Final report

AUSTRALIAN MEAT PROCESSOR CORPORATION

Beef Zero

Leap 4 Beef- Project 0 (Stage 1) for Various modules

Project code
2024-1088

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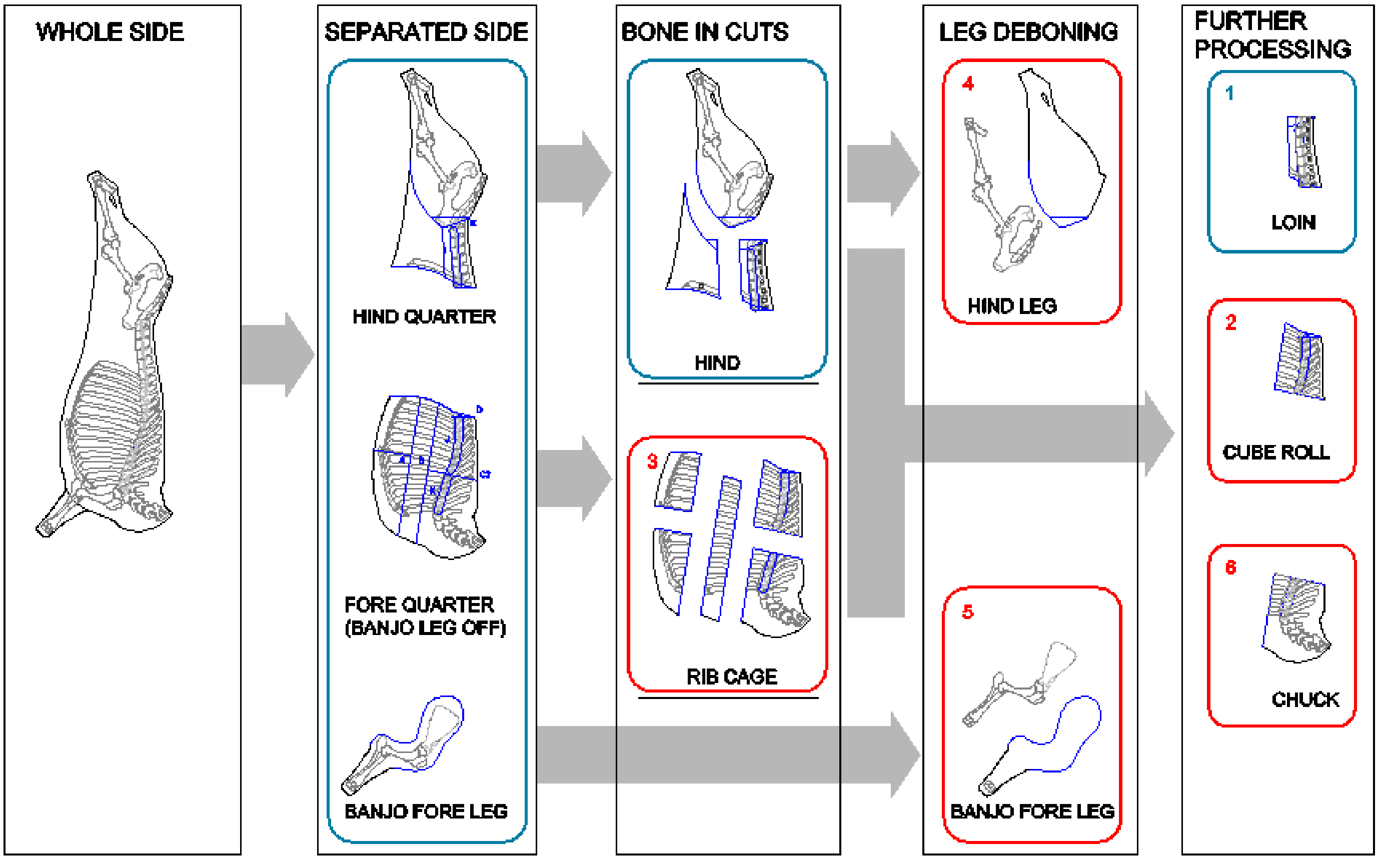
1 Executive summary

One of the recommendations of the most recent comprehensive beef boning automation project funded by MLA was that a modular approach to beef boning automation should be taken.



The aim of this project was to assess the feasibility of modules 2 to 6.

To assess the feasibility of these modules it is necessary to understand

- the items produced
- the specifications that govern production of the produced items
- the production methods that are followed
- the value of produced items
- the possible benefits of automation in terms of labour requirements, yield and value

Site visits to a Australian processor provided an understanding of current processing methods and outcomes. Small cutting trials provided some indication of how methods and outcomes might benefit from the envisaged automatic modules.

Automation of beef processing has good has good potential to increase product value. If development builds on test equipment installed for the development of module 1, the development path could be relatively fast and low cost.

For the various modules the finding were:

1.1 Module 2

It is proposed that further development of the cube further processing concept is justified. Where variation of settings, further finetuning, supported with trials and associated accuracy measurements should be the next step.

1.2 Module 3

Development of the fore cutting module should be pursued because it is likely to provide good direct benefits, return on investment and provides cuts that are ideal for other beef automation modules.

1.3 Modules 4 and 5

Further development of the Hind and Fore leg boning automation should be pursued. Particularly to establish capital costs of the approaches proposed and enable completion of the return on investment calculation.

1.4 Module 6

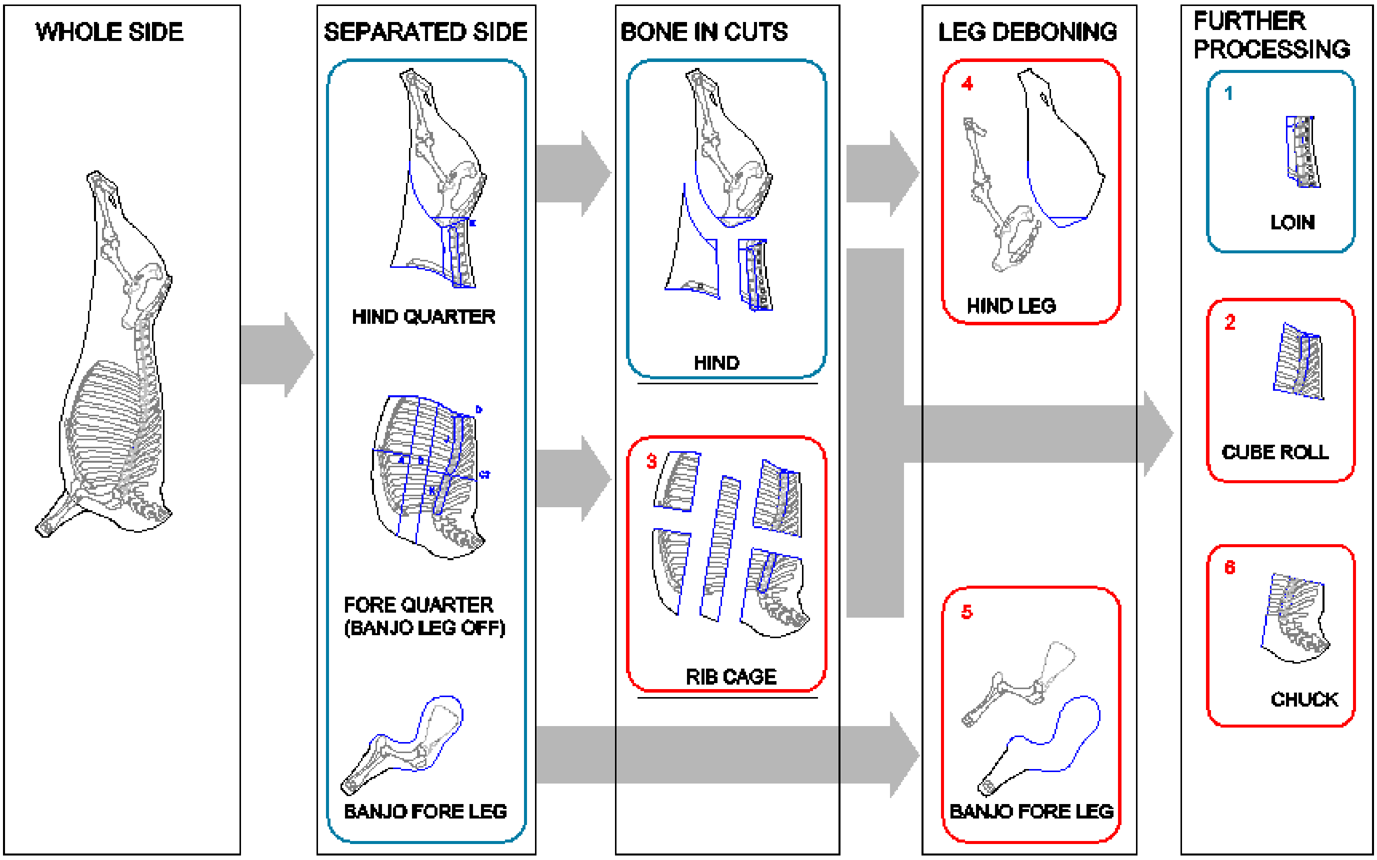
It is proposed that further development of the chuck further processing concept is justified. Where variation of settings, further finetuning, supported with trials and associated accuracy measurements should be the next step.

2 Introduction

Following successful automation of lamb cutting with the Leap lamb cutting system developed with and manufactured by Scott Technology, cutting and boning automation has been a desire of the Australasian beef industry for many years. Automation concepts have been based around processing a beef side. While work has been undertaken to investigate feasibility and develop various aspects of the concepts, the concepts are necessarily large and expensive. Funding and processor appetite to develop something that big in one hit does not exist. A recommendation from a previous MLA project P.PIP.0772 was that development of a modular beef cutting and boning system should be pursued.

A modular approach should provide faster development and delivery of beneficial equipment to processors that can be combined to form a larger automatic system.

Current thinking is that a modular approach to automatic bone in cutting and de-boning of beef sides might group beef fabrication.



Work on 'Leap 4 Beef Module 01 Loin chine bone removal' is progressing under a separate project with a proof of concept robot currently installed at a host beef processing facility.

The purpose of this project is to assess the feasibility of modules 2 to 6.

The scope of the project is to undertake manual cutting trials based on current manual cutting practices and previous automation work to understand the outcomes that each module must achieve and to devise a concept for each module together with an estimated ROI.

3 Project objectives

To ascertain the most plausible technology approach and ROI for the following modules:

- Leap 4 Beef Module 02
- Leap 4 Beef Module 03
- Leap 4 Beef Module 04
- Leap 4 Beef Module 05
- Leap 4 Beef Module 06

To provide high level concepts and an ROI for each module.

4 Methodology

4.1 General Methodology

For each module:

4.1.1 Understand the past work (literature research)

- To understand past work a brief internet search was undertaken and previous work by SCOTT was reviewed.

4.1.2 Understand the current process and the ROI opportunity(s)

- The current process was understood by visiting a Australian processor to discuss cut specifications and observe and discuss production methods and produced items.

4.1.3 Identify constraints and trade-offs

- Input product metrics – minimum and maximum size constraints.
- Output product cut specifications hard constraints
- Benefit versus cut accuracy models
- Benefit versus labour input models
- Benefit versus quality models.
- Process rates, and appropriate trade-offs.
- Development risk and time versus cost and lost opportunity models

4.1.4 Establish the design constraints

- Plant constraints

4.1.5 Generate possible approaches and concepts

- Generate possible approaches and concepts
- Enrich the possible approaches and concepts, with regard to reducing the knowledge gaps as much as possible, within the project scope (including utilising “knife & fork” methods).
- Model the expected performance of the possible approaches and derive an evaluation matrix.

4.1.6 Ascertain possible approach(s) and ROI

- Given the preferred approach(s) and concept(s), forecast the return on investment.

5 Project outcomes

5.1 All Modules

5.1.1 Understand the current process and the ROI opportunity(s)

Reported in the module specific section.

5.1.2 Identify constraints and trade-offs

5.1.2.1 Input product metrics – Carcass minimum and maximum size and weight constraints

An Australian weight data set for beef sides has been used to determine limits.

5.1.2.2 Cuts and Specifications

5.1.2.2.1 AUS-MEAT

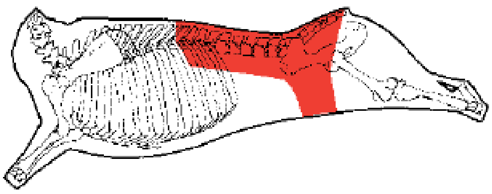
It is Scott's understanding that beef produced in Australia for export must comply with Aus-meat specifications. If a customer requires a non-compliant cut, approval must be granted by Aus-meat before it can be exported.

While cuts made by the proposed system of manual and automatic beef cutting will be compliant with Aus-meat specifications, they do preclude production of some Aus-meat specified Items.

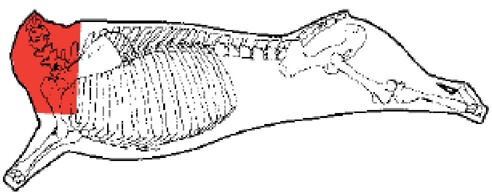
5.1.2.2.2 Proposed System Cuts

Ausmeat specified cuts precluded by the proposed system are:

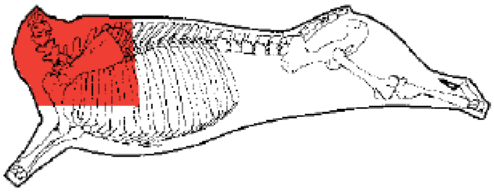
Rump and Loin 1540



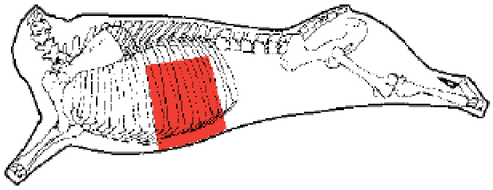
Neck 1630 (bone in) and Neck 2280 (boneless)



Chuck and Blade 2250



Short Plate 2346



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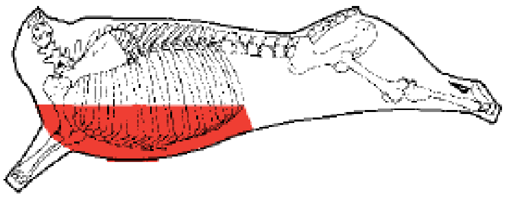
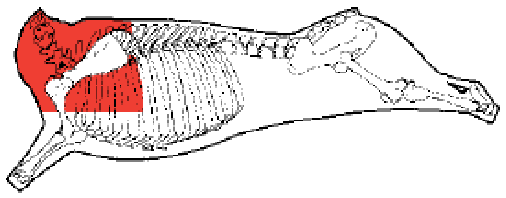
The proposed system cuts do not preclude or devalue items currently produced.

5.1.2.2.3 Cut System Variations

Brisket 1643 (bone in) and Brisket 2323 (boneless)



Chuck 2260 and Chuck 2270



North American Cut Lines

Expected North American cut lines based on USDA Institutional Meat Purchase Specifications are shown. Site visits and / or discussion with processors is required to understand cutting practices, variability and ROI opportunities.

Whilst the cutting system needs enough flexibility to suit the Australian meat industry in general, design should also consider the flexibility required to suit the North American meat industry. With sufficient cut sequence flexibility, a system capable of achieving the USDA IMPS cut lines would facilitate production of all AUS-MEAT specified cuts.

5.1.3 Establish the design constraints

Typical constraints include:

- Processing floor space.
- Plant safety, typically necessitating guarding cells
- Capital cost
- Ausmeat cut specifications
- Capital cost.
- Hygiene and wash down requirements

5.1.4 Generate possible approaches and concepts

Reported in the module specific section

5.1.5 Ascertain possible approach and ROI

Reported in the module specific section

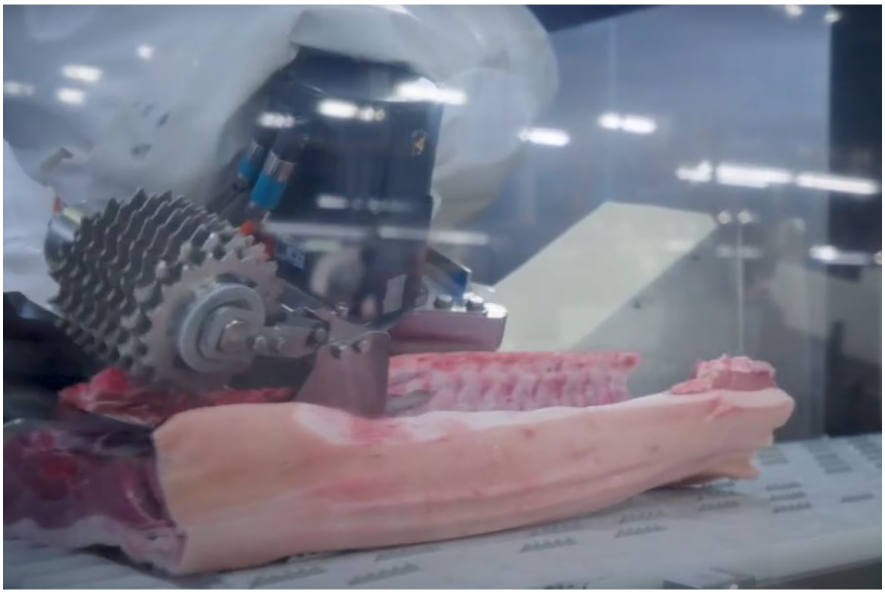
5.2 Leap 4 Beef Module 02

5.2.1 Understand the past work (literature research)

Scott P.PSH.0893

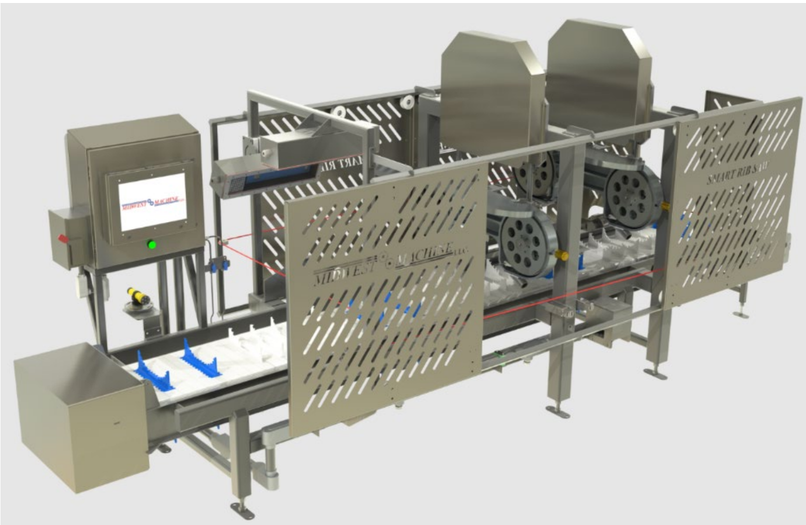
A robot mounted bandsaw was used to chine racks. The optimal cut path was determined from CT data. The optimal cut path was driven by yield and overridden as necessary to avoid saw band contact with the ventral end of ribs.

Frontmatec



Frontmatec have developed a robot mounted circular cutting disc for pork chine bone cutting. Because product can move as it is cut, a planned cut path relative to product that is being cut could be difficult to achieve with good accuracy. Using a circular saw instead of a bandsaw enables the chine bone to be cut while the ribs are complete and the brisket is still attached to them.

Smart Rib Saw



Midwest machine have developed a system to chine cube rolls. The cube roll is placed on a belt, scanned and cut. Saw height varies as the cut is made. Saw angle does not appear to change. Chine cut angle seems totally dependent on how the operator loads the belt. Because the product appears to be sitting on the belt unclamped, product may be able to move as the cut as made making good accuracy difficult to achieve. The chine cut angle is limited by the ventral tip of the ribs which must be avoided by the band saw.

When boneless cube roll is produced, ribs are cut 75mm beyond the eye muscle and meat is separated from them in one of three ways:

5.3 Leap 4 Beef Module 03

5.3.1 Understanding past work (literature research)

Scott P.PIP.0772

Project P.PIP.0772 identified 12 cuts as having potential for automation. By the end of the project the cuts considered for automation had evolved.

5.3.2 Understand the current process and ROI opportunity(s)

The proposed bone in rib cage primal cuts are of a size that can be table boned and permit fabrication of all cuts typically produced in Australia.

5.3.3 Identify constraints and trade-offs

A proof-of-concept machine could be reasonably compact and fit into a typical processor plant.

5.3.4 Generate possible approaches and concepts

The possible approaches include:

Vertical or Horizontal product delivery

5.3.5 Ascertain possible approach(s) and ROI

Various approaches have been considered.

5.3.6 Preferred approach(s)

The preferred approach has been established.

5.3.7 Expected ROI

Based on the estimated size of an average cattle beast, cut plane areas of each product have been estimated.

5.4 Leap 4 Beef Module 04

5.4.1 Understand the past work (literature research)

Mayekawa Hamdas R

Mayekawa have developed an automatic deboning machine for pork hind legs capable of processing 500 legs per hour. The machine uses robots and various devices to cut and strip meat. It is not capable of deboning sow or beef legs.

Scott Technology

Scott have undertaken some experimental work to debone sow hind legs. The work did not progress to development of a machine, but some insights applicable to beef hind leg deboning were gained.

5.4.2 Understand the current process and the ROI opportunity(s)

5.4.2.1 ROI Opportunity

Yield

Because automatic separation of the muscles without damage is unlikely to be possible and because manual deboning leaves very clean bones, increasing value by increasing accuracy or yield is an unlikely outcome.

It is also likely that yield will not be as good as what is achieved manually.

5.4.3 Identify constraints and trade-offs

5.4.4 Establish the design constraints

As per constraints relevant for all modules.

And the demands of seam following requirements.

5.4.5 Generate possible approaches and concepts

Automatic cutting against a bone is possible but is not fast.

Approach 1

1. automatically remove the aitchbone by pulling and cutting

Approach 2

1. Automatically remove the aitchbone

5.4.6 Ascertain possible approach(s) and ROI

Some work-shop testing to crudely simulate possible approaches will be necessary to determine the most likely approach. It is likely that approach 2 and 3 will be faster than approach 1.

5.4.6.1 Most likely approach and concept

Some work-shop testing to crudely simulate possible approaches will be necessary to determine the most likely approach.

5.4.6.2 Expected ROI

Yield

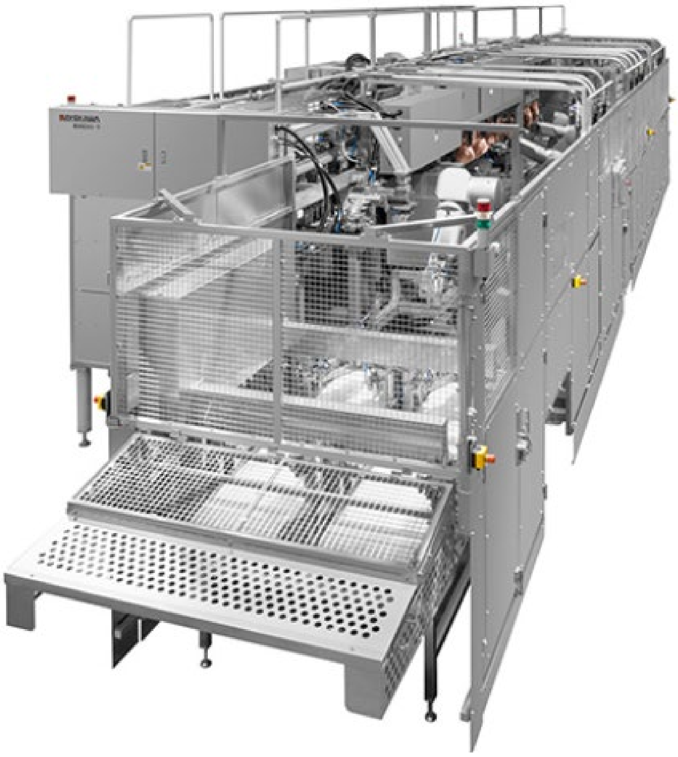
There will not be a yield gain.

At best there will be no yield loss. Some yield loss compared to manual boning is possible.

5.5 Leap 4 Beef Module 05

5.5.1 Understand the past work (literature research)

Mayekawa Wandas RX



Mayekawa have developed an automatic deboning machine for pork fore legs capable of processing 600 legs per hour. The machine uses robots and various devices to cut and strip meat. It is not capable of deboning sow or beef legs.

Scott Technology

Scott have undertaken some experimental work to debone sow fore legs. The work did not progress to development of a machine, but some insights applicable to beef foreleg deboning were gained.

An automatic system following similar principles to manual boning is likely to be slower than manual boning.

The arrangement might be slightly more compact and lower cost but would still be relatively large and expensive for a low financial return.

The automatic system would debone a banjo foreleg. This fits with a module to cut a whole rib cage that has been removed from the foreleg. Separation of the rib cage and associated meat from the banjo foreleg precludes production of cuts that contain chuck meat AND leg meat.

5.5.2 Generate possible approaches and concepts

In a previous project some work with limited success has been undertaken to remove the scapula from a beef banjo foreleg. In pork the scapula can be successfully pulled from meat on its lateral side both automatically and with a manual assist device. The concept for beef is worth re-visiting.

5.5.3 Ascertain possible approach(s) and ROI

5.5.3.1 Most likely approach and concept

Some work-shop testing to crudely simulate possible approaches will be necessary to determine the most likely approach. From a size, speed and cost point of view, a solution with minimal cutting and maximum meat stripping from a single bone is likely to be the most viable.

5.5.3.2 Expected ROI

Yield

There will not be a yield gain.

At best there will be no yield loss. Some yield loss compared to manual boning is possible.

5.6 Leap 4 Beef Module 06

5.6.1 Understand the past work (literature research)

P.PIP.0772

Although no work directly related to chuck chine bone removal has been undertaken by Scott Technology the cut is one of 12 bone-in cuts identified early in project P.PIP.0772 as having automation potential.

Scott P.PSH.0893

Part of the scope of project P.PSH.0893 was to investigate chine bone removal from racks and loins. Some of the learnings from this work may be applicable to chuck chine cutting.

5.6.2 Current process and ROI opportunity

5.6.2.1 Products

From the chuck it is typical to produce products as per Ausmeat

5.6.2.2 ROI Opportunity

The overall effect on labour has been determined.

5.6.3 Identify constraints and trade-offs

ITEM NO.
2289

CHUCK ROLL - LONG CUT 2289

Chuck Roll - Long Cut is prepared from a Forequarter after the removal of the Brisket and Ribs Prepared. The ventral cutting line is approximately 75mm from the eye muscle (M. longissimus dorsi) and parallel to the vertebral column. The Neck is removed by a straight cut parallel to the caudal cutting line between the 3rd and 4th cervical vertebrae. The M. trapezius and the M. rhomboideus are removed and the undercut (M. subscapularis) remains firmly attached.

Points requiring specification:

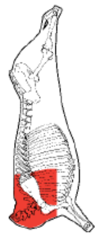
- M. trapezius retained.
- Ligamentum nuchae removed.
- Undercut (M. subscapularis) removed.

CHUCK 2260

Chuck is prepared from a Forequarter by the removal of the Rib Set (item 2223) at the specified rib number. The Brisket is removed along the cropping line. The Shin, Blade, Chuck Tender is removed along with all bones cartilage, tendons, ligamentum nuchae and lymph nodes.

Points requiring specification:

- Rib number required.
- Intercostals removed.
- Undercut (M. subscapularis) removed.



ITEM NO.

2260 (5-rib)
2261 (4-rib)
2262 (6-rib)

5.6.4 Generate possible approaches and concepts

Possible alternatives include:

- Establish cutting means.

5.6.5 Ascertain possible approach(s) and ROI

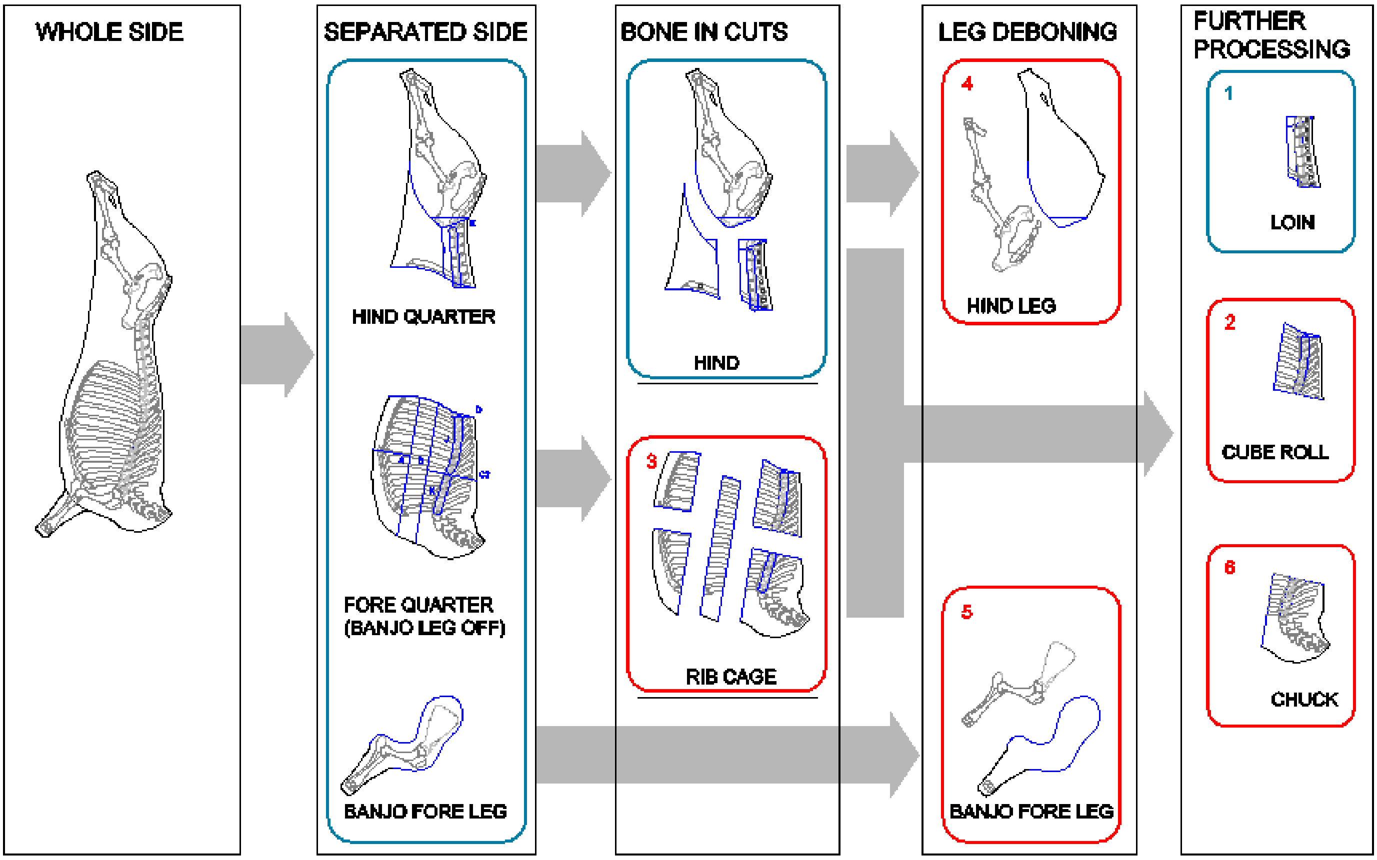
5.6.5.1 Most likely approach and concept

Preliminary development of clamps and vision analysis might be possible at a local processor.

5.6.5.2 Expected ROI

Data is very limited.

6 Discussion



6.1 Module 2

A very limited cube roll further processing trial demonstrated that good yield improvement compared to manual processing is achievable.

Expected Return on Investment is (assuming 200-300,000 cattle per year)

	Annual Saving (min)	Annual Saving (max)
Yield	$800,000	$2,400,000
Labour	$90,000	$190,000
Total	$890,000	$2,830,000

6.2 Module 3

Automatic cutting of a banjo-leg-off fore quarter is likely to provide a significant increase in the sum of item values and reduce the required skill level of labour.

The module also provides a chuck and cube roll that are suitable for further processing and encourages production of a banjo fore leg which could feed an automatic deboning module.

Based on the estimated size of an average cattle beast, cut plane areas of each product have been estimated.

Expected Return on Investment is (assuming 200-300,000 cattle per year)

And using current product values, the total value of a 1mm slice on each side of cut planes has been calculated for cuts A, B and C2, if moved an average of 10mm for every side, the benefit would be $3.2 – $6.4 per head.

Expected return is:

	Annual Saving (min)	Annual Saving (max)
Yield	$640,000	$1,920,000
Labour	$80,400	$160,000
Total	$720,400	$2,080,000

6.3 Modules 4 and 5

Three approaches have been proposed. No yield benefit is anticipated.

Expected Return on Investment is (assuming 200-300,000 cattle per year)

	Annual Saving (min)	Annual Saving (max)
Yield	$0	$0
Labour	$335,000	$665,000
Total	$335,000	$665,000

6.4 Module 6

A very limited chuck roll further processing trial demonstrated that good yield improvement compared to manual processing is achievable.

Expected Return on Investment is (assuming 200-300,000 cattle per year)

	Annual Saving (min)	Annual Saving (max)	

Benefit	$400,000	$1,800,000	Dependant on combination of saleable items and associated markets.

7 Conclusions / recommendations

7.1 Module 2

It is proposed that further development of the cube further processing concept is justified. Where variation of settings, further finetuning, supported with trials and associated accuracy measurements should be the next step.

7.2 Module 3

Development of the fore cutting module should be pursued because it is likely to provide good direct benefits, return on investment and provides cuts that are ideal for other beef automation modules.

7.3 Modules 4 and 5

Further development of the Hind and Fore leg boning automation should be pursued. Particularly to establish capital costs of the approaches proposed and enable completion of the return on investment calculation.

7.4 Module 6

It is proposed that further development of the chuck further processing concept is justified. Where variation of settings, further finetuning, supported with trials and associated accuracy measurements should be the next step.

8 Bibliography

Cut specifications and diagrams are taken from ‘Handbook of Australian Meat 7th Edition (International Red Meat Manual) published by AUS-MEAT limited.

Cross sectional photos are taken from the University of Nebraska – Lincoln website. (https://bovine.unl.edu)

The published report for MLA project p.pip.0772 is available from the Meat & Livestock Australia website. (https://www.mla.com.au)

9 Appendices