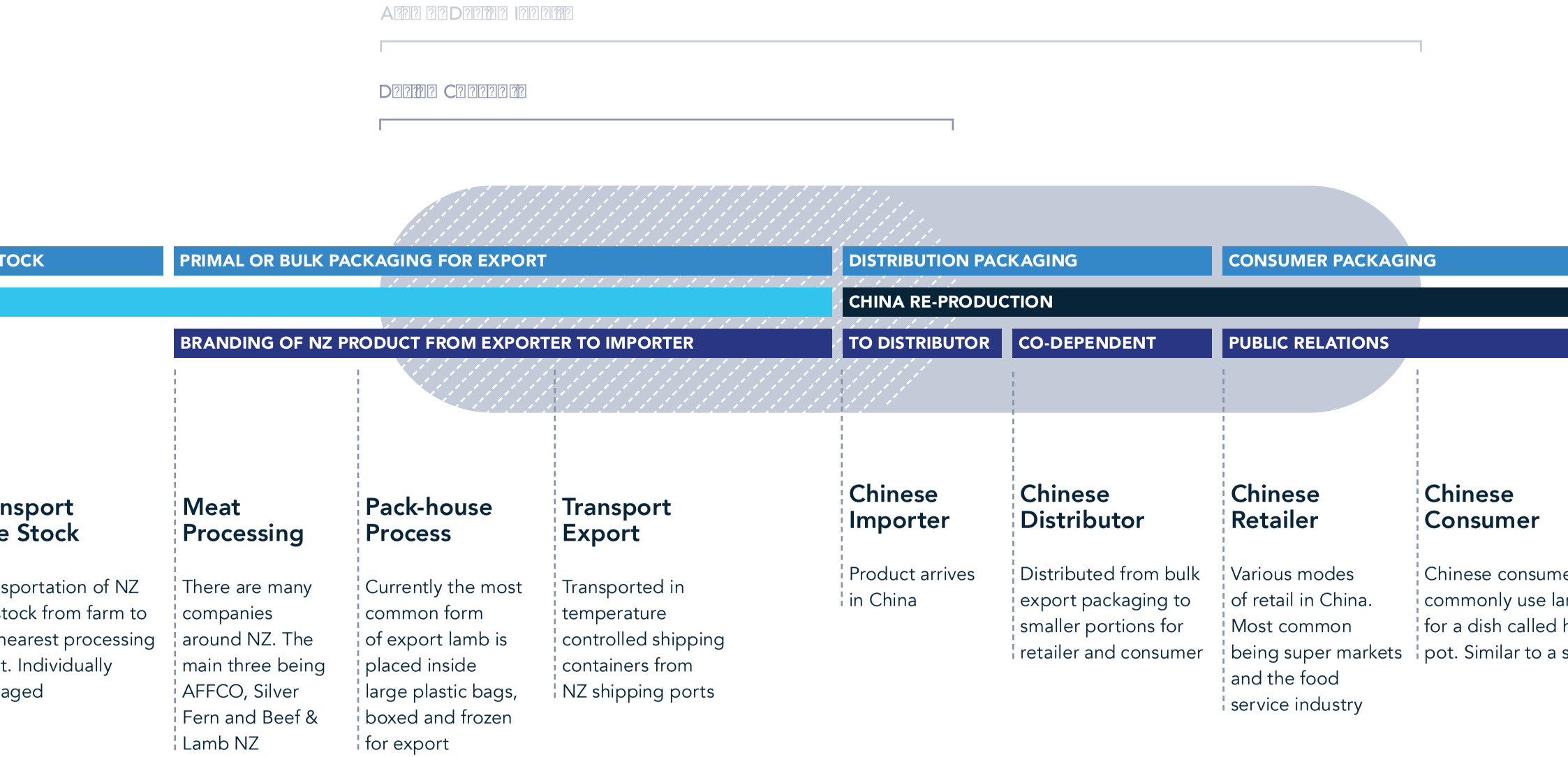
CENTRE PORT

43% of all imported reefer co
arriving in Wellington's Centre

Exploring the existing research
the New Zealand export and
transportation industry, my fin
expand on current knowledge

Research institute SCION is actively involved with research which can benefit New Zealand's economy. They specialise in science and technology development for forestry, wood-derived materials and other bio-material sectors *(SCION, 2009)*. Nicola Dooley, a scientist who is currently working on a

cardboard shipping cartons
throughout the supply chai
the cartons is conducted in
which mimics the condition
during export. The aim is to
issues of carton design and



and

Fig. 18. is a supply chain map of export lamb from New Zealand to the international consumer. The map is oriented in chronological order and demonstrates each identity which export lamb travels specifically through on its way to Chinese consumers. This map helped in determining the scope of this project and identify where possible design opportunities met my field of interest and expertise.

transportation infrastructure of refrigerated and frozen meat exports. This supply chain mapping exercise was requested by SCION strictly for the development of shelf-ready-packaging design. I chose to pursue research in the field of shipping container transportation and infrastructure.

Equipped with an understanding of the supply

ort trade with China
w faster than
other major nation
New Zealand's
ding history between
09-2011

Figure 19. Shipping and its supply chain practices are a EMEX annual exhibition targeting manufac

Another source of current research was EMEX, a engineering, machinery & electronics exhibition in Auckland. My visit to EMEX demonstrated how little current research was being conducted on systems and infrastructure for exporting refrigerated product. This differs to SCION's research which is based on export product and

logistics. However, despite being the leading tradeshow in New Zealand, there was very little current research and development on logistical systems, packaging specialists automated machinery, or systems and infrastructure. This lack of current research confirmed

Zealand is the injuries recei
industry. ACC provides rese
these injuries. The meat pro
highest rate of injury, costin
from July 2011 to June 2012

ors changes the thinking to prevention, rather than acceptance of status quo

tasks. These types of injuries can be hard to eliminate completely, however by re-considering how export product is packaged and handled, some can be eliminated. Robotic automation of heavy lifting and moving would

assessing emerging market opportunities. As an isolated disease free environment, New Zealand has a unique opportunity to produce and supply safe,

opp
to l
lea
hol
of
adv
any

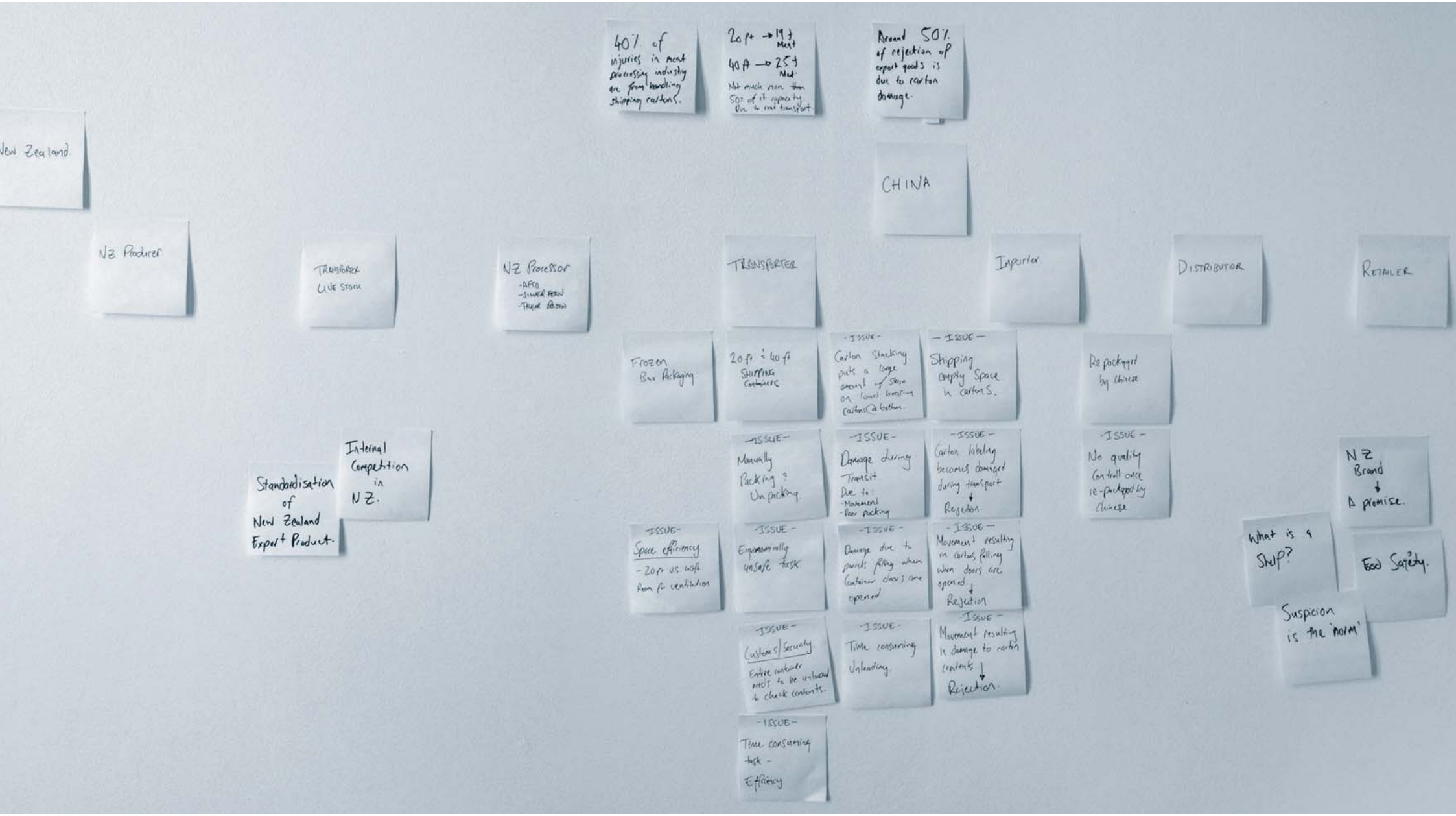
a continued trade relationsh
of potential damage and co
bio-security system in a glo
overshadowed by the total
opportunity cost and the o
trade reputation.' 'We have
world leading, yet hold the
at any moment' (*Smith & Sn*

Along with injury and p
efficiency and logistics are
researched. The City Univer
conducted a study for Orie
Ltd, exploring the logistics
shipping containers being t
Middle and Far East. This st
and predicting the supply a
containers, with the aim of
terms of leasing, storage, p
The results were an insight
saving regarding space effi
the company (*Lai, Lam & Ch*

Shipping companies ha
cost of relocating empty co
many ports. It is critical to e
and demand of empty cont
study shows there is substa

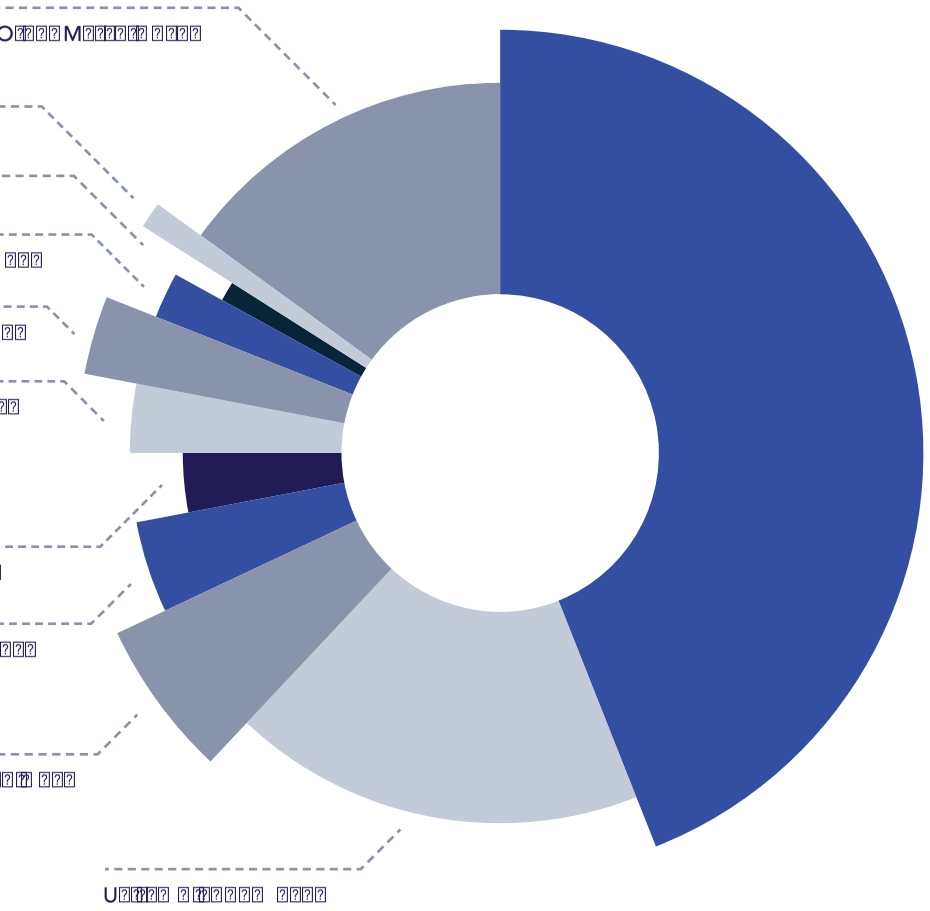
DESIGN
OPPORTUNITIES
MAPPING

The previous designs, systems
research are all actively contrib
to the advancement of the ship
transportation and logistics of
export industry on both a natio
international scale. These exan
are exploring methods for solv
issues of food safety, quality as
security, damage/rejection pre
and ergonomic issues resulting
injury. The approach these exa
take are reactions to what is oc
further down the supply chain.
has taken current practices and
design to addressing the start
supply chain.This would preven
before they occur. The followin
illustrates the significant oppo



1. Mapping what is and what could be

roject



$787 million worth of sheep me
exported from New Zealand to
2013/14, making up 44% of the
of export lamb from New Zeal
Industry Association of New Ze
Inc, 2014).

The rise of a globalised and cosmopolitan middle class in China has created a high demand for foreign imported meat products. With the addition of the FTA, New Zealand has a unique opportunity to capitalise on this market *(Barber, 2014)*. Growing demand for export lamb is pushing the limits of New Zealand's capacity as a global trader. While confident in New

systems and infrastructure
our primary produce *(Hui, 2*

This project has taken
investigation into a wide ra
transportation and logistics
the export of frozen lamb.
identified shipping containe

empty reefer containers, both 20ft
l 40ft, are imported into New Zealand
cifically for the export of frozen and
led meat products.

ners, both 20ft and 40ft,
nd specifically for the
meat products. This is due
and exported goods.
ported reefer containers
re Port in June 2014
ping containers are the
the export of frozen
presents space efficiency
y be loaded up to 25t
egulations in New Zealand.

This results in a mere 66% capacity. *(Food Science Australia Meat Industry Services, 2005, p. 4).*

The second issue is poor ergonomics which result in human injury. Exported frozen meat is packaged in cardboard shipping cartons which can weigh up 27.2 kg. These cartons are often loaded into shipping containers manually in cold working conditions, creating a hazardous environment. 40% of all injuries in the meat processing industry are from lifting, handling and carrying frozen shipping cartons *(Food Science Australia Meat Industry Services, 2005, p. 1).*

Figure 24. Conveyor system lacks innovation solving issues of ergonomics i

0 tonne of Australian eat exports to the US re rejected in 2003

e third issue is the amount of consequential damage and rejection of export product. been identified as a significant design opportunity when meeting the demand urrent global export market. However information regarding the exact quantity of product has proven difficult to locate. In 2003, 400 tonne of Australian meat to the US, worth $1.3 million *(AUD)* were rejected due to damage occurred during g and unloading *(Food Science Australia Meat Industry Services, 2005, p. 3)*. ound 50% of product rejection is due to carton damage during loading, transit and ng. This is caused from movement during transit, which can damage the identifying the carton or worse, rest against the reefer doors, where they will fall when opened. ed or unidentifiable packaging results in the carton being rejected *(Food Science a Meat Industry Services, 2005, p. 3)*.

acking a poorly

Figure 27. 27.2 kg shipping carton are manually handled and stacked

Food safety and quality assurance is the fourth issue identified. New Zealand's export lamb is a primary product which requires further handling, processing and packaging before it reaches the consumer. Despite having stringent safety and quality assurance systems in place, these may become redundant when being reprocessed by a third party outside of New Zealand. Food safety and quality assurance is a strong concern for the Chinese consumer. New Zealand has built a strong reputation for supplying high quality export food product with high food safety standards. Ensuring food safety as a priority is imperative when considering the future of New Zealand's export economy in the Chinese market.

BLAIR & JANE SMITH

Ensuring food safety a priority is imperati considering the futur New Zealand's expo in the Chinese marke

AIMS & OBJECTIVES

There are four aims for this pro
first responds to the four key c
that the research has identifie

I have identified significant opportunities for financial benefit in the export of frozen meat products to the global market, forming the foundation of design development within this project. Secondly, the project offers a vision of how change could take place to meet the demands of future global trade in New Zealand's export lamb market to China. Thirdly, it represents and

and development into the s
industry. To date this indus
from a design overview per
scope of possible projects.

The objectives this pro
were to provide an alternat
addresses the current short

oncept

The four key design issues wer
identified and developed from
research conducted to form th
starting point for design ideati
worked towards generating thr
design concepts which establis
three different design respons
The concepts range from cons

ncept one is the most compatible concept which could be easily
ed in the current containerisation system and infrastructure
transport export goods to a global market. This concept explores
ng configuration and rethinks the interior space of a shipping
er and its cargo. It is designed for 'today', utilising current, well
ned technology, materials and manufacturing methods to
a viable solution which can reduce ergonomically unsafe tasks
g in injury and increase quality assurance and food safety of the
product.

KEYWORDS

- *compatible*
- *designed for ‘today’*
- *ergonomic*
- *injury prevention*
- *quality assurance*
- *food safety*

sing cartons with unsustainable materials

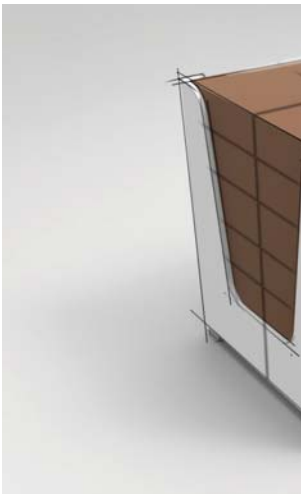


*Figure 29. Stabilised cargo is c
modules containing shipping c*

Figure 30. Exploration of fastening cargo to the ‘T’ s

e second concept focuses on the transportation and logistical
involved with the export of New Zealand meat from the
ocessor to the international shipping port. This segment of the
hain crosses multiple forms of transport including truck, rail
. This presents a range of design challenges of space efficiency,
nics and quality assurance. This concept is a realistic and
red future vision of how New Zealand's transportation and logistics
cture could operate more efficiently.

KEYWORDS

- *system design*
- *processor to port*
- *packaging format*
- *transportation*
- *space efficiency*
- *future vision*

*Figure 32. 20ft container bein
an inter-modal truck*

*Figure 33. Multiple forms of transportation including
range of design challenges*

e final concept takes a conceptual approach to the key design
The proposition of this concept is that the demand for New Zealand
growing rapidly which will push the export infrastructure to its
here quality and safety could be compromised. In the future it could
e to design and develop a vessel where the transportation and
infrastructure is specific for exporting meat products from New
to the Chinese market. This concept explores and rethinks what the
hain from processor to plate could look like in 15+ years.

Figure 35. Ulstein X bow conc
profitability of container ships

KEYWORDS

- *conceptual*
- *proccessor to plate*
- *visionary*
- *efficiency*
- *singular purpose*
- *15+ years*

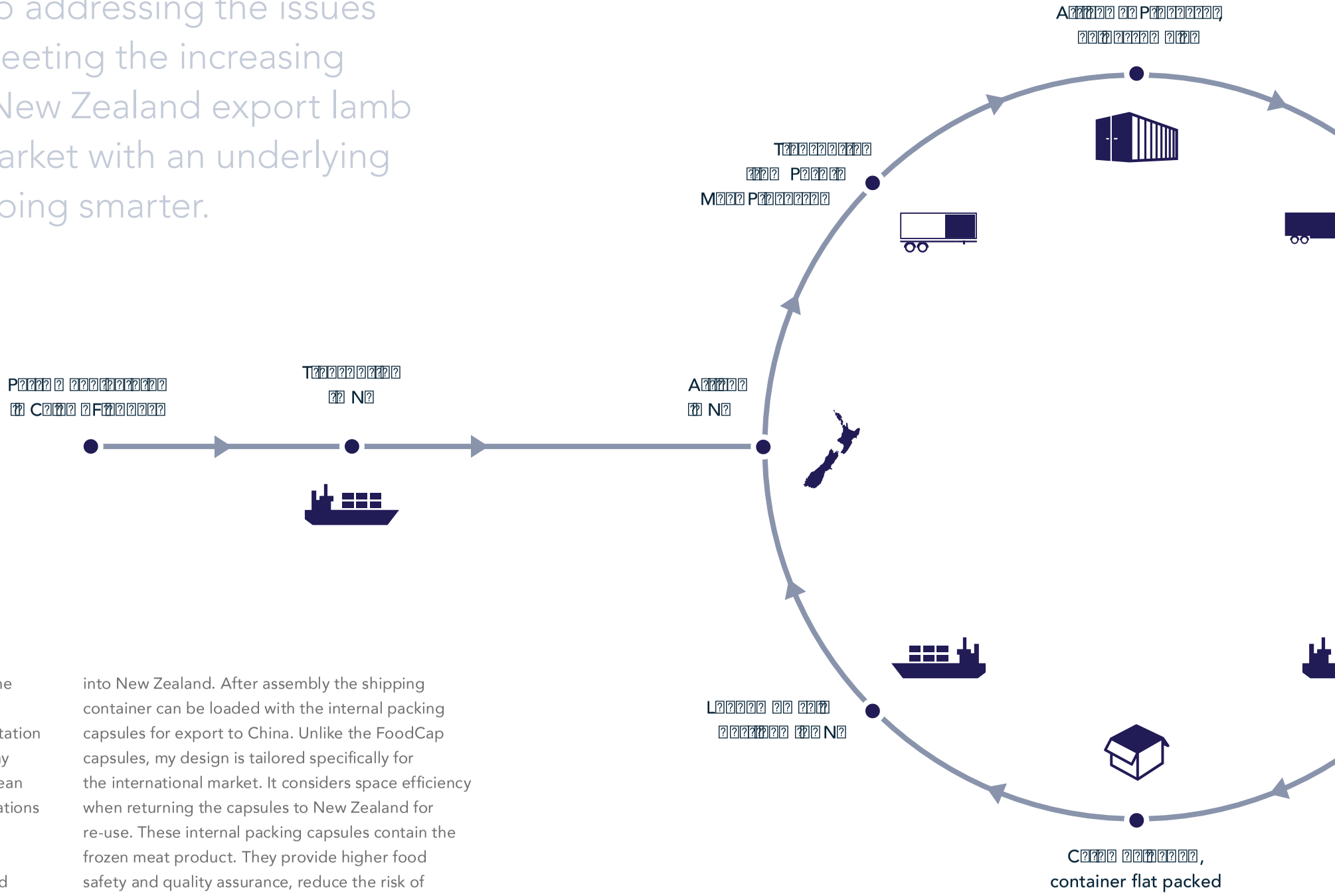
rch vessel in use

Figure 36. There are many forms of

FEEDBACK

I presented three concepts for
on ideation to aid in the select
and progression of a singular c
and direction. Concept two tal
visionary approach to system c
covers many forms of transpor
throughout the supply chain w
significant opportunities uniqu
export of frozen meat product
concept presents the best opp

e chosen concept explores future
rnatives to addressing the issues
olved in meeting the increasing
mand for New Zealand export lamb
global market with an underlying
os of shipping smarter.



rporates aspects of the
tandard which allows
inter-modal transportation
ardisation across many
railway, truck and ocean
challenges and limitations
design development

flat-pack, refrigerated
ith integrated internal
pecifically for exporting

into New Zealand. After assembly the shipping container can be loaded with the internal packing capsules for export to China. Unlike the FoodCap capsules, my design is tailored specifically for the international market. It considers space efficiency when returning the capsules to New Zealand for re-use. These internal packing capsules contain the frozen meat product. They provide higher food safety and quality assurance, reduce the risk of damaging product and also improving and addressing ergonomic issues reulting in injury. On arrival in

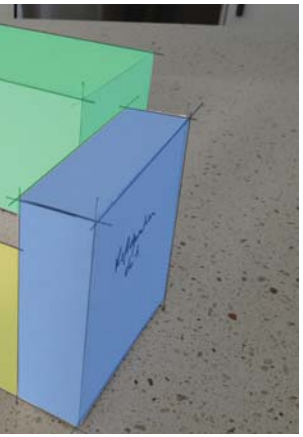
oncept
xploration &

FLAT-PACK EXPLORATION

Mock-ups and sketching were
design tools used to explore th
beginning of a useful, workabl
of the flat-pack container desig

I started with some basic requirements, space efficiency, during assembling/disassembly and when flat-packed, ergonomics/injury prevention and access to the cargo. The context of the assembly

floor with the use of a forkli
the floor is needed to ensu
to manoeuvre a fork lift. Th
and injury issues which occu



efrigeration unit

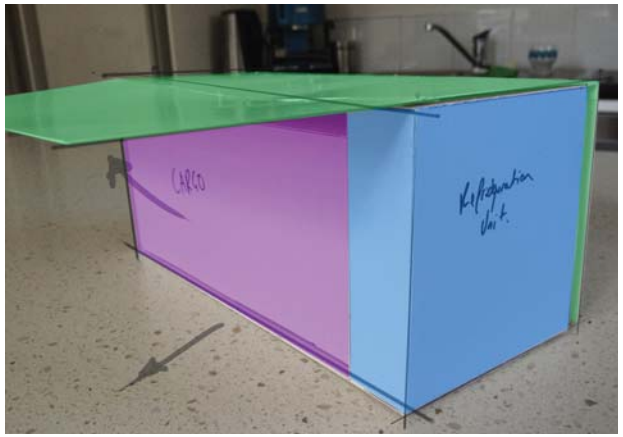


Figure 39. Access to the cargo could be from the side, however it provides restrictions to forklift maneuverability

frigerated container
must be as small
ancially viable to return
orations show a variation
lysed to identify the

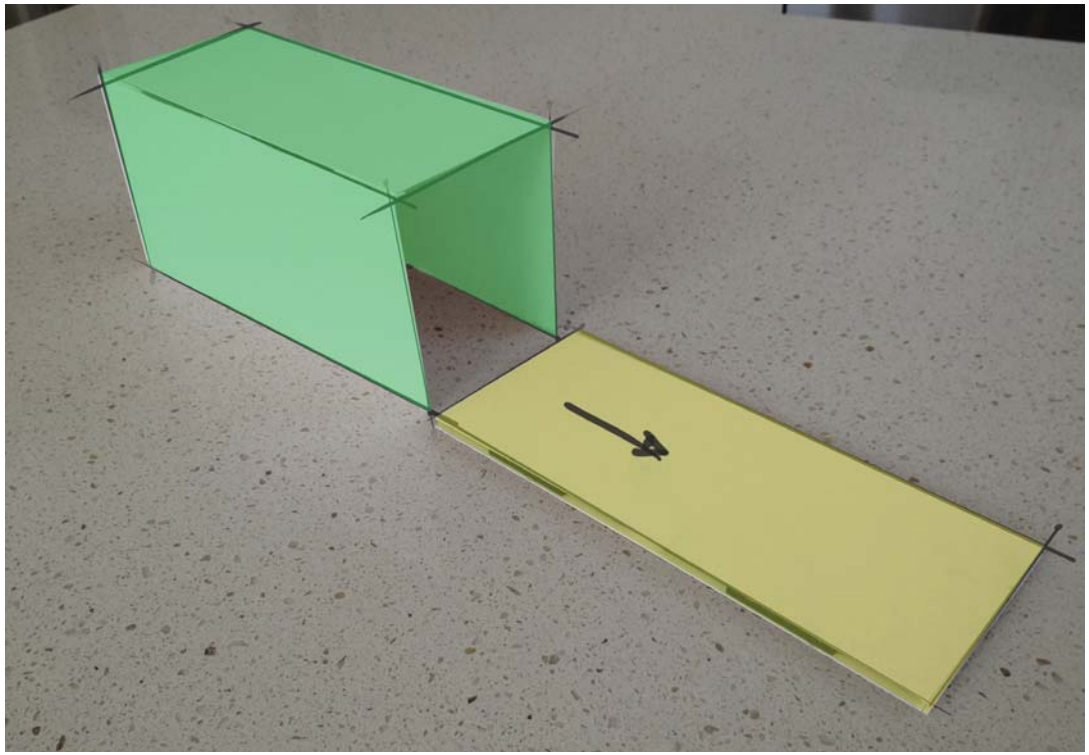


Figure 40. Sliding floor allows cargo to be

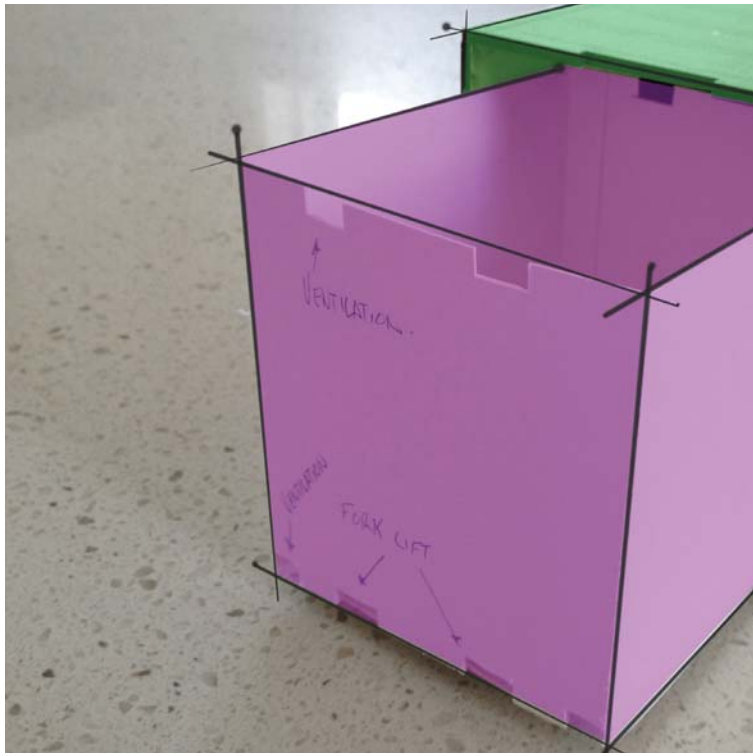


Figure 41. Modular packaging units allow cargo to be moved by a forklift ar

Figure 42. Modular packing cubes loaded with shipping cartons can be stac

r extrusion locking system

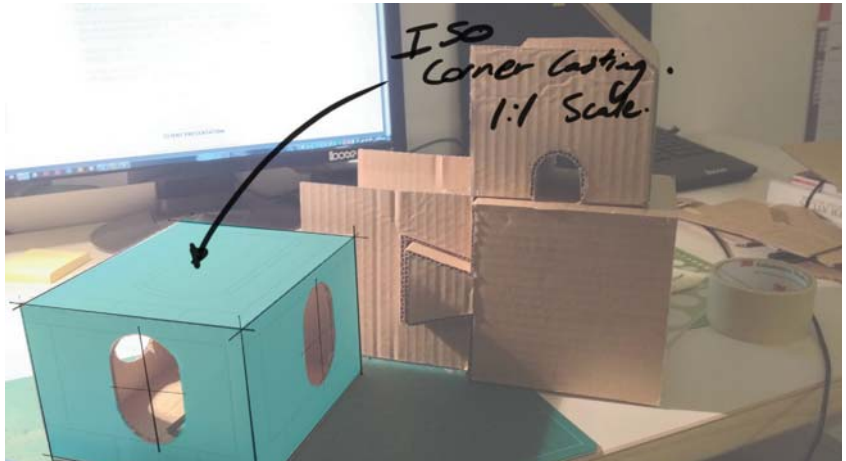


Figure 45. My second iteration focuses on developing a secure join without the use of pneumatic hose

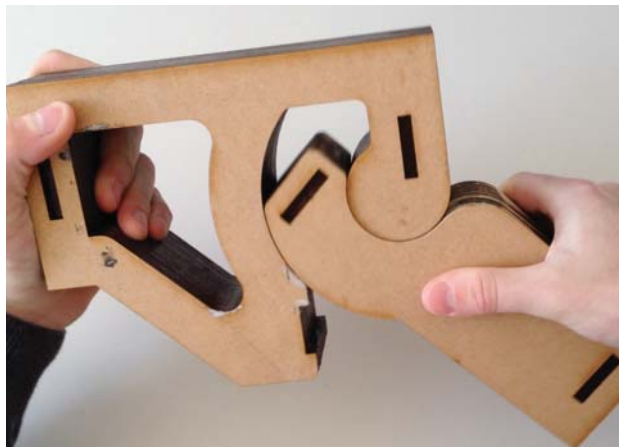
Figure 46. Laser cut MDF prov full scale

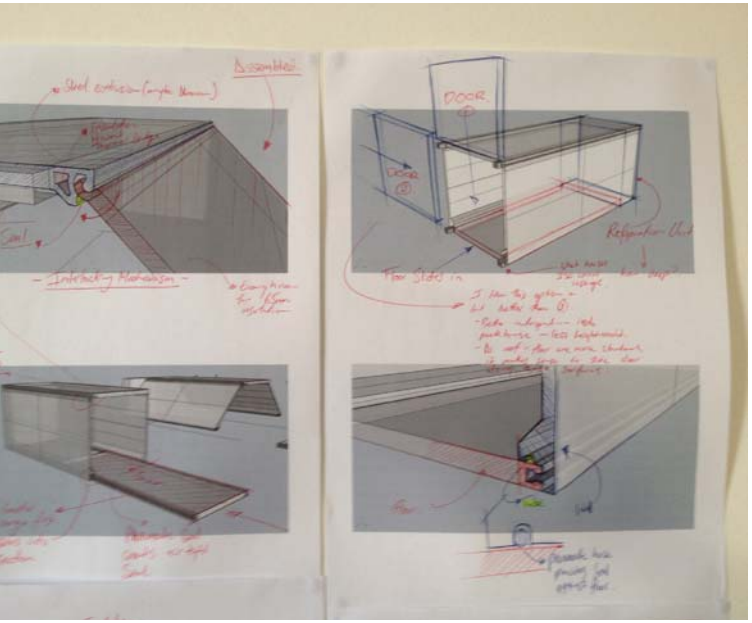
I used cardboard to visualise, test and develop ideas for the joining mechanisms that will allow these flat panels to join and interlock together. Envisaging how this unit could be assembled, I took inspiration from interlocking joins and how mirrored and tessellated shapes can interlock together. I used cardboard mock-ups to test the way these interlocking shapes interacted with each other. The vision was that the joins would rotate together to form a solid connection and an air tight seal. This mechanism plays a key role of the flat-pack design. They are the sole joining connection which allows all four panels to become one. This results in a careful balance between seamless assembly, disassembly and structural integrity.

To develop and refine a smooth interlocking mechanism I chose to switch between analogue and digital modes. Working across mediums such as; sketching, cardboard mock-ups, CAD and laser cut MDF mock-ups, provide a balance between technical and accurate design while providing the functionality of testing in physical form.

g and digital modes in parallel

Figure 49. A solid, air tight seal is achieved





2. After CAD modeling basic parts, sketching aids in the on of further ideas

h the interlocking joins developed I was able to bring the components D and test ideas with exact dimensions. The first iteration shown in has the wall panels rotating and locking into the roof panel. The floor es into the walls. A cavity on the interacting surfaces of the walls r allows for a pneumatic hose which can be inflated to clamp the join vide an airtight seal. The end 'caps' then slide horizontally across an assembled container.

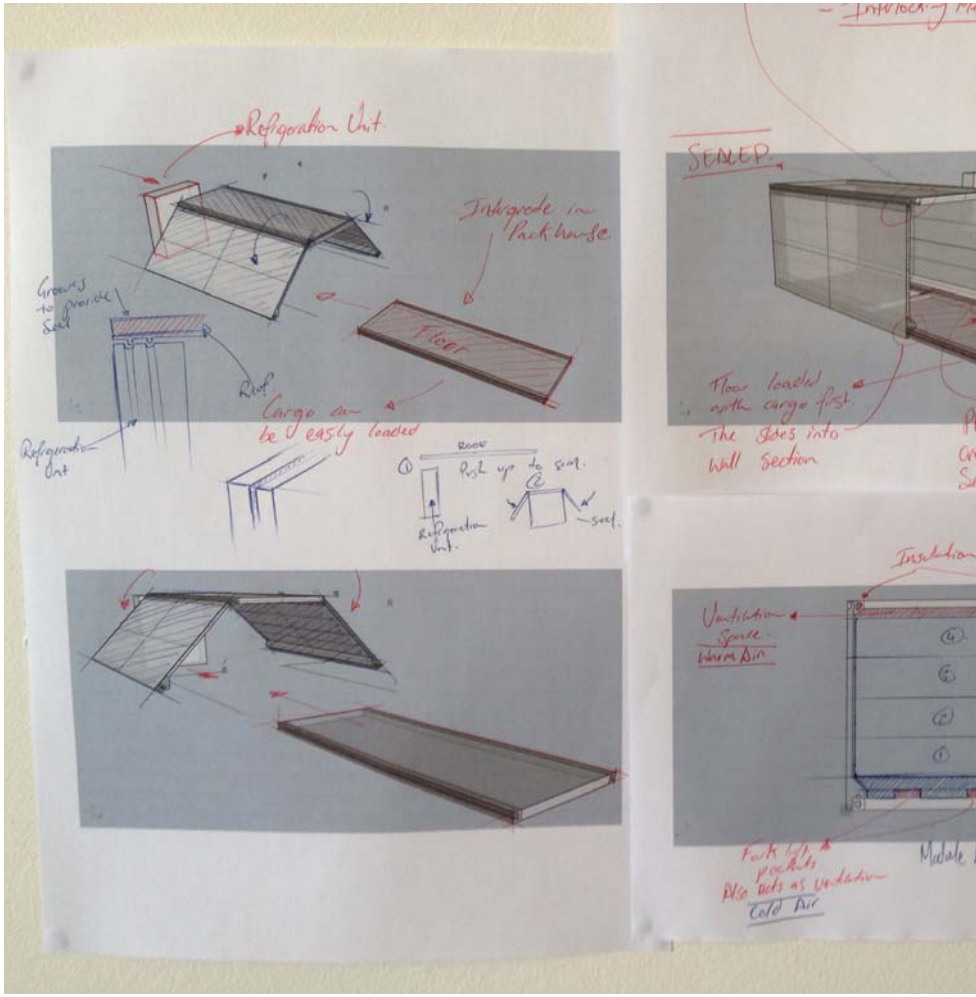
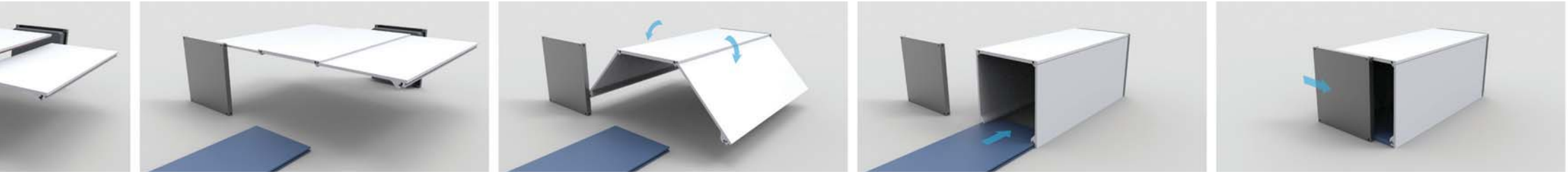


Figure 54. Initial components were drawn in CAD to apply real, physical dimensions. Alternating b modes prompted various explorations of configuration



r the first uration

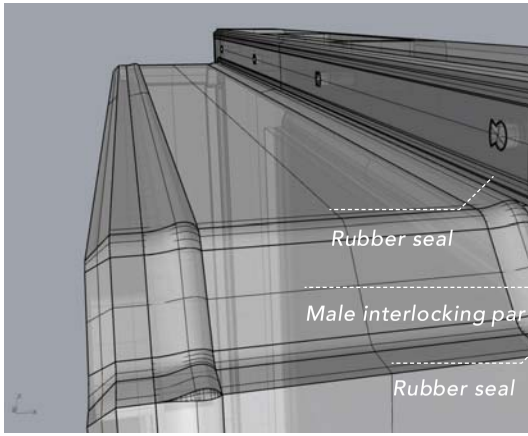


Figure 56. Inset plug design provides two surfaces fo achieved

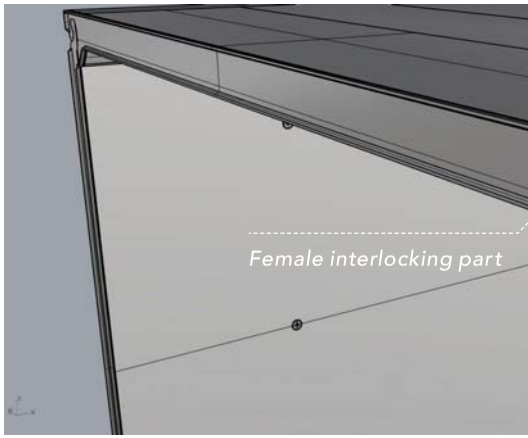
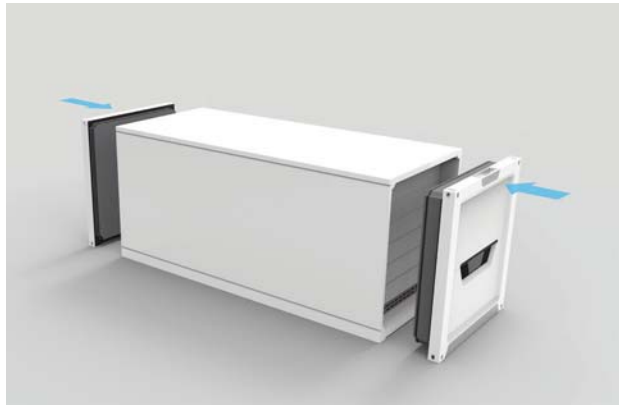


Figure 57. An interlocking surface ensures the parts s sealing surface from damage which could compromis



This first iteration had when assembled as the enc and strong assembly. The s in fig. 58, removed the slidi replaced by a 'plug' design floor/roof assembly. The wa in the same way as the prev ends of these panels create provide a great surface for With appropriate fasteners the torsional stiffness of the

esigned a specialty cargo system
it the new interior dimensions
he shipping container. By designing
nique cargo system specific to the
en meat cargo, air flow, accessibility,
onomics, food safety/quality assurance

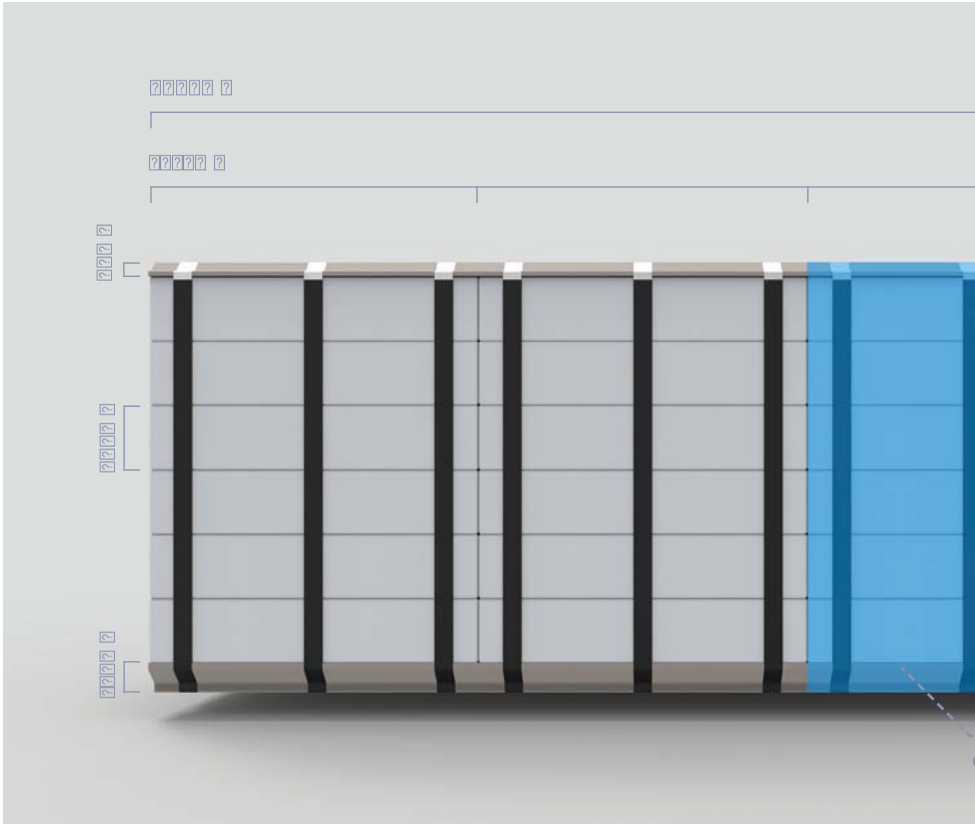
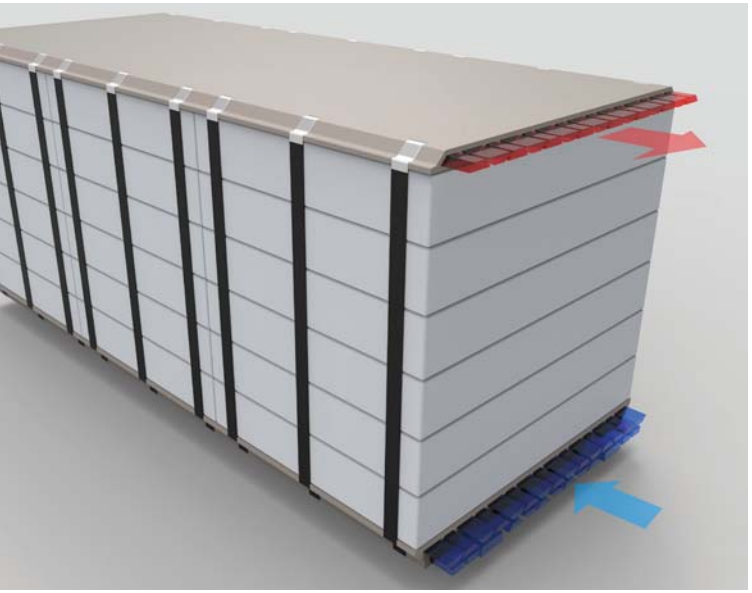


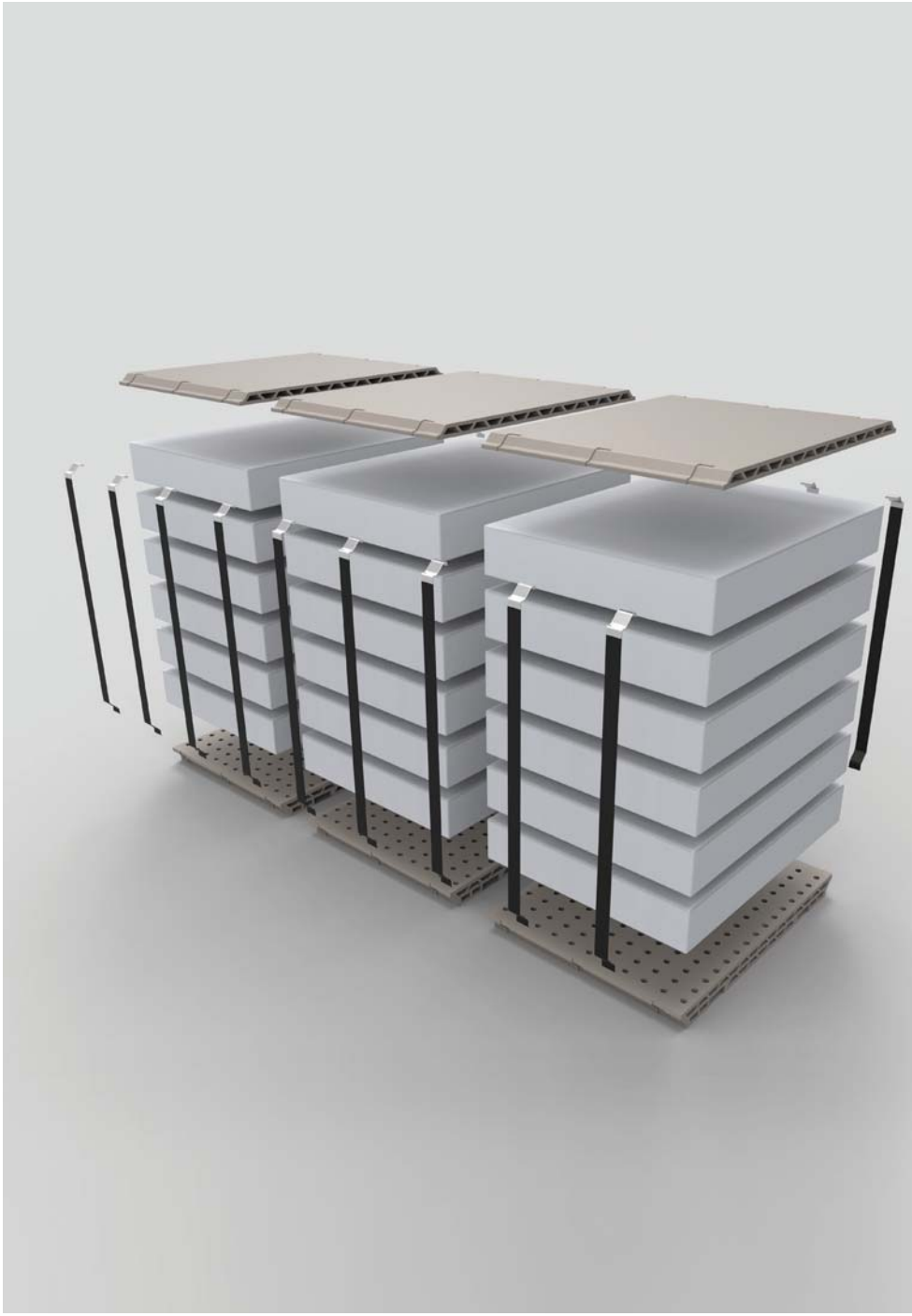
Figure 59. My initial cargo design for a 20ft reefer

The design divides the cargo into capsules which contain the frozen meat product which are loaded prior to being placed on the unique pallet system. This forms one of three modules which comprise a 20ft container. These modules are loaded onto the container floor via a forklift, then the container can be assembled around the cargo. By splitting the cargo



. Warm air is extracted while cold directly into the ventilation system ated in my pallet design

I made the following considerations when designing the cargo to fit the unique interior of the container design. I did not wish to include the 'T' slot extrusion which is located on the floor of a standard reefer and provides the contents with ventilation of cold air. Removing the 'T' slot extrusion, allows easier cleaning and improves space efficiency, however requires the cargo system to incorporate its own ventilation system. This ensures an even distribution of cold air into the cargo and an even withdrawal of warm air away from the cargo. Securely fastening the cargo prevents the risk of damage and therefore rejection. The work environment this design is situated in is rugged and the design should take into consideration that all components need to be crush proof as product-anarchy commonly takes place. All these components need to form a closed system, capable of being seamlessly and



veloped the concept to a point
ere I could present a visualisation
panel of critics to identify any
rtfalls in the design which would
d further development. A lack of in
oth consideration of manufacturability
identified as the largest issue. The
n focus was the extrusions which
the floor, wall and roof panels. In
presented iteration the extrusion
ign would be too expensive and
se to manufacture. Also consideration
needed into how the design and
porting infrastructure would assemble

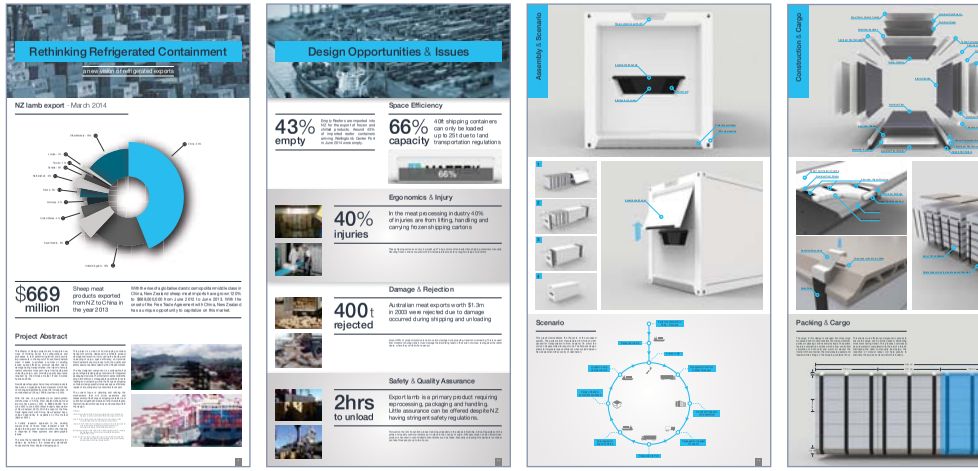
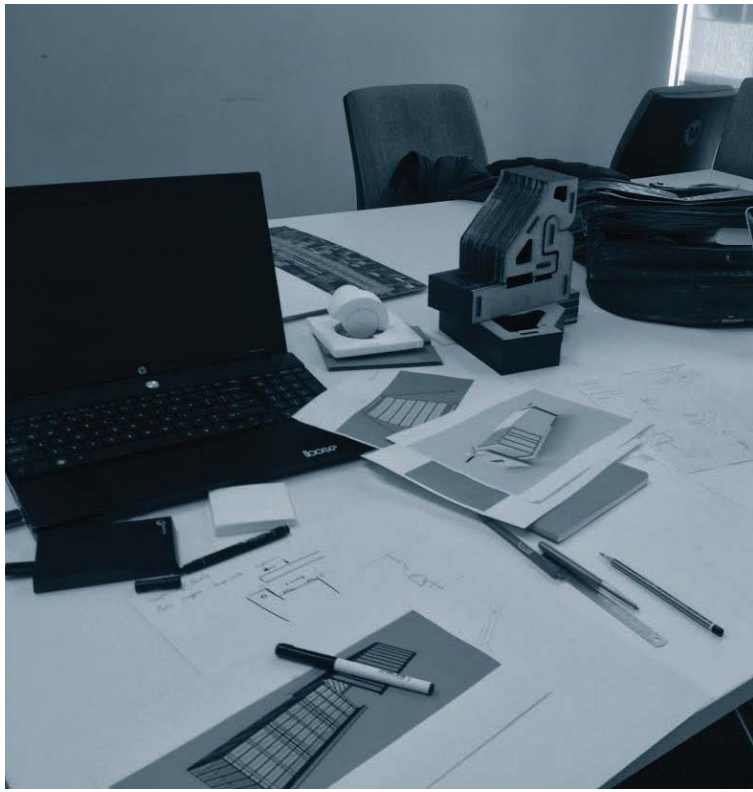


Figure 63. Printed panels visualised the concept



esign

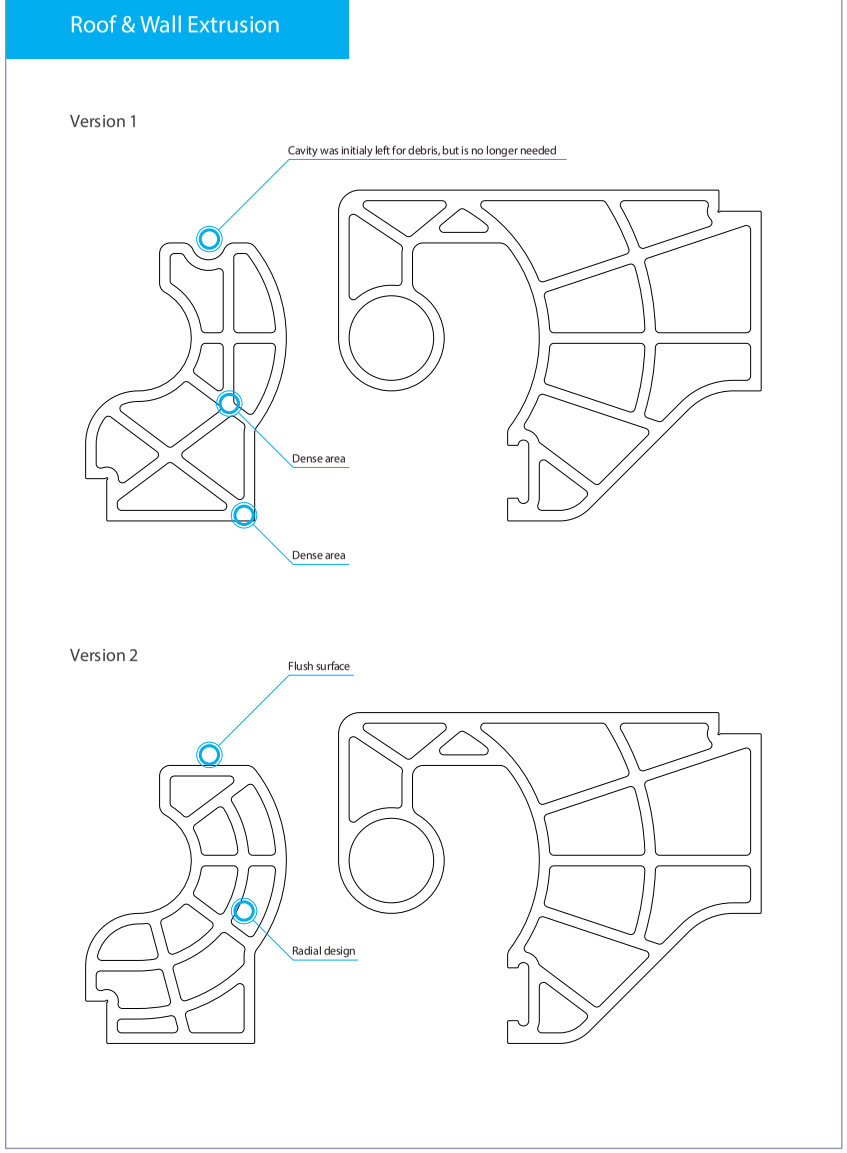


Figure 65. Roof and wall extrusion development

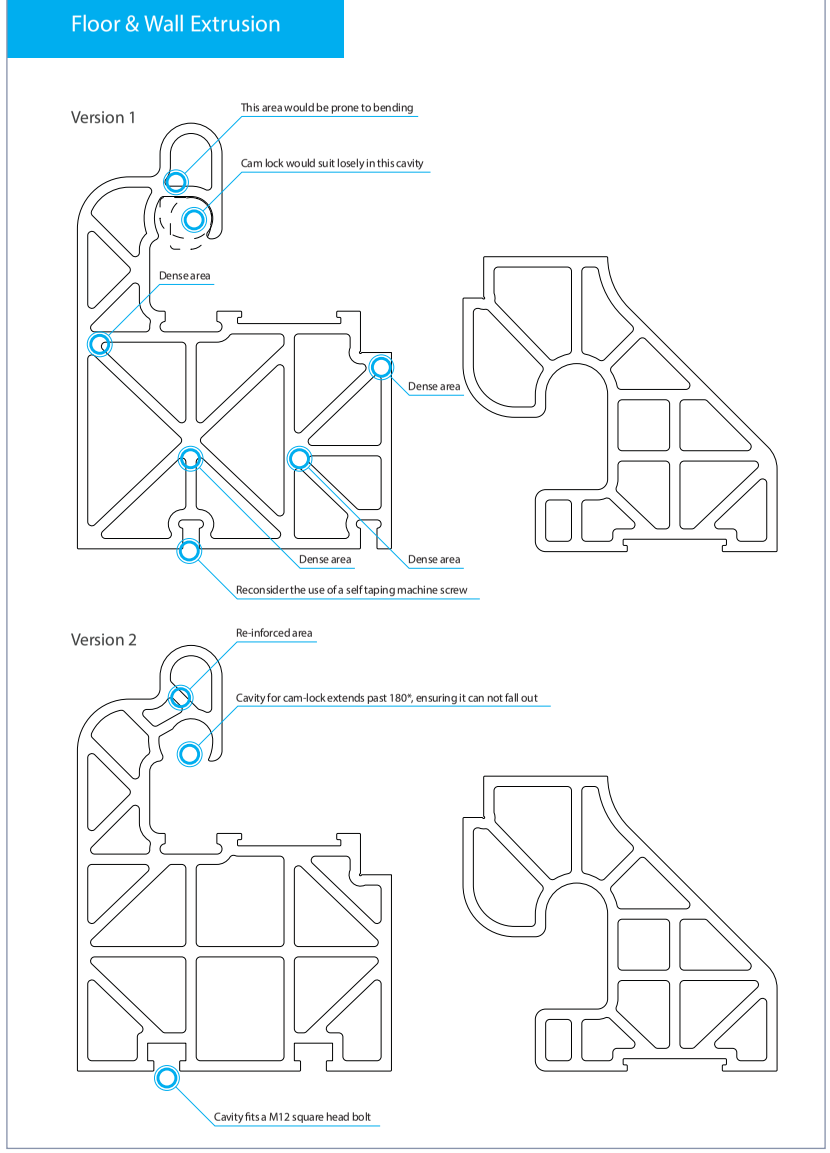
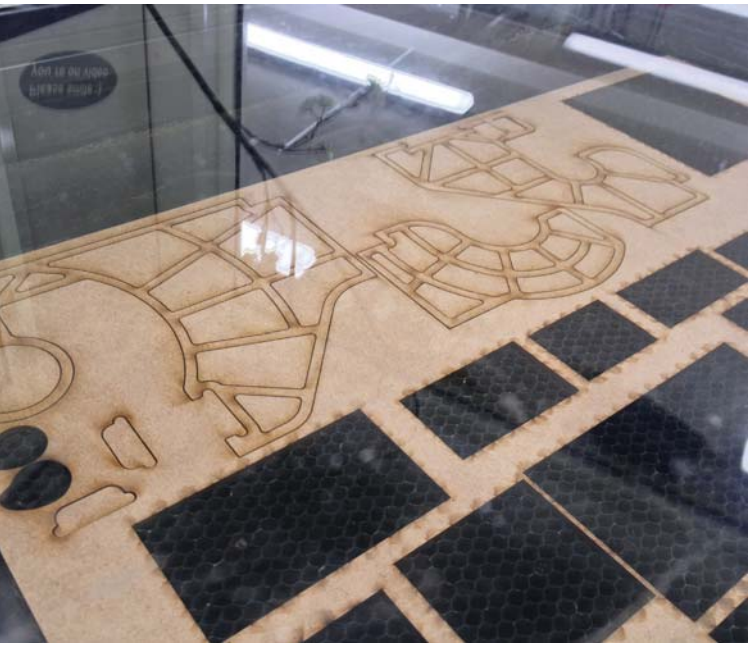


Figure 66. Floor and wall extrusion development

esponse to the manufacturing
tations of the design and
assembly process, I made some
siderations and alterations

As the concept has progressed I was able to make more informed decisions about material choice. Aluminium is an appropriate material for extrusion as it can be extruded into complex shapes, has a suitable strength to weight ratio and oxidation behaviour. I used an engineering extrusion design guide to inform the methods of manufacture and therefore the limitations of extrusion design *(Aluminium Design, 2015)*.

different cooling rates of va
crucial that there were no la
where the radii met, to ensu
and repeatability. After tak
engineering protocols I wer
extrusions. In fig. 65 and fig
I made of the extrusion des
were made regarding engin



7. Final laser cut test of the extrusion design

8. Final design being CNC router cut from MDF

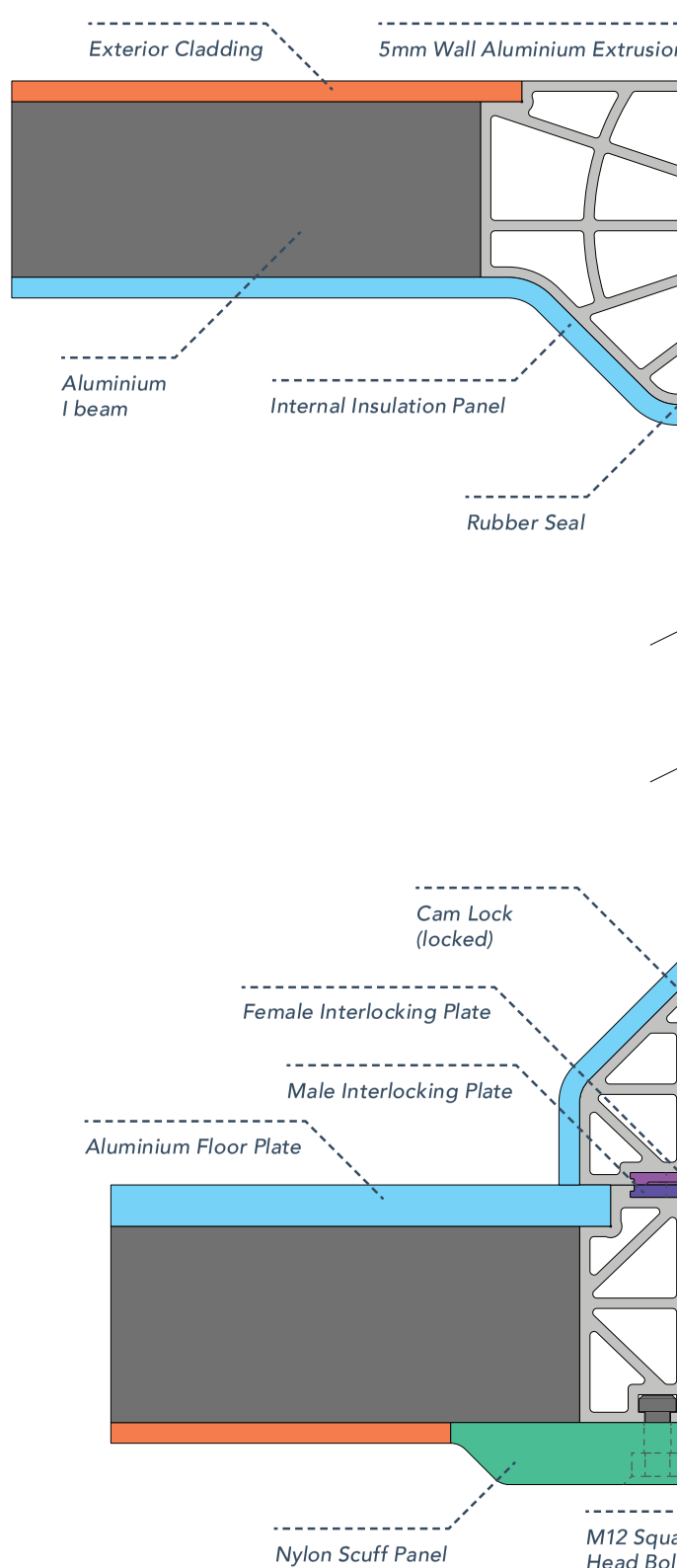
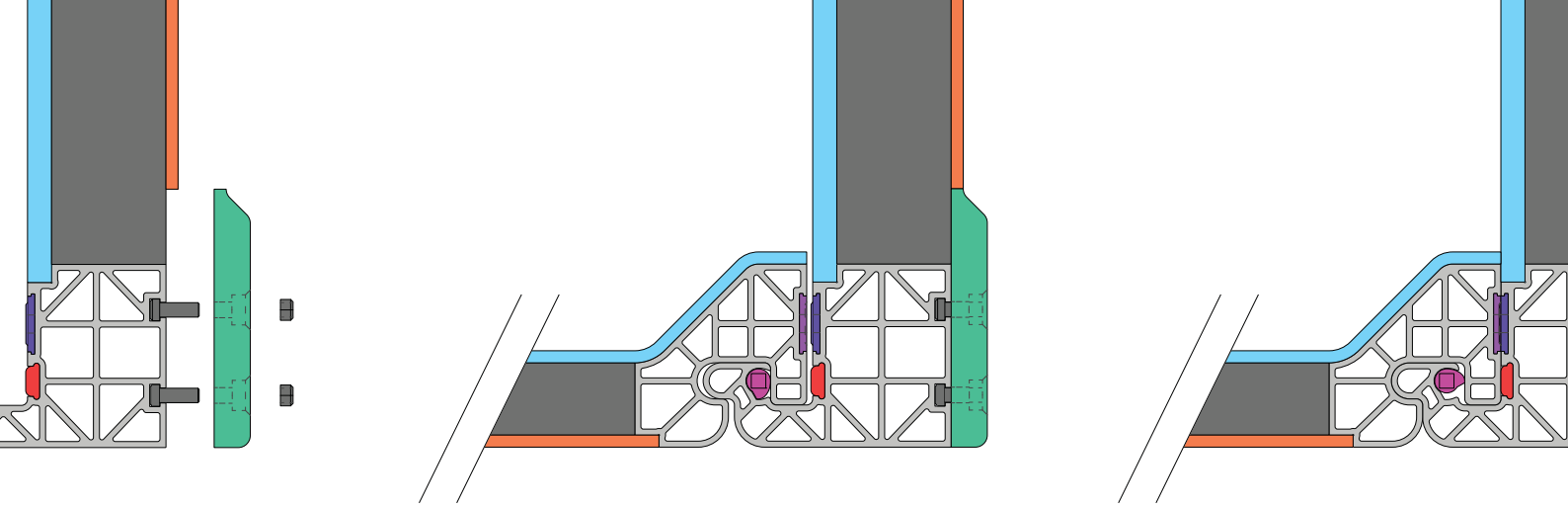
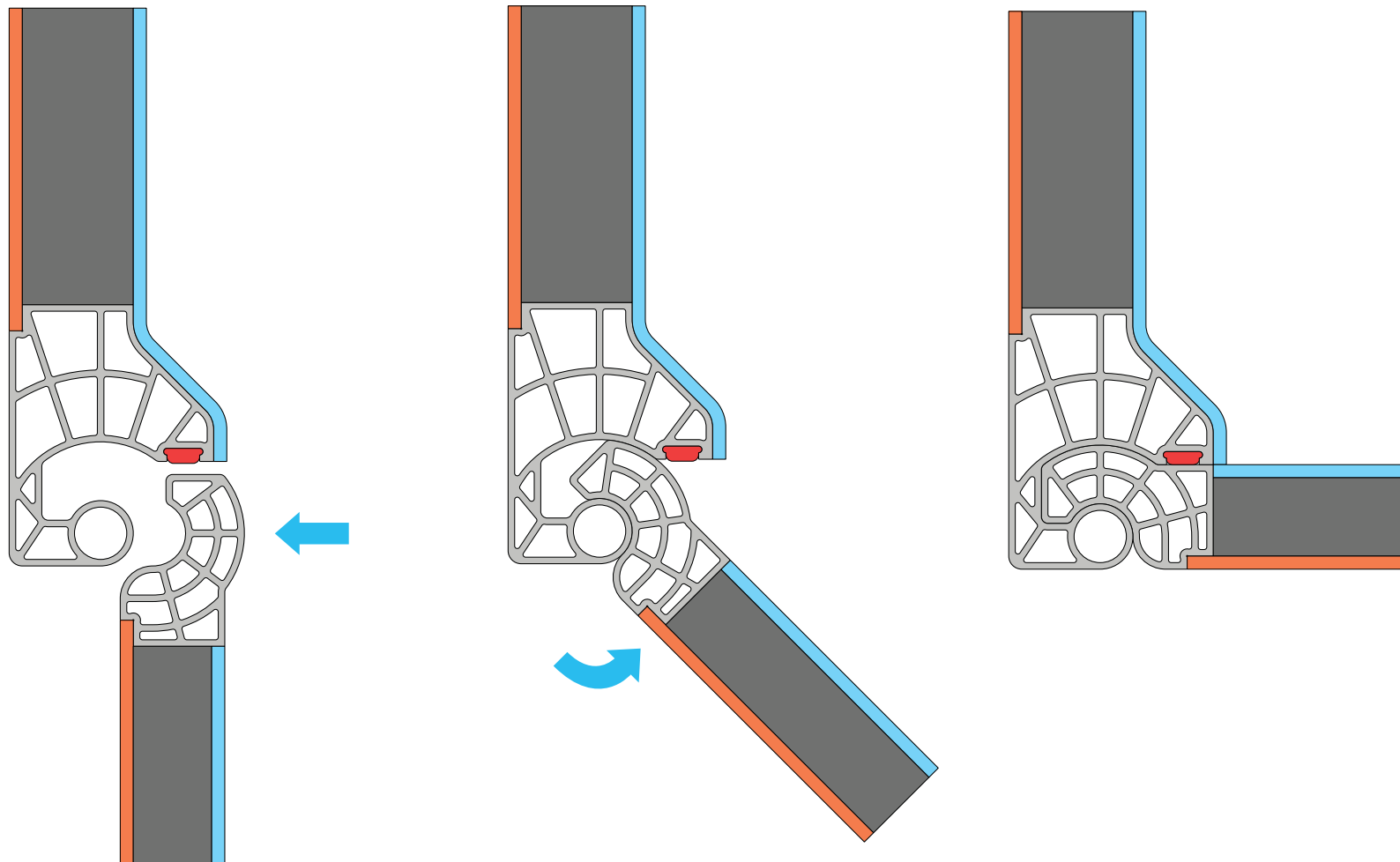


Figure 69. Final design of extrusions and construction





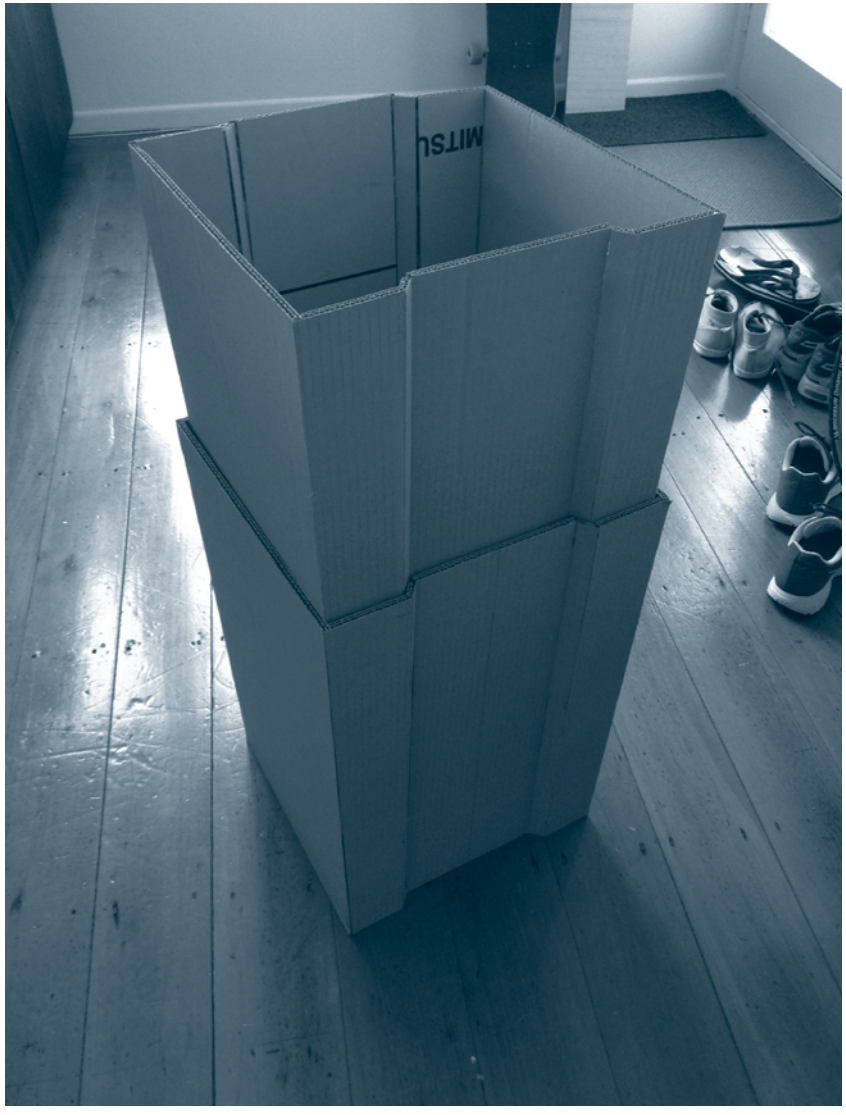
capsules are used to contain
l package the export meat
duct. Currently all primal cut, frozen
b is exported in cardboard
tons as identified earlier in the
sting design section.

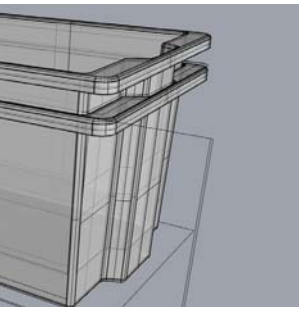
a reusable packaging system which is far more durable than cardboard cartons and greatly reduces the rate of rejection. This idea is based on the FoodCap system, but it is developed specifically for the international market.

When designing these capsules I explored the stacking and nesting of asymmetrical shapes to reduce the space they occupied when they are empty. An asymmetrical form allowed the design to have two orientations. One allows the capsules to stack on top of each other while the opposite orientation can nest

these capsules makes them
the shipping container floo
create a safe environment f
be easily cleaned when unl

I made full scale cardb
and test the idea of asymm
problems and areas for imp
translated into CAD to form
design. Capsules are stacke
form one module. One mod
each with a volume of 63.25





ng in CAD

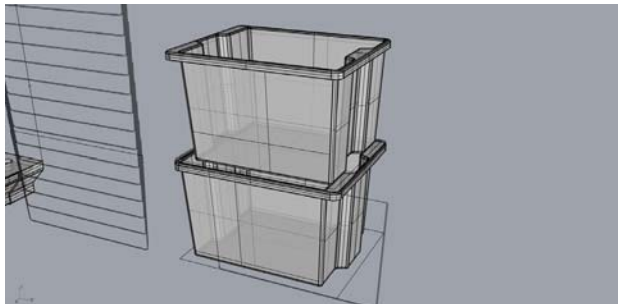
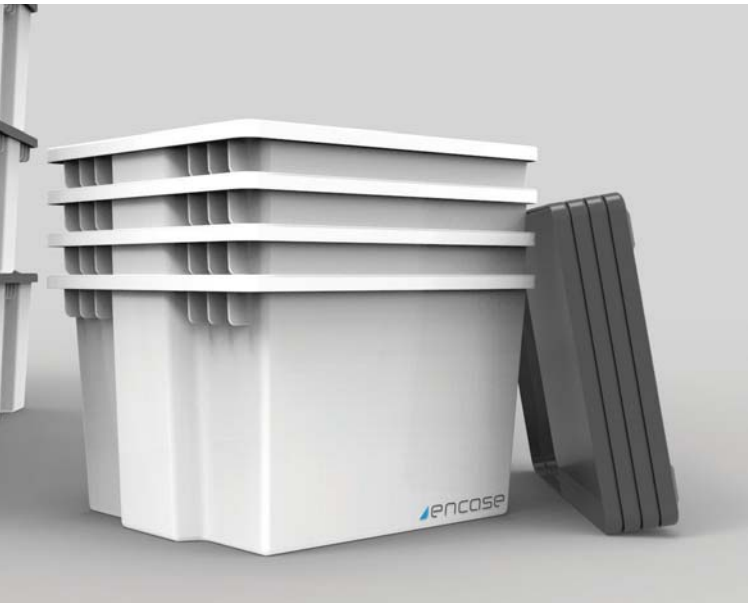


Figure 76. Capsule design stacking in CAD



ith appropriate materials

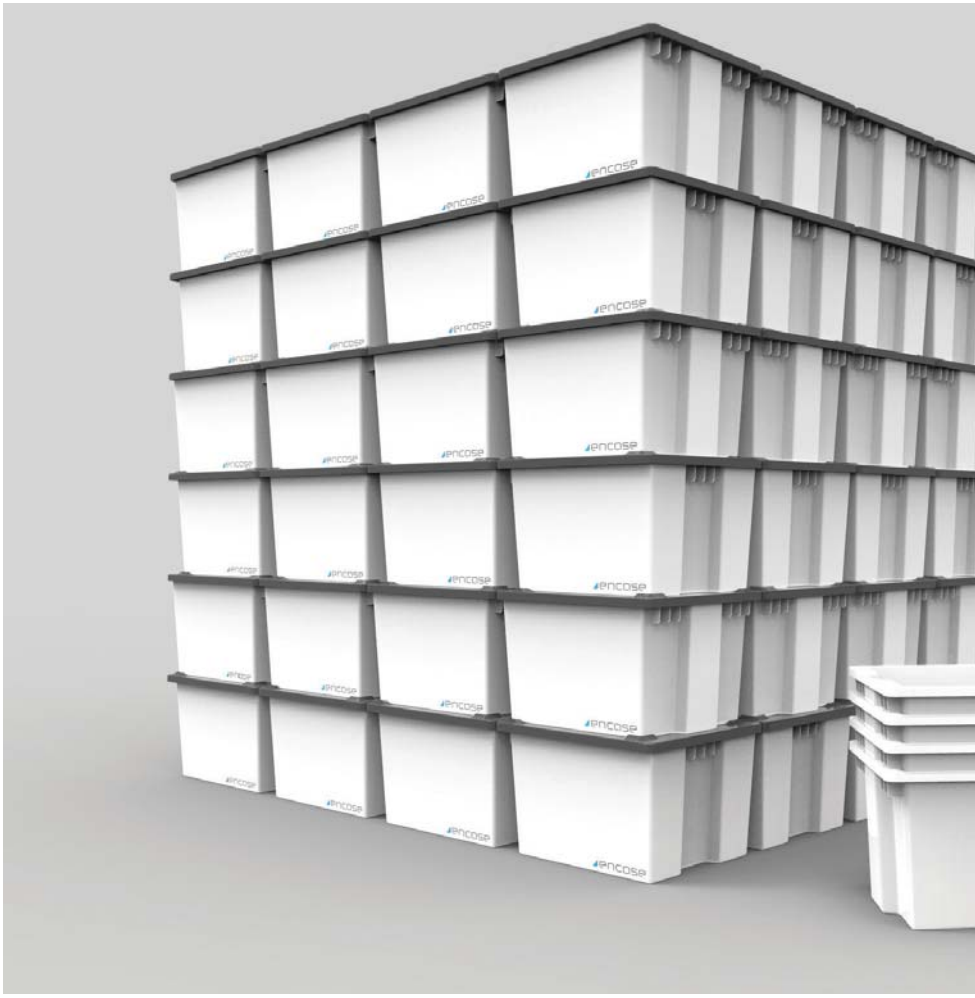
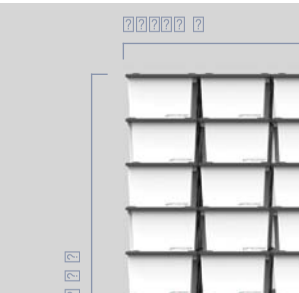


Figure 78. Capsules are stacked in a 4 L x 4 W x 6 H to form one module. One module contains 96 capsules each with a volume of 63.25 L



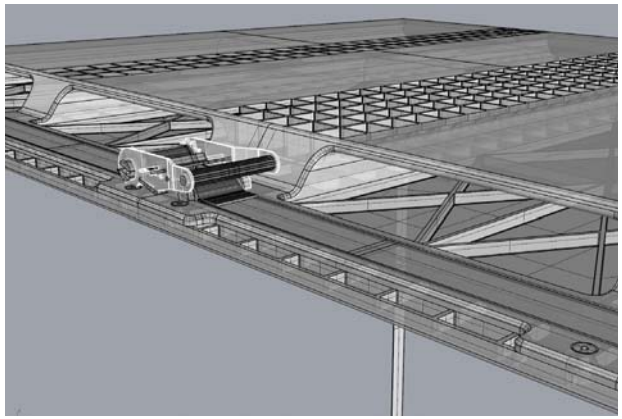
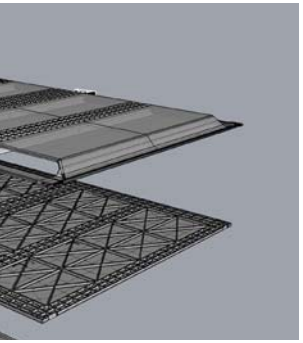


Figure 81. Integrated strap system

The pallet system went through several iterations to ensure manufacturing processes were considered. The internal ventilation cavity would not allow the design to be injection molded in one piece, so both the top and bottom pallet were split into two separate parts . The two-part pallets are bolted together to form a strong, durable pallet which features a ventilation cavity for warm and cold air.

The loaded capsules seat into the pallets by 10mm, eliminating movement and stabilising the entire cargo. An integrated strap system hooks into the pallets, with a ratchet mechanism on top, securing the module firmly.



p pallet

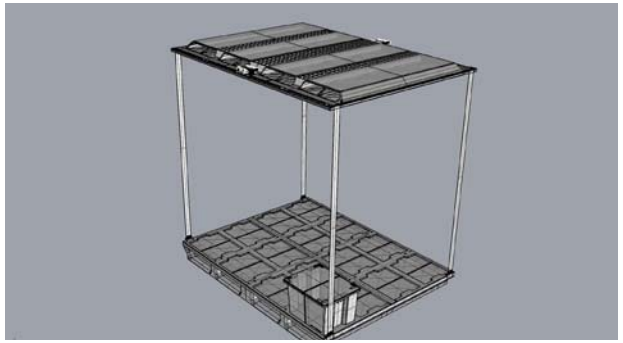


Figure 83. Cargo is stabilised with capsule seated in pallet

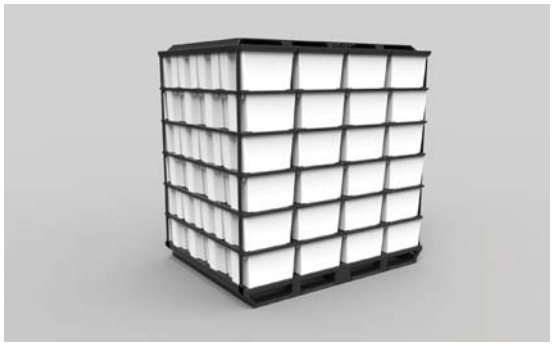


Figure 84. Module ready to be loaded for export

Figure 85. Integrated ventilation ensures even distribution of air around the cargo

Figure 8

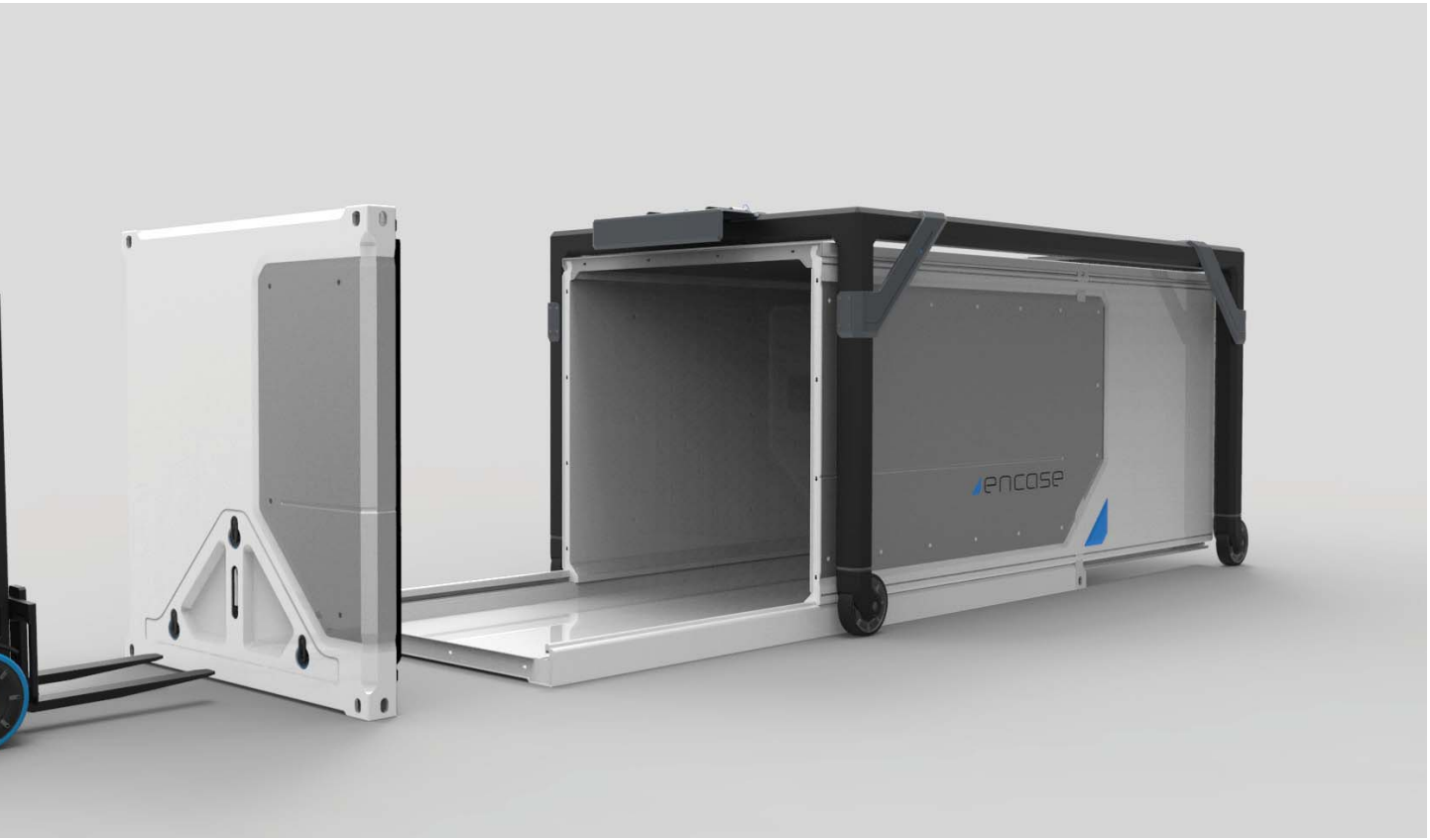
unique design of this shipping
tainer requires an infrastructure
cifically designed to ensure safe
secure assembly of the container.

The cargo and container assembly infrastructure I have designed occurs within the environment of a New Zealand meat processing plant. It reduces human contact and therefore eliminates injury, improves time efficiency and increases food safety.

The process starts with full capsules being placed onto the pallet by an automated robotic arm. After all 96 capsules are stacked onto the base pallet, the top pallet is strapped down, securing one module. A forklift is used to manoeuvre three modules onto the container floor to complete the loading of cargo.

Assembly of the conta
of a hydraulic lifting platfor
Demonstrated in fig. 89 the
rises from ground level, rot
extrusions 90 degrees to lo

The gantry frame is us
assembly onto the containe
can then be maneuvered m
jockey wheels and pushed i
assembly. Twist locks faster
a singular encapsulating ex



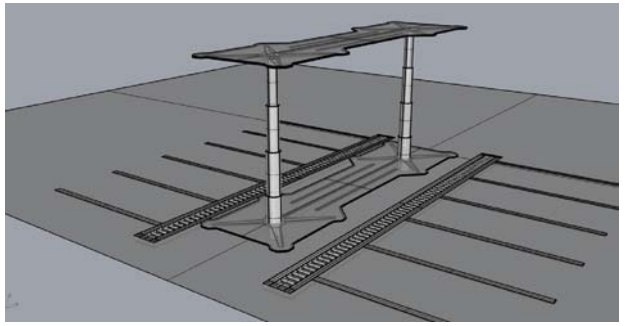


Figure 89. Hydraulic lifting plate

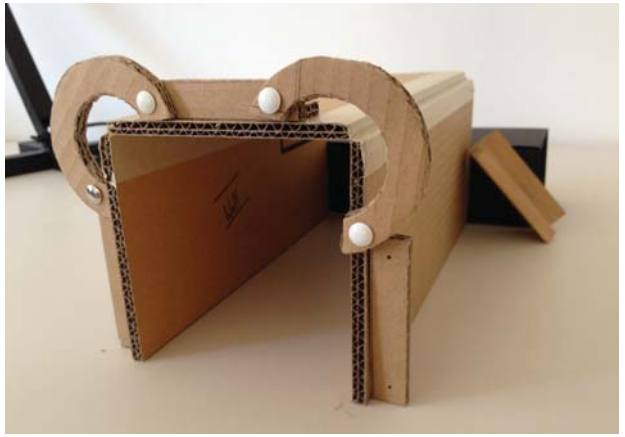
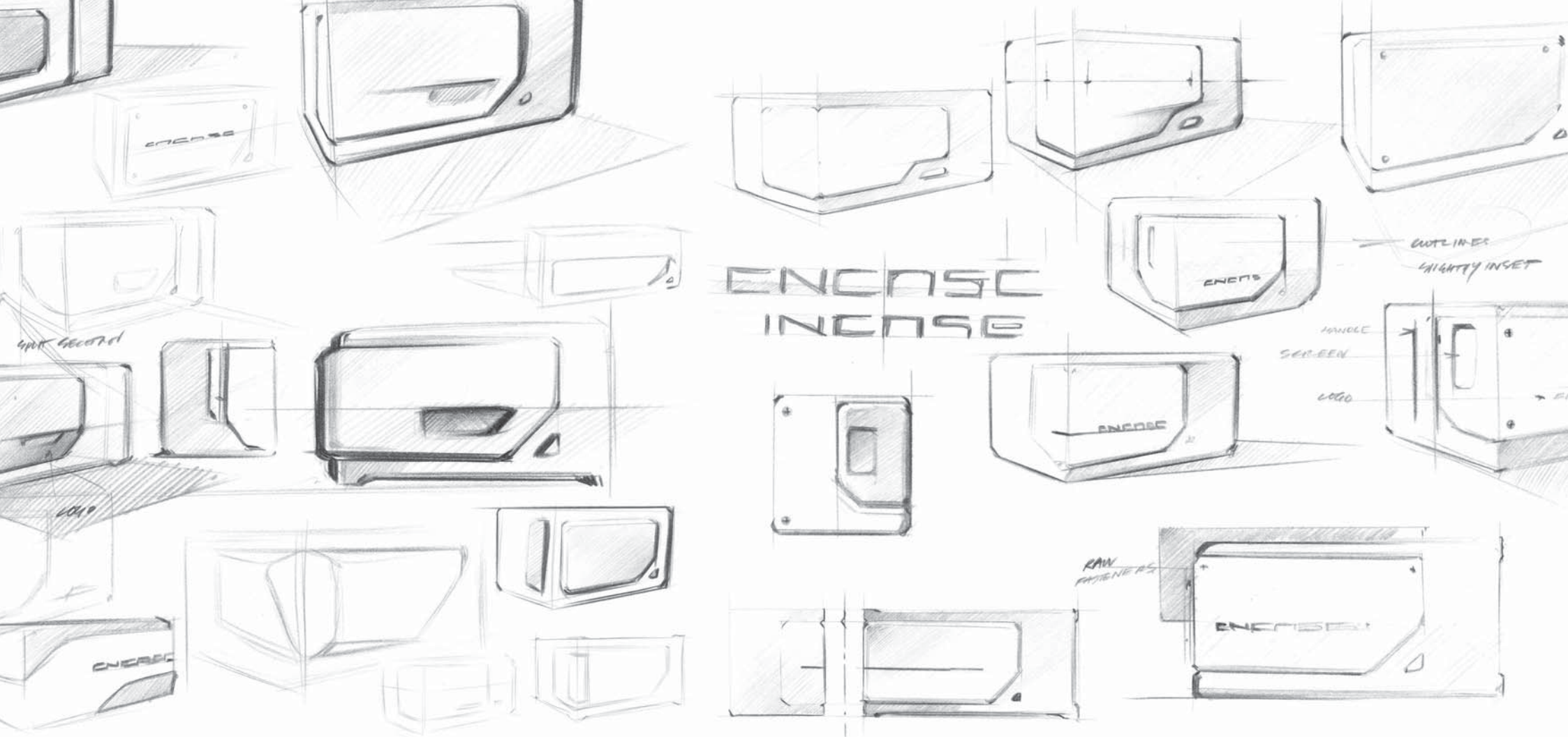


Figure 90. Early cardboard exploration of infrastructure



n and discussions with Sam McCafferty.

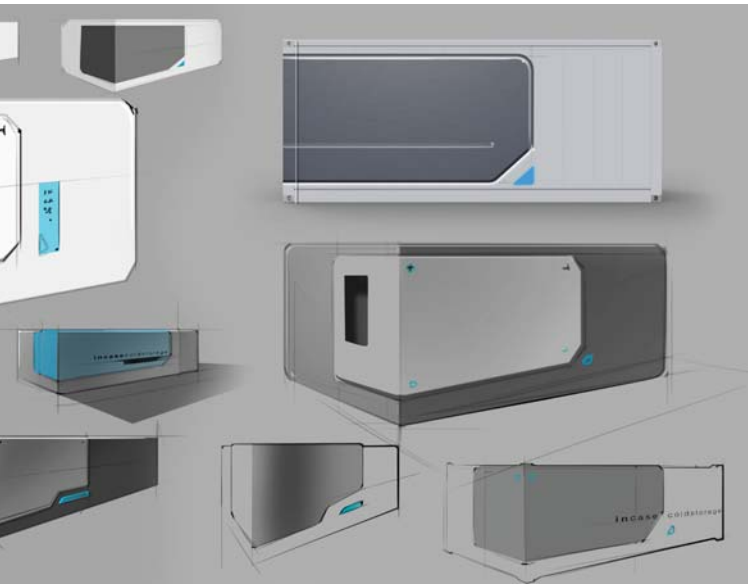
ombination of my prior knowledge
existing design skills were applied
propriately to develop the aesthetic and
al language of this project.

The shipping industry crosses many forms of transportation from physically harsh marine environments to negligent logistical movements. The visual language needs to reflect a robust and durable design as product-anarchy is common.

The innovation of this project is the rethinking of a system which has been unchanged since its introduction. Current shipping containers have a distinct and recognisable aesthetic, which is essentially a large metal box. My vision for this

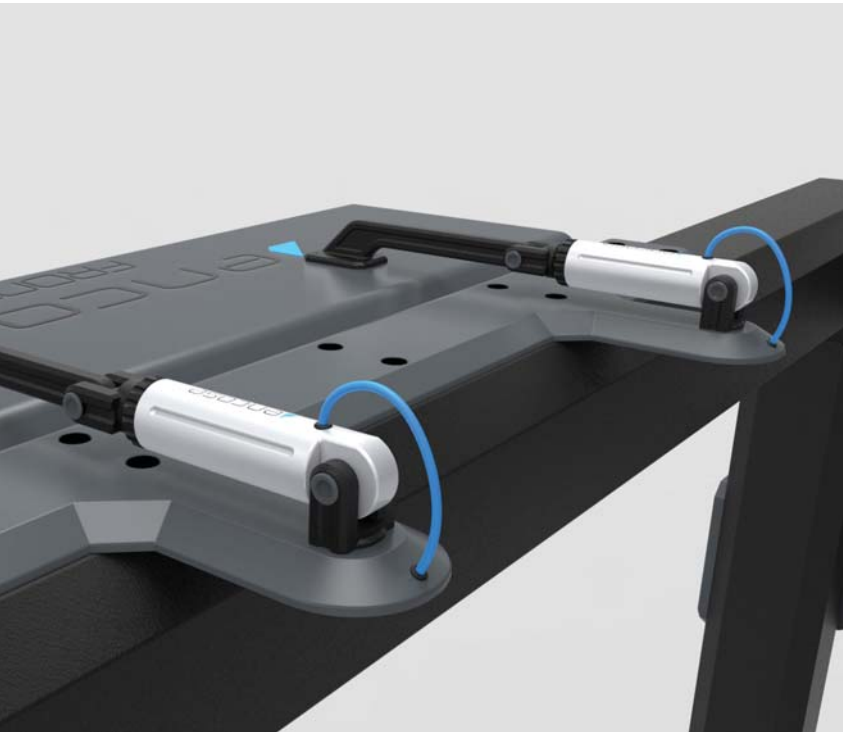
chamfers and balanced the
symmetry to aid in the com
unique system.

The main aesthetic cor
is the exterior panels of the
used to communicated two
panels wrap around opposi
creating a visual encasemer
and solidifying the flat-pack
tight assembled unit. Secor



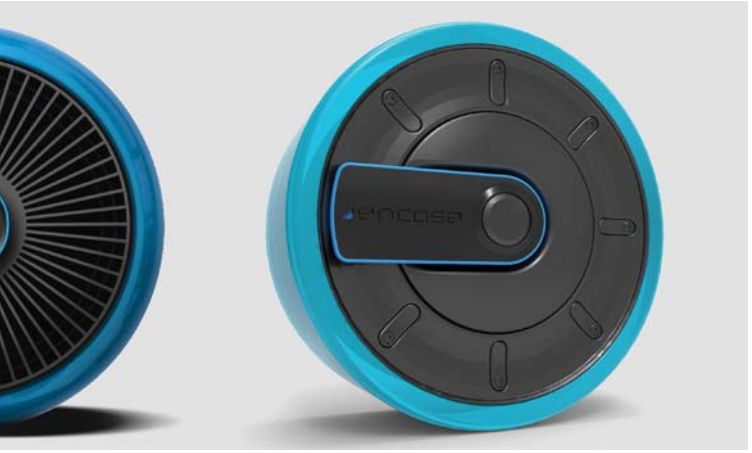
enforces aesthetic design language

Figure 94. Robust, balanced, considered and appropriate



n design language in all aspects of the

Figure 98. Durable, bold and appropriate design language communicated i
the infrastructure components



ns. I explored design language of all aspects in my design

Figure 100. I reflected a bold,
throughout the design

nalysis &

This Masters project has taken disciplinary design approach. I offered entirely new perspectiv role and scope of some New Z industrial design thinking beyo refining of status quo practices responding design objects.

It revisits the motivations and goals of core design practices, by scoping a larger, longer-term outlook. This also addresses the issues of identifying New Zealand's uniqueness in delivery well above other successful global producers with regards to value, quality, and safety of our primary export produce.

For this project I set out to produce a vision of how design could help the future of refrigerated export. This addresses some of the issues that global trade may

solutions within the many a possibilities related to glob the start of this project I wa step in developing a concep small iterations.

My reasoning for pursu was the thirst for a challeng of my honours year in Indus wanting more. This project

TRAJECTORY

This project introduced me to
scope of existing research, whi
able to focus my own research

Locating an area among the large scope which matched both my expertise and interest, opened up many research and design challenges, issues and obstacles. Each of these provided an opportunity to develop and refine my approach to creative problem solving and demonstrate mastery of my own enquiry, research and design processes. My aim for the future of this design and knowledge is to contribute to a larger global argument. Looking towards the future of New Zealand's global trade economy we can see how vital export meat products are. With increasing demand, I believe we as a nation should be considering the future of transportation in the export of primary product to meet global demand more efficiently.

I designed a flat-pack refrigerated shipping

by improving space efficien
product, eliminating human
product safety and quality a
the beginning of a new way
operation of the global tran
This project is a vision for th
will start a conversation of c
transportation systems with
shipping. It provides a platf
creative problem solvers an
investigate in greater detail
transportation and supply c
can be re-evaluated, improv
re-imagined. This industry h
untouched from a design o

NICHOLSON

I hope this project will start a
conversation for developing
the efficiency of future transp
systems with an ethos of sma
shipping through holistic syst
design analysis.

D E F G H I J L M N O P R S T U V

r aided design,
ftware

Inter-model

Involves the transportation of freight in a shipping container using multiple modes of transportation (rail, ocean and truck) without any handling if the freight itself when changing modes.

ISO

International Organisation of Standardisation. In the context of shipping containers refers to a international standard shipping container.

FTA

A Free Trade Agreement between New Zealand and China which liberalises and facilitates trade in goods and services, improves the business environment and promotes cooperation between the two countries in a broad range of economic areas.

NZ

New Zealand

Reefer

Refrigerated shipping container

TEU

Twenty-foot equivalent – a unit to describe the cargo capacity of a 20ft inter-modal shipping container. A 40ft container would be referred to as having a cargo capacity of 2 TEU.

MDF

Medium Density Fibre board

Primal Cut

A primal cut is a piece of meat initially separated from the carcass of an animal during butchering.

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