final report

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Feasibility study into the use of reusable plastic totes in the meat industry

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Abstract

This report details and discusses the capital expenditure required to convert an existing red meat processing facility from use of cardboard cartons to reusable plastic totes as the secondary packaging of both Primary Processing products, and Retail Ready products.

All financial data, product quantities, and some technical details have been removed or rounded to protect the interests of the plant. Each facility has its own unique layout, customer requirements, operating cost structure, and shareholder expectations; so any costs or returns should be taken as indicative only.

Impacts on, and by the wider supply chain are discussed but not included in the analysis, as they are beyond the scope of the research.

Executive Summary

A capital expenditure of $25M is required to convert all Retail Ready products, and a large portion of Primary Processing products from packing in cardboard cartons to reusable plastic totes. The annual benefit of the capital expenditure is an operational cost increase of $500k, resulting in a Net Present Value of -$25M.

The cost per use of totes in this study is $0.65. This is higher than the purchase cost of cardboard cartons used to package Retail Ready products, resulting in increased operational costs and a negative Net Present Value.

Regardless of the cost per use of totes, the operational savings through the reduction in expenditure on cardboard cartons is insufficient to recover the cost of capital expenditure over a 5 year period.

There are capital expenditure costs included in this project that will be unique to the plant, such as a dedicated conveyor network, and the conversion of a 2,000m^2 facility from defunct to a fully hygienic processing area for handling of clean totes. The capital expenditure costs is also exacerbated by inclusion of costs related to maintaining full functionality throughout the installation phase without interruption to business as usual deliveries to their customers.

The product handling of totes at cold store facilities associated with this facility must be modified, as the cold store automatically assigns destinations across conveyors and robots. Costs will vary significantly dependent upon the level of automation, and customer requirements for palletisation. In this instance, the cost is around $10M, which will deliver numerous automated palletisation workstations with stacking, buffering, labelling and pallet wrapping.

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1 Background

Reusable totes are widely utilised in the retail industry as secondary packaging of bread, milk, fruit, vegetables, and beverages. This project investigates the feasibility of utilising totes for the transportation of Retail Ready packed meats and/or Primal products.

Financial benefits were anticipated with the conversion to re-useable totes. The elimination of costs associated with purchase, stock holding, and later waste removal of cardboard cartons was anticipated to be significantly higher than the costs associated with re-use of totes. Further, non-financial benefits were also anticipated, however they are beyond the scope of this report.

Prior to the engagement of Apex Engineering Services Ltd (herein Apex) to complete this study, Apex engineering were engaged as part of a larger team of engineering consultants for the design of a new Retail Ready processing facility utilising plastic totes. While the conversion of an existing facility bring about additional challenges, Apex engineering were intimately aware of the detailed design aspects of related equipment and data management systems. Furthermore, Apex collaborated with an Australasian equipment supplier engaged at the new facility to determine costs for this plant.

In addition to functioning as Engineering Consultants, Apex has sole responsibility to provide maintenance and engineering services to a large Retail Ready facility operating in New Zealand, which utilises plastic totes for the storage of Primal's and distribution of Retail Ready packs to individual stores in the relevant supermarket chain.

The tote is a proprietary design, incorporating swing bars, ventilation slots, hand grips, unique identification markings, and incorporates a removable label for product and batch identification. There are two variants of the tote, with only the height changing between the two tote designs.

The feasibility study was undertaken at an Australian processing facility (herein the subject), dispatching over 150,000 cartons per week to a single cold store facility. Around two thirds of the cartons contain retail ready products, while the remaining one third contains products from Primary Processing.

3 Projective Objectives

The purpose of this project is to understand the feasibility of implementing a new tote design within the subjects processing facility and related cold store facility. The objectives are to:

- Set up a trial with a tote designed with the input of the subject and their client, which fits within current processing flow.
- Collect data through each of the project stages to support and understand the feasibility of using plastic totes.

Write a final report that covers the feasibility, costs and benefits of changing to use of totes.

4 Methodology

The following text has been copied directly from the contract:

The feasibility project team will comprise of representatives of the subject, the cold store operator, the subjects primary client, MLA and consultation by Apex Engineering Services Pty Ltd. The project team was formed prior to the commencement of the project to provide guidance and oversee the project.

The team will work collaboratively in an R&D partnership to gain an overview of existing operations and the intended benefits of replacing cardboard cartons with plastic totes into the subject's facility and the related cold store operator.

The following stages were proposed.

- Stage 1: Product Flow Study
- Stage 2: Provisional feasibility study for conversion to totes
- Stage 3: Preliminary cost verses benefit analysis
- Stage 4: Feasibility team submission to study sponsors
- Stage 5: Design and Process Implementation

The contract agreement detailed activities and deliverables by stage for both the subject and Apex.

6 Results

The feasibility of conversion from cartons to totes will be determined by both financial and non-financial measures. This study investigates and specifies the financial benefits to the subjects operation, but does not attempt to quantify either the financial benefits throughout the wider supply chain, or the non-financial benefits to the subject's primary client.

6.1 Financial Feasibility: conversion from carton to tote at subjects plant

The table below details the Capital Costs and Operational Cost benefits to the subject's operation, when converting both Retail Ready and Primary Processing, when completed as a large single Capital Expenditure Project.

Processing Lines	**Capital Cost**
Pallet recieval, depalletising, accumulation, conveyors to Retail Ready, civil works.	$ 10 M
Ten Retail Ready Packing Lines	$ 8 M
Primary Processing	$ 3 M
Data Integration	$ 2 M
TOTAL	**$ 23 M**

Table 1: Capital Equipment Cost

The table below details the forecast operational cost benefits per annum once all equipment has been installed and successfully commissioned.

Processing Lines	**Operational Benefit per annum**
Retail Ready	-$300k
Primary Processing	+$300k
Common Facilities	-$600k
Total	**-$600k**

Table 2: Changes to operational cost due to conversion from carton to tote

The operational cost benefits arise primarily through a reduction in quantity of cartons and glue procured and a reduction in labour at the carton erectors and the individual packing areas. These are offset by the costs of operating the tote recieval area and the cost per use of totes.

Utilising the MLA financial analysis tool, the Net Present Value of the project proposal is -$25M. The magnitude of the loss is greater than the cost of the capital equipment due to the ongoing negative impact on operational costs.

6.1.1 Retail Ready:

All Retail Ready products can be successfully packaged and transported in plastic totes.

Dedicated carton erectors can be disestablished, and the costs associated to cardboard cartons can be eliminated; however the purchase price of cardboard cartons is lower than the cost per use of totes, resulting in a negative operational cost benefit.

6.1.2 Primary Processing:

Primary Processing comprises of Primal's, Trim and Offal products. Of those, only the Primal's are likely to be converted to tote in significant volumes. Trim is typically packed into bulk vessels or is packed for freezing which is unlikely to be viable in totes. Offal is typically exported, where it is considered unlikely a tote return system will be viable, so use of cardboard cartons must be maintained.

A different carton, to that used in Retail Ready is utilised for packing of primal's that has a purchase cost higher than the cost per use of the proposed plastic totes. This results in a positive operational cost benefit.

6.2 Financial Feasibility – conversion of the cold store operation to mixed tote and carton

There are independent systems servicing Primary Processing products, and Retail Ready products at the cold store operation that require conversion from carton to tote handling.

Primary Processing products are directed through a cooling system to a dedicated carton palletiser. It is proposed to duplicate the palletising system for Primary Processing to deliver a second palletiser that will only function with totes.

Retail Ready products are currently palletised manually. The proposal automates the palletising process and introduces significant accumulation prior to palletising.

Operational benefits arise from a reduction in manual labour, and health and safety considerations of manual handling of high volumes of product.

7 Discussion

The following discussion points provide additional detail and commentary regarding the results above. There are many factors that have contributed to the negative Net Present Value that collectively may yield a better financial outcome as the factors are altered. Options to improve the Net Present Value have been explored, and some unintended consequences discussed.

7.1 Impact of MLA tool on financial outcomes

The standard MLA tool has been utilised to calculate Net Present Value. The following should be noted in conjunction with the financial results:

- The MLA tool assumes nil compound growth in sales, so the volumes for the current year, stand for all future years.
- The MLA tool calculates Net Present Value over 5 years only. This equipment will be in service for a minimum of 10 years.
- Net Present Value calculations in the MLA tool assume all works are complete in year 1, and that a full years benefits are realised in year 1. Equipment lead times and installation restrictions will push a portion of capital expenditure into years 2 and 3, with benefits ramping up from year 2 onwards.

7.2 Assumptions and other factors influencing feasibility

- Equipment and other capital costs are budgetary only, with an estimated accuracy of +/-20%
- Changes in operational cost is estimated based upon typical per square meter rates for processing areas, lease rates of forklifts etc.
- A substantial portion of the projects costs is the conversion of a defunct 2,000m^2 facility to a fully hygienic facility, including suitable ventilation, lighting, wall and ceiling panels, floor coatings, fire protection systems and new electrical infeed.
- Installation and commissioning costs are estimates only based upon restricted access times and requirements to leave the facility operational between visits. This would be refined as access arrangements were clarified later in the project.
- Interest rate for Net Present Value calculations has been set at 7%
- Cost per use of the totes has been set at $0.65.

7.3 Discussion on high capital costs.

Apex Engineering acknowledge that the cost of Capital Investment is higher than would be expected. A significant portion of the costs are incurred as the tote handling system must be overlaid on an existing plant layout which cannot be shutdown, rather than being incorporated into a new plant layout, or a significant overhaul of an existing plant. The facility has developed organically over time as opportunities arose, with each addition constructed in the most cost effective solution, with carton packing functions widely spread between interconnecting buildings.

The following discussion provides some details.

7.3.1 Costs incurred by conducting installation works in a live facility

Capital costs and project duration are significantly impacted by the requirement to maintain business as usual operations, enabling production processing to be completed at the normal schedules. See section 7.11

The requirement to maintain normal production has also altered the design of the tote distribution system, necessitating the inclusion of a new elevated conveyor set running through some of the Retail Ready

7.3.2 Impact of health and safety considerations

Capital costs are impacted by health and safety considerations. These include

- A requirement to have permanent platforms in areas where regular maintenance access is required to elevated plastic tote distribution conveyors.
- The network of conveyors required to service tote packing stations is very long, as required to service the widely distributed locations of plastic tote packing. Due to the length of conveyor network, and the resulting time for the totes to travel the path, it is necessary to install a secondary buffer of clean totes. As the floor area is consumed with processing equipment and related services, a 200m^2 raised platform must be constructed to house the secondary buffer of clean totes.

- Significant costs will also be incurred ensuring that installation sites are safe for production operators to be around during normal production. When equipment is being installed overhead of normal operations it is likely the area below will be required to be barricaded.

7.3.3 Resolution of existing plant issues

As this is an existing processing facility, that has been developed over time there are issues that must be resolved, during the conversion from cartons to plastic totes.

- The bottleneck rate in the cold store facility is above the typical rate of supply from the subject, however the subject has the capability to exceed the bottleneck rate of the cold store facility, particularly in the lead-up to promotions and/or public holidays when elevated demand requires more processing lines to be functioning simultaneously.
- Depending upon the operational circumstances, equipment limitations in Primary Processing can become the bottleneck.
- Inbound plastic totes coming into Primary Processing will operate
- Factory supervision software in some parts of the facility is outdated, and no longer supported. These areas will be converted to the new, replacement software.

7.3.4 Impact of existing plant layout

- The civil works cost of converting a defunct space to a hygienic processing area for the recieval and storage of clean totes.
- The conveyor network is required to change elevation levels many times throughout the plant. This adds complexity and risk as Retail Ready trays can be dislodged from their neat stacks, and stacks of nested clean totes can topple over. The designated plastic tote recieval area is on the 2nd story, requiring a pallet elevator.
- The path between the plastic tote recieval and buffer, to the first usage point is torturous in both horizontal and vertical directions, and requires construction of a small enclosed bridge.
- The distance between the first plastic tote usage point, and the last necessitates the inclusion of a second large accumulation system to guarantee supply to distant plastic tote packing lines.
- For various reasons, the technical solution is required to have a single supply conveyor, delivering clean totes to all plastic tote packing stations. Careful design consideration is required to ensure each work station is not periodically starved, and the system is not clogged with unwanted totes as there are two sizes of totes sent down the same line.

7.4 Supply chain considerations

7.4.1 Internal tote washing (at depalletising location)

The supply and usage of plastic totes within a network of facilities must be considered when designing the overall distribution of facilities including hygienic washing facilities, and buffer storage facilities.

While small processing plants may benefit from distributing the expense of a centralised washing and storage facility, larger facilities will find it easier to justify the cost of their own washing and storage facilities, and will be able to avoid or minimise costs associated with:

- Clean tote palletising, wrapping, labelling and storage
- Transportation costs from tote wash facility to processing facilities
- Depreciation of capital assets at the tote wash facility
- Profit margin for tote wash operator

At the subject's facility, a reduction in plastic tote usage charges from $0.65 to $0.45, coupled with a one off investment of $2M, would improve the Net Present Value by $4M. It is envisaged the $0.45 cost per use, would recover:

- Transport from retail store to the subjects facility (possibly via DC)
- Operating costs of tote washer
- Repair and Maintenance, including replacement of worn totes
- Storage of clean totes on pallets
- Depreciation of totes

7.4.2 Quantity of totes in service, and the impact on equipment design

The total number of totes in service is proportional to the duration it takes for the totes to move from packing plant, to the retailer, and back to the packing plant. This is assumed to be 10 days for the purpose of this discussion.

At the subject's facility, the quantity of totes required to service an average 10 day period is 260,000 totes, which increases to 320,000 totes in peak times such as the Christmas/ New Year period. The increase will be further exacerbated by the closure of distribution centres, retail stores, tote wash facilities and meat processing plants over the period.

The overall supply chain can respond to the increased demand in totes, by purchasing and storing the total quantity of totes required to service the peak period, or the manufacturing plants can be required to supply product in cardboard cartons once the supply of totes run out.

A requirement for the equipment at the subject's facility to operate at peak rates with totes or cardboard cartons will likely increase the equipment costs, and will greatly increase the complexity of commissioning.

There will also be a significant impact on the palletising equipment at the cold storage operation, which are likely to have robotic heads uniquely designed for collecting and palletising totes only. A significant increase in capital expenditure would be incurred if a secondary set of robotic heads were required for cartons, and a significant volume of product

would be required during commissioning to develop and validate picking and stacking with a different interlocking stack design for each alternative carton size.

Totes which are not in use will need to be stored. Where the maximum quantity of required totes is 320,000 to service the peak 10 day turnaround cycle, the minimum quantity in use is 150,000. The difference (170,000) must therefore be store, likely clean and stacked on pallets. This will likely require around 900 pallet storage locations. If a centralised tote washing facility was used, the quantity of storage locations required would increase as each meat processor will have a similar uplift or drop in demand based upon holidays and seasonal effects.

The overall supply chain design, will require consideration of where totes should be stored. Storage at the tote wash facility may be a lower cost than at a processing plant, and may reduce shortages at the tote wash facility and oversupply at other plants. Consideration needs to be made of the delivery service levels of the totes to the subject to guarantee supply and eliminate the risk of downtime on the processing lines.

As shortages may occur, it is a critical design element that the depalletising facility can supply the rates required to match the packing lines.

7.4.3 Cold Store Operation

Mid-way through this project it was advised that the cold store operation had undertaken an independent project to investigate the feasibility of automating palletising operations, and moving from a single SKU per pallet, to a store order per pallet.

The technical solution developed for this project only encompassed the conversion from cartons to plastic totes, not considering the requirements for store order pallets. Store order pallets require many SKU’s of product to be held inside a buffer chiller, which must be autonomous to be effective.

The solution for the cold store operation consists of two independent systems.

The first palletises all Primary products from the chiller system that are in totes. The existing system will be retained for export products, which will still be packed in cartons. The second system palletises all Retail Ready products.

All tote handling and palletising is to be autonomous, as the required rates, tote weights and ergonomics do not suit manual processes.

The estimated cost for both systems is: $9M +/-20%

7.4.5 Customer order schedules

The scheduling and forecasting systems and timing of customer orders, has a large impact on how each facility operates. In the subjects operation the orders cannot be received and complied each day before the production crew start on the floor. Therefore regular, high demand product must be produced first before other products which vary more in demand on a day to day basis.

As the destination of products produced before the orders are compiled cannot be determined, the product must be retained after individual product packing, but prior to labelling of the carton/tote and subsequent dispatch to the cold store.

When the compiled order is released, the backlog of product can be released. This causes a significant but temporary increase in the rate being dispatched to the cold store, as the backlog is released while production continues as normal.

The system proposed for the subject does not include ability to store the backlog, and does not include the ability to function at the elevated rate. It is assumed these issues are better resolved through improved communications from the customer.

7.4.6 Primary Processing - duplication of work orders

Currently when Primal's are packed into cartons the facility where the next stage of processing will be completed is unknown, with all being sent to the cold storage operation for aging. Around 20% of Primal's are called back for further processing, with the remaining 80% sent to other facilities.

As some of those 80% are distributed to other States or organisations, it may be impractical to arrange return of the plastic tote. To enable a portion to be packed into plastic totes, it is proposed to generate a second packing specification for each primal, and split each days production quantity. The addition of secondary packing specifications for each Primal's, will cause a duplication of work orders.

7.4.7 Primary Processing – cut plan and forecast accuracy

The portion of primal's packaged into totes will need to match the forecast consumption after aging. As plants other than the subjects facility adapt to recieval of Primal's in totes, the quantity or portion used may be increased.

Careful consideration is required to ensure that totes are not overused, to ensure that losses associated with downgrading of product is minimised. It is anticipated that this could occur when large quantities of Primal's in totes are approaching product age at delivery limits. The alternative of repacking into cartons to facilitate dispatch to other processors is considered undesirable due to the incremental cost.

The duplication of packing specifications will likely proliferate through the cold store operation, and through other facilities after they are converted or otherwise able to receive plastic totes, or either plastic totes and/or cartons.

Responsibility between processor and customer, for determining the optimal quantity or proportion of totes must be clarified, to ensure that costs of associated product loss, downgrading, or repackaging is routed to the appropriate company.

The increased quantity of stock keeping units will increase the complexity at the subject's daily production scheduling, based upon the weekly plan.

7.4.8 Primary Processing – destination of totes

As per section 0, the Net Present Value calculations have been based upon a full conversion of domestic cartons of Primal's to Totes.

If totes are to be dispatched to other states, where a similar or identical crate is in use with other crate washing facilities, ownership and traceability must be considered.

7.5 Sensitivity to tote usage costs.

Financial feasibility of the project is directly related to the quoted cost per use of totes ($0.65) as this is significantly higher than the cost of the Retail Ready cartons currently in use.

The cost per use of crates will include a portion for repair and maintenance of the crates in service, and replacement cost when the individual totes reach end of life. The actual future cost of repairs and maintenance will be directly related to the durability of the tote, and the roughness of handling around the supply chain.

The selection and design of equipment at the subjects facility has ensured that totes are handled with care, and are unlikely to be damaged during normal handling at their facility. This level of care and detailed design has incurred additional capital expenditure, to minimise the ongoing costs of repairs and maintenance. The additional capital expenditure should have a benefit, otherwise when considered in isolation, the subject would be better off by installing cheaper equipment that was rough on the totes, with a high rate of damage caused.

The chart below graphically demonstrates the sensitivity of Net Present Value, against the cost per use of the tote. As the cost per use trends towards zero, the Net Present Value remains negative as the reduced operational expense of carton purchase is inadequate to repay the required capital expenditure.

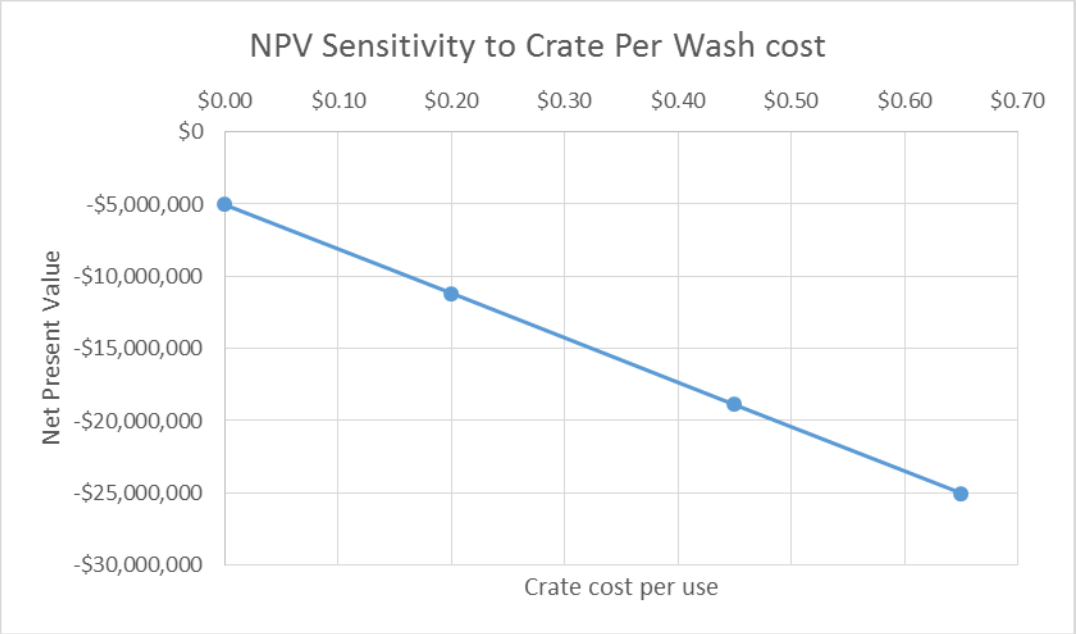

Table 3: Sensitivity of Net Present Value to changes in the cost per use of totes

This result is caused by the relatively low purchase cost of cartons per annum against the relatively large capital cost of the project. As the MLA tool only considers a 5 year period and no growth, the cost of cartons for five years is lower than the capital costs.

For the purpose of the above discussion, it has been assumed that the existing tote washing facility cannot be utilised to clean incoming totes.

7.6 Product packing specifications

A detailed review was conducted to review the quantity of individual product units (primary packaging) that could be retained in the tote (secondary packaging). The subject utilises a wide variety of tray formats and depths each of which required validation, while other products are vacuum packed with significant natural variation between individual products.

7.6.1 Primary Processing – tampering of Primary Processing products

Cartons sealed with glue are inherently tamper proof, as is strapping of cartons to a lesser degree. There are various forms of tampering that must be considered if applicable.

- Product may be removed from liners.
- Foreign matter may be inserted into liners
- The contents of totes can be swapped while still being sealed inside liners.

If it is determined that evidence of tampering is required, this can be achieved utilising the plastic liner that is inside the current carton, and will be reused in totes. A system will need to be devised, equipment procured, and operational labour and consumable costs considered as it has not been investigated by this study. One option, amongst many, is to apply a third printed label across a top fold in the liner. A printed label showing product code and relevant dates is possibly required, as products in sealed liners could be easily moved between totes. Both the label and liner may need to be a tamper evident type.

7.6.2 Primary Processing – quantity of primal's

Primary Processing products required a detailed review utilising actual totes and product due to the irregular shape and size of each product, and the natural variation between products from different carcasses. Bone in products typically could be manipulated to fit the required quantity per tote. Bone out products, particularly large primal's proved more difficult, often with one end of the primal protruding above the top level of the tote.

Current processes within the primary processing packaging areas allow primal's to protrude over the top edge of the carton, as the lidding process actively pushes the lid down as it is applied and glued in place. Furthermore it is currently acceptable for the cardboard lid to deflect around the contents, resulting in a bulge in the packaging.

Further validation is required, to determine the optimal quantity per tote of the large bone in primal's.

7.6.3 Primary Processing – trim removal once frozen

Trim is currently packaged as per the process described above for primal's, with a greater force applied during lidding to remove air gaps between the individual pieces of trim. Trim is later frozen, and utilised as a raw material in further processing, while still in frozen form. If Trim were crushed into totes in a similar manner to the cartons, the contents would be pushed outwards into the ventilation holes in the sidewalls of the tote. Once frozen, it will become impractical to remove the contents of the tote as the frozen contents would be interlocked with the sidewalls of the tote.

7.6.4

7.6.5 Retail Ready – optimal packing pattern

Retail Ready products packed in trays are ideally suited to packing in totes due to their uniform shape. Trays are to be stacked without interlocking. Where possible each level of trays should be complete to minimise scuffing caused by trays moving horizontally during transit.

During site trials it was noted that when the totes are bumped, the stacked contents can move around within the tote in a haphazard fashion. This may result in trays protruding through handle openings or protruding over the side of the tote. This is likely to occur in packing configurations where there is a significant space around the trays.

7.7 Retaining products inside totes during transit

Totes are typically open at the top, with bail arm mechanisms to carry the weight of totes stacked on top. There are no other design features to otherwise close the lid of the tote.

Packed totes are typically moved around the facility on conveyors, which has associated equipment such as sensors or fastenings for the conveyor itself in close proximity of the tote as it passes over the conveyor. When a tote passes by with protruding product, the primary packaging of the project may be damaged and the item hit by the product may be effected, such as sensor alignment.

Trials during this project identified that the internal contents of the tote can be disrupted by severe conveyor transfers, caused by large gaps or level changes, and orientation changes such as when packed totes are transferred over incline or decline conveyors.

7.7.1 Retail Ready products

Product contained within totes as secondary packaging are only retained in the tote by forces of gravity, and the presence of bail arms. As totes transfer between conveyors the impact causes the product to move in both horizontal and vertical directions. A severe impact can transfer sufficient energy to the product that it can either become totally or partially dislodged from within the tote. The product may become lost with product falling to the ground and lost, or the product may be angled upwards protruding from the confines of the tote. Any product protruding from the case, either through the opening at the top, or potentially through the cavities associated with the handles is at risk of damage as the tote passes by equipment and/or fixtures within close proximity. Any such damage would be unlikely to be detected prior to arrival at retail stores.

A similar effect can be caused by totes passing onto incline or decline conveyors. The transfer onto and off these conveyors can drop one end of the tote causing a similar impact and effect described above. Furthermore, while on the incline or decline conveyors the product in the tote will move and resettle with the change in orientation. Where products are neatly stacked inside a partially full tote, the stack may topple with the products landing in a haphazard fashion. It is possible in this circumstance that product may protrude from the top of the tote, or may protrude from the handle holes.

Transfers between conveyors should be level, and totes should remain horizontal as they are transferred through the plant to ensure product does not become dislodged from the totes.

Similar effects are possible as totes move through the supply chain, however the likelihood of damage to products is lower as totes are handled as stacks on pallets, with de-stacking and unloading being manually undertaken.

7.7.2 Primary Processing products

Product contained within totes as secondary packaging are only retained in the tote by forces of gravity, the presence of bail arms, and the plastic liner which is folded and secured over the contents of the tote.

Bone out product such as tenderloin and rump are unlikely to move during transit as the individual components bind together and will be packed tight into the tote.

Bone in product, especially large products such as T-Bone are likely to move during transit when the tote receives and impact or a change in orientation. It is unlikely the person packing the tote will be able to interlock the large primal's, and some will sit at obscure angles within the tote. With only a small bump the primal's can move within the tote, and pivot into a new position, potentially protruding from the tote.

Further Research Required: alternative tote liner materials providing an armoured enclosure.

7.8 Equipment and processes

7.8.1 Pallet storage:

Pallets of cartons are currently unloaded to a holding area, where they can either be dispatched directly to the processing lines, or moved into a remote store location. The quantity of cartons per pallet varies depending on carton size, with 500-700 typically on each pallet. Pallets are stored in a remote location three high, being stacked directly on top of each other. On a random day, it was observed that there were nearly 400 pallets of cartons in the store.

Totes will arrive nested in stacks with 180 per pallet. These pallets cannot be stacked, as the totes have not been designed to withstand the load of a full pallet. Therefore, the floor space required to hold an equivalent quantity of secondary packs has increased. Previously each pallet footprint could hold 1500-2100 secondary packs, but will now only hold 180 secondary packs. Totes on pallets would typically be stored on multi-level flow racking, however there is insufficient ceiling height in the proposed clean tote recieval area.

7.8.2 Depalletising and tote accumulation

Currently cartons are manually loaded directly into carton erectors that are located adjacent to process areas. Stacks of empty erected cartons are stocked on the production floor to buffer against the likelihood of breakdowns.

Due to the space required to depalletise and accumulate empty totes in a hygienic area, it is necessary to construct an additional hygienic facility, with tote handling conveyors incurring capital expense and ongoing operational and maintenance costs. The size and cost of this system directly relate to the required buffer duration, where the facility can operate without depalletising. In this solution, 2 hours of buffer has been utilised.

It is anticipated with this automated solution, the entire clean tote recieval, depalletising and buffer store could be operated by a single individual, who's primary task is to remove wrapping and slip sheets from the pallets. These functions could be automated, but would leave the operator no tasks to complete, or render the entire old slaughter facility

autonomous. Any issues such as displaced stacks would have to be responded to by a remotely based operator.

7.8.3 Tote storage hygienic requirements

For the purposes of this project, the totes are to be washed at an offsite facility. These are to be nested and loaded onto pallets for transportation. Each pallet is to be stretched wrapped and uniquely identified by label.

To maintain hygiene levels, the handling and storage of totes must be treated similar to that of raw materials or ingredients.

Pallets must be removed from the truck and must be immediately transferred into a pest and weather free environment. A full risk assessment will be required to clarify that an overhead canopy is not required, particularly during wet weather when rain can enter the stretch wrap.

The integrity of the pallet wrapping must be maintained, until the pallet has been moved into a fully hygienic facility. Once in a fully hygienic facility, the stacks can be removed from the pallet, and stored in an accumulation conveyor system.

7.8.4 Optional secondary tote washer onsite

An option to reduce the cost per use of the totes, is to install and operate a dedicated tote washing facility at the depalletising location. Totes would be routed directly from the truck into a small fully hygienic room where totes would be depalletised and washed, before being sent out for use as normal. This will require civil works, and additional equipment including the tote wash and a second pallet lift section for recieval of dirty totes.

7.8.5 Tote cleanliness upon arrival – AQIS licenced meat export facility

As the facility is accredited for export of meat products, there are additional control measures that are required. At this early stage in the project to introduce reusable totes to the plant, it is unclear the specific verification checks that the qualifying agency will accept. No equipment or facilities for this has been included in the Capital Cost estimate.

A risk remains, that the qualifying agency may demand onsite washing and/or sterilising of all totes entering the plant. An alternative, is that the tote washing facility may be considered an offsite operation of the subject and subject to the same monitoring and controls requirements.

7.8.6 Tote supply rates

Current processes around the facility include multiple independent carton erectors and conveyor distribution systems to the packing work stations. Due to ongoing reliability issues with the carton erectors, stock of assembled cartons is maintained on the lines. This acts as a buffer for downtime, and also allows each line to exceed the rate of supply from the carton erectors.

Each carton erector supplies multiple packing work stations, each of which may or may not be operational simultaneously, typically depending on the overall facility run hours for the days production demand.

With the transition to totes, it is proposed to eliminate the practice of storing empty totes on the lines. These may be contaminated during wash-down, and would then require offsite washing.

The tote supply system must therefore be designed to meet the peak tote demand cycles.

For this project it has been assumed that all lines will not be planned to operate simultaneously and furthermore each will be subject to the efficiency losses of Overall Equipment Effectiveness.

7.8.7 Tote labelling

Current formatting of carton labels are unique to this plant, while being designed to meet the requirements of the retailer and all relevant legislative and certification bodies.

It is proposed to alter the format of retail products to standardise with the retailers own operations The label stock would be purchased from the same vendor, incorporating the same adhesive suited to automated removal during tote washing.

Primary processing products must have a new format of label, incorporating additional details. Furthermore this label is required to be non-removable to eliminate the possibility of tampering.

Primary processing will required additional labels to secure the liner closed, and will require matching details with the tote label to enable validation that the liner and its contents match the tote. The label used to seal the liner closed will need to be permanent and tamper proof.

The equipment proposal for the facility includes two tote labellers for each packing line. This facilitates application of tote labels onto opposing ends of the tote. This decision was made as rates at palletising are considered prohibitive of selective tote turning to ensure labels are presented outwards from the pallets. While palletising may not be automated now, it is considered prudent to design and allow sufficient space for a second label applicator. Moving and reconfiguring the pack off equipment in the future will cause significant additional expense. It is also possible that an abrupt turning moment may have a similar effect to a transfer on or off incline conveyors, causing trays stacks to be disrupted, resulting in trays protruding above the top edge of the tote.

If/When generating new tote labels consideration must be made for the capability and location of existing inline sensors, the taper angle of the totes surface where the label will be applied, and the location on the tote must be suitably flat and with a surface finish suited to the label material and wash off process.

Further research is required:

- Whether an open tote can meet the requirements and spirit of legalisation, and if not whether tamper evident tote liners and/or sealing labels could be utilised.

7.9 Tote design or selection

The tote utilised throughout the design of the system, is the proprietary design of the primary customer. This tote has hinged bail arms that allow totes to be withdrawn and stacked in a nested pattern greatly increasing the quantity that can be packed per pallet. With bail arms engaged the totes can sit on each other without applying load to the product within.

7.9.1 Thermal conductivity

All product from Primary Processing (trim, offal, and primal's) and routed through chillers at the cold store operation. The retention duration has been historically validated as being suitable for cardboard cartons. Swapping the secondary packaging from a fully enclosing cardboard insulator, to a plastic tote with many ventilation openings will reduce the retention period required.

A reduction in retention duration will increase the throughput capacity of the chillers, the heat load on the chillers, which may result in a cost reduction to the primary customer.

Similarly, primary products that pass through warm environments will thermally react quicker than products packed in cardboard cartons. This will require further validation through the distribution processes for products dispatched offsite.

7.9.2 Robustness

Single use cartons, currently utilised for secondary packaging are not expected to arrive in immaculate condition. There is acceptance that cartons may be damaged on the processing line or in transit as long as the contents are protected from harm. This allows the current facility to utilise processes to transfer empty cartons through gravity fed raceways.

Due to the increased weight of the secondary pack (tote vs. carton) and a desire to maintain tote expected lifetime, it is no longer practical to utilise gravity fed raceways to deliver totes to each line.

It is noted that the expected lifetime of the tote is directly related to the quality of tote handling and the associated transitions between equipment. Further investigation is required into the assumptions utilised to calculate the cost per use of totes. It may be possible to reduce this cost, if the expected lifetime of totes can be increased.

7.9.3 Retention of fluids

Consideration is required, where loaded totes can pass over other loaded totes. The open structure of the totes allows leaked fluids to escape the secondary packaging, and ultimately drip on product below. This may be unacceptable to HALAL inspectors, and further investigation is required.

7.10 Automation

Two opportunities for increased automation were considered through the development of the final solution.

The first opportunity was the introduction of automated case packers on a number of the high speed Retail Ready production lines. If these lines are planned to be automated within the next 3 years, the overall capital expenditure cost will be lower if automation is installed

upfront, and it will avoid having to write off partially depreciated assets unique to the manual operation. However, the automated solution requires additional floor space which is not immediately available without incurring other expenses.

The comparable equipment costs per line are:

- Manual Packing workstations: $600k
- Automated Packing: $1M

The second opportunity is the elimination of the pallet handling forklift to be permanently located into the clean tote recieval area. The comparable equipment costs are:

- With additional forklift and driver: $2.7M
- With automation: $3.4M

The overall capital expenditure with four automated case packers and automated pallet handling increases as follows:

	Operational Cost	Capital Cost	Net Present Value
Manual handing	-$500k	$25M	-$25 M
Limited Automation	-$400k	$28M	-$28 M

Table 4: Impact on Net Present Value of select Automation

As the Net Present Value has decreased, the manual solution is preferable.

7.11 Installation and commissioning restrictions

The subject has explicitly asked for a proposal, where all installation and commissioning works that impact current production processes must be completed outside normal operating hours. This will have an impact on project schedule and cost.

7.11.1 Project schedule.

The entire project duration is forecast to take 30 months from approval of capital funding until the commissioning of the final processing line is complete.

A significant portion of this duration is incurred during installation and commissioning of equipment inside the current processing areas, as the subject has specified that all works must be inside the ~24 hour period after Saturday production, and prior to Monday morning wash-down.

At the completion of each period of work, the area must be left clean as it is within the processing areas, and must be safe for operational staff who will be working in close proximity to the recently installed equipment.

7.11.2 Project cost

The restrictions on access for installation and commissioning will increase cost in the following ways:

1) Some equipment vendors will not have a local presence, and will be relying on a remote workforce to work remotely at the site. Typically engineers would be flown to the site and would work continuously at site until finished, when they would return

home. This arrangement would not be practical when access is only available one day per week, so a subcontracting workforce would be required at additional cost. Supervisors and technical leads from equipment vendors will still be required on site, likely being flown in/out at regularly intervals at significantly escalated costs.

2) Reduced efficiency as each day a full work setup, breakdown and clean-up is required. Temporary measures may be required to be fabricated and installed to ensure operator safety – such as when overhead walkways are partially completed/ partially installed.
3) Due to the restrictions, it is only practical to work on a single processing line at a time, over a period of approximately 10 months. Over the 10 month period lines will progressively switch from supplying product in cartons to product in totes. Therefore, full operation of the carton erectors must be maintained and supply to the various lines cannot be compromised. This is one (of many) reasons why a new overhead conveyor system is required to feed stacked totes throughout the plant. As there is no space remaining around the existing carton distribution system, a new overhead conveyor system with access platforms is required at significant cost.

The total incremental cost of the restrictions has been included in the capital cost estimate as $600k. It is likely that the final magnitude of restrictions and the incremental cost will vary significantly from the estimate as all parties negotiate to determine the best possible outcome as a balance of project duration and cost.

7.11.3 Health and safety of operators

A significant portion of the installation works in the processing areas, is to install the tote accumulation and distribution systems which are overhead of current production equipment. To ensure safety of the subject's employees below, it is likely that some areas will need to be barricaded off, or otherwise secured to guarantee zero harm at work.

Despite best efforts, it may be impossible to avoid impacting production. Current production equipment may need to be temporarily relocated to allow production to continue, and egress walkways may be compromised which will require careful management where exiting the building in an emergency is impacted.

7.12 Industry perspectives

7.12.1 Industry perspective – feasibility factors

The feasibility of conversion to totes depends upon a number of factors

- Automated delivery of empty totes and extraction of packed totes suits high speed, high volume production lines. Production lines that are either low speed or produce low quantities of product daily would suit manual delivery of totes to the packing lines. Careful consideration is required regarding the rate of manual delivery, and ergonomic considerations of moving stacks of totes manually, as each tote weighs up to 1.9kg each.
- Depalletising of 30 nested totes per stack is not suited to manual operations as the weight of the stack is 56kg. For plants using few totes per day it will not be viable to install a $12M automated solution. An alternative solution would need to be developed with less automation and less accumulation.

The purchasing power of the subject is high, due to the large volume of cartons that are consumed daily. Other plants utilising less cartons will be forced to purchase cartons at a higher cost, and in turn will yield greater operational cost benefits.

8 Conclusions and recommendations

8.1 Overall statement

Conversion of an existing operational facility such as that of the subject, from carton packing to tote packing is unfeasible as the capital expenditure is amplified by costs associated with nonsensical retrofitting of tote distribution conveyors around a facility from a remote depalletising area that will be located where space permits rather than by good design. Packing operations in the subject's facility are widely distributed around the plant, serviced by multiple independent case erectors which are located near the packing line, where interruptions caused by installation cannot be tolerated as dispatches to retail stores would be negatively impacted.

The cost per use of totes, is higher than the purchase price of the cartons utilised in Retail Ready negating cost savings and eliminating the recovery mechanism of capital expenditure that would typically be used to justify a project.

Purely on the basis of financial analysis of the subject's facility in isolation it is the recommendation of Apex Engineering to decline a request for capital funding of this project.

However, there are likely many costs and benefits that have not been captured as they fall outside of this study which focused solely upon the subjects plant. If a wider supply chain financial analysis yields a positive result when combined with the non-financial benefits then the project should proceed. If this analysis yields a borderline result, further research should be conducted investigating options to reduce the cost per use of totes and the capital expenditure required.

If the subject were to undertake a major rearrangement or relocation of the packing lines in the future for other unrelated benefits it is highly likely a more cost effective solution could be developed.

8.2 Feasibility of conversion at the subject's facility.

A capital expenditure of $25M is required to convert all Retail Ready products, and all domestically consumed Primary Processing products from packing in cardboard cartons to reusable plastic totes. The annual benefit of the capital expenditure is an operational cost increase of $500k, resulting in a Net Present Value of -$25M.

The cost per use of totes has been set at $0.65 by the tote owners. This is significantly higher than the purchase cost of cardboard cartons used in Retail Ready, resulting in increased operational costs and a negative Net Present Value.

Regardless of the cost per use of totes, the operational savings through the reduction in expenditure on cardboard cartons is insufficient to recover the cost of capital expenditure over a 5 year period.

The capital expenditure includes aspects unique to the subject's facility. Included in the cost is an overhaul of a defunct 2,000m^2, and a system to convey totes from the remote depalletising system to the Retail Ready processing lines on overhead conveyors. Equipment installation costs have been raised to reflect severe restrictions on installation timeframes to avoid impacting downtime.

Options can be explored, such as utilisation of an in-house tote washing facility and minor cost reductions in the equipment through simplification, however it is unlikely that a positive Net Present Value could be achieved.

8.3 Feasibility of conversion at the Cold Store Operation

Operations at the cold store facility can be converted with a capital expenditure of $10M. This provides a fully autonomous tote handling and palletising system for both Primary Processing and Retail Ready. This system is only capable of pick to DC, with only one SKU per pallet.

8.4 Recommendation for future Research and Development

8.4.1 Lower cost per use of totes.

The financial feasibility of the conversion project is directly and severely impacted by the cost of per use of the totes. Any Research and Development in this domain, reducing the cost per use of totes will dramatically improve the financial sensitivity of this proposal.

8.4.2 Reduction in installation restrictions

A significant cost element arises from the requirement to keep production processing going during normal operational hours. The increased cost and complexity incurred may result in processing plants forgoing improvements. Options and impacts around pulling forward production schedules, and temporary utilisation of alternative sources should be investigated.

8.4.3 Development of low cost, low rate depalletising equipment

If totes are to be successfully utilised in low volume plants, a low cost depalletising solution is required.

8.4.4 Development of trim tote

An alternative tote, possibly using the existing injection moulds could be created that would suit the loading, squashing, freezing and unloading while frozen; which are processes that are unique to Trim.

Consideration of the liner is also required, which if trapped inside the individual pieces of trim become trapped in place. This can be difficult to remove when blocks are required to be used in a semi frozen state.

8.4.5 Integral baffle inside tote

To eliminate tray movement inside the tote during transportation, a moveable baffle inside the tote could be developed. Consideration would be required for washing, repairs and maintenance, cost, and loss of unsecured components.

8.4.6 Alternative Pallet wrapping (incoming clean totes)

Pallets of clean empty totes are to be stretch wrapped in plastic that would be sent to waste after a single use. As the quantity of secondary packs per pallet is decreasing (500 to 180) the quantity of plastic wrap will increase in proportion to the quantity of pallets required. A reusable, washable hood would eliminate waste, but would also require washing after each use, and would incur transportation cost as it is returned.

8.4.7 Impact of increased thermal conductivity

There are likely to be changes in the required retention duration after conversion to totes, to achieve specified temperatures at the core of Primal's. The impact of those changes on product quality and shelf life should be explored and exploited if applicable.

Similarly the Primal's will react quicker to warmer environments that may be encountered when outside industrial temperature control systems, such as during transit and movement between stores and trucks. The impact of these changes on product quality and shelf life should be explored both for Primary Processing products and Retail Ready products.

8.4.9 Thermal pallet hood / tote liner

A reusable hood to replace pallet wrapping of outgoing products could be developed if economically viable. This would lock stacks of totes on the pallets, and would provide thermal insulation of the product inside. This would be particularly beneficial to products from Primary Processing.

Alternatively the carton liner could be thermally insulated, however this would increase the required cooling durations, unless a insulation system were devised that allowed product to cool rapidly, while resisting increases in temperature.

8.4.10 Tamper evident system for primary processing products

If deemed necessary, it may be possible to develop a tamper evident liner with integrated sealing mechanism. Consideration for marking is then required, to reduce the risk of liners full of product being switched between totes. An inline inkjet coder may be able to be utilised however the unpredictable folding of the liner will likely cause issues.

8.5 Industry utilisation of these findings

The results of the project findings discussed in this report strongly suggest that financial feasibility is difficult to achieve when attempting to retrofit a tote handling system into a working plant.

Conversion to totes should be considered, when industry members are contemplating a new plant, or a major rearrangement of their processing lines. As totes are associated with the final stages of packing, the depalletising and accumulation of totes should be located near the dispatch area of the plant, which in turn should be located near the end of the packing lines.

10 Key Messages

10.1 Operational cost variances

In this study it was discovered that the cost per use of totes was significantly higher than the purchase price of cardboard cartons. This immediately challenged the financial feasibility of the proposal, which has not been resolved. These costs should be reviewed prior to designing systems to distribute the totes around a plant.

10.2 Capital costs are escalated by retrofitting to distributed plant

As typical of projects installing equipment into working plants, it is difficult and costly. Due to the weight and size of totes a network of interconnecting conveyors must be formed to distribute totes from a central depalletising location to the dispersed packing lines. To avoid congestion these will likely have to be installed overhead, which substantially increases capital costs as access platforms are required to ensure safety of maintenance activities. Furthermore the wide distribution of the network will require additional accumulation systems to ensure packing lines are not periodically starved of totes, causing downtime.

A typical requirement of the red meat industry is to maintain regular supply to retail stores as building stock to facilitate a shutdown cannot be reasonably achieved due to degradation of product shelf life. This necessitates an incremental approach to installation, where installation activities are slotted into insignificant time blocks outside of normal production and cleaning times. The scale of works impacts all packing lines in an invasive manner as large structures are built overhead, and packing areas are progressively converted. The incremental costs to equipment suppliers and installers is substantial with this type of work as the production lines must be maintained in safe working order throughout the project and staff must be allocated to other projects or clients to maintain their productivity.

12 Appendix

12.1 List of Tables