final report

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LEAP III Ovine X-ray Primal Cutting System, Ex-post Review

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Executive Summary

Scott Technology in conjunction with MLA and a New Zealand lamb processing company have developed an automated lamb primal cutting system guided with the use of x-ray technology (LEAP III). This report is an ex-post review of the commercial outcomes from installing the system into a large Australian lamb abattoir.

The system conducts two automated cuts separating the shoulder and barrel, and separating the barrel and legs. The system has the capability to conduct additional cuts separating the rack and loin but will not be done in this plant. The installation has been operating successfully at commercial line speeds for a number of months and the ex-post analysis demonstrated a net benefit of between $1.32-$1.49 per carcase. Current performance represents a return on investment in close to 1 year.

Table 1 summarises the investment and likely payback with the following scenarios from left to right:

1. The ex-ante study compares the manual performance against the expected performance of the LEAP III system (based on performance observed in other installations). The value estimated is due to:
   - Improvements in yield on both leg and shoulder cuts.
   - Reduction in bandsaw operators representing a 7.2% increase in volume per person for remaining staff.
   - Setting a consistent product flow into the room increases volume per person.
2. The ex-post performance of the new system.
   - This assessment uses the same production volumes as the ex-ante study and actual LEAP III system performance accuracies after installation.

Table 1: Summary of benefits for ex-post and maximum machine speed relative to manual cutting performance

SUMMARY PERFORMANCE MEASURES				
	Ex-Ante		Ex-Post	
Hd / annum	1,200,534		1,200,534	
Production increase with equipment	7.21%		7.21%	
	From	To	From	To
Capital cost (pmt option, upfront)	$2,690,000		$2,690,000	
Gross return Per head	$1.90	$2.18	$1.65	$1.82
Total costs Per head	$0.32		$0.32	
Net Benefit Per head	$1.57	$1.85	$1.32	$1.49
Annual Net Benefit for the plant	$1,886,970	$2,222,596	$1,586,706	$1,790,801
Annual Net Benefit for the ex cap	$2,036,181	$2,371,807	$1,735,917	$1,940,013
Pay back (years)	1.32	1.13	1.55	1.39
Net Present Value of investment	$12,452,628	$14,809,928	$10,343,700	$11,777,181

The ex-post performance was approximately 22% smaller than estimated in the ex-ante analysis due to smaller benefits associated with the hind leg cut. The actual benefit is between $0.25 and $0.36/hd less than estimated as a result of the following:

- The partial scallop cut, costed in the ex-ante study for all carcases is not yet implemented by the plant and is a decision on customer specification.
- The target cutting line used for the ex-ante estimation assumed a cut well into the cartilage on the aitch bone. Ex-post settings are producing a slightly longer leg (shorter shortloin pair) by only tipping the cartilage on the aitch bone. This is a customer specification and can be adjusted on the LEAP system.
- The combination of leg cut differences between ex-ante and ex-post studies caused a $0.38/hd to $0.44/hd variation in benefit.
- The forequarter cut only varied slightly with $0.08 to $0.013/hd variation between the ex-ante and ex-post studies.

Substantial benefits have been demonstrated through the installation of this system including improvements in both production efficiency and increased saleable product value as shown in the left of Figure 1. All product value benefits are from increased saleable meat yield due to increased cutting accuracy. The breakdown of benefits is summarised in the figure on the right and primarily focused on increased saleable yield, reducing the number of bandsaws and decreasing likelihood of OH&S incidents as well as improving production efficiencies.

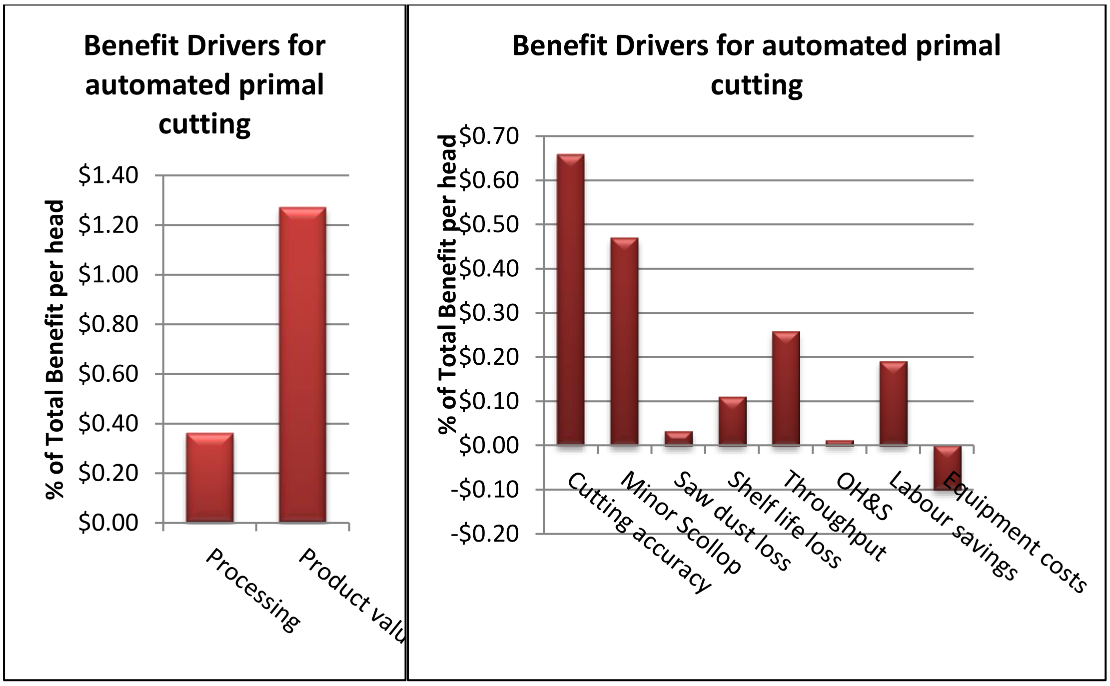

Figure 1: Broad grouping and detailed breakdown of benefits delivered by Scott's x-ray primal cutting system

Glossary

Term	Description
CBA	Cost Benefit Analysis
Ex-ante	"*before the event*". Ex-ante is used most commonly in the commercial world, where results of a particular action, or series of actions, are forecast in advance (or intended).
Ex-post	The opposite of ex-ante is ex-post (actual) or "*after the event*".
Statistical hypothesis test	A method of making decisions using data, whether from a controlled experiment or an observational study (not controlled). In statistics, a result is called statistically significant if it is unlikely to have occurred by chance alone, according to a pre-determined threshold probability, the significance level. The phrase "test of significance" was coined by Ronald Fisher: "Critical tests of this kind may be called tests of significance, and when such tests are available we may discover whether a second sample is or is not significantly different from the first."[1]
Caudal	Caudally: toward the posterior end of the body
Cranial	Refers to the direction toward the head of carcass
Dorsal	Belonging to or on or near the back or upper surface of an animal
Ventral	Pertaining to the front or anterior of any structure. The ventral surfaces of the carcass include the brisket /abdomen cavity
HSCW	Hot Standard Carcase Weight
FQ	Forequarter
HQ	Hindquarter
LD	Longissimus Dorsi muscle (or strip loin)
Lairage	Livestock lairage refers to the physical pens required to hold livestock after delivery to plant and prior to abattoir processing.
MLA	Meat and Livestock Australia
SLP	Short Loin Pair
TDR	Tender Loin (Psoas major muscle)

Contents

1 Introduction

Robotic Technologies (RTL) in conjunction with MLA have been developing automated lamb boning equipment, with a vision towards developing a fully automated process from the chiller exit through to the packaged product. The development has been occurring in stages/modules starting from the chiller output.

The first of these modules, the LEAP III automated primal cutter and x-ray system has been in commercial operation in New Zealand and now in Australia for more than 12 months with further installations planned in Australia.

The ex-ante studies indicated the primary financial benefit of the LEAP III system would be an improvement in yield. Although yield benefits are a significant part of the total benefit, improvements in plant productivity have shown to be larger than first expected. Other benefits including reductions in full time labour and training costs and improvements in safety, product quality and production rates all contribute to the return on equipment investment.

The report is designed to build on the methods used for data collection and analysis to enable comparison of ex-post results back to manual processes where appropriate.

2 Objectives

The objectives of this study were to:

1. Using the benchmarks and measurement methods developed in the ex-post study at the plant, measure the ex-post value improvement when compared against manual cutting systems for each area of benefit that exists.
2. Summarise the value benefit and main drivers for adoption of the equipment for Australian lamb processing plants.

Both outcomes were achieved effectively.

3 Technology Description

The x-ray primal cutting system for lamb carcases (otherwise known as LEAP III) consists of two main technologies described here.

3.1 Whole Carcase X-ray System

The first task in lamb deboning is breaking the carcase into smaller portions. This is undertaken by locating specific bones and cutting between them. In the same way that the medical industry uses x-rays to look at bones in humans, RTL uses an x-ray system to find bones in lamb carcases and feeds this information to downstream processing units.

Figure 2: x-ray visioning system

3.2 Primal System

Utilising the x-ray image from the x-ray system, the primal system determines the required cut location between the 3rd-4th, 4th-5th or 5th-6th ribs, then removes the forequarter from the carcase in the first tower.

The second tower removes the saddle from the hindquarter at the required specification location using the x-ray image. The forequarter is then further processed by the LEAP V forequarter system, the saddle is processed by the LEAP IV middle/saddle system and the hindquarter is processed by the LEAP II hindquarter system. The LEAP II and LEAP V are still under development and not commercially available.

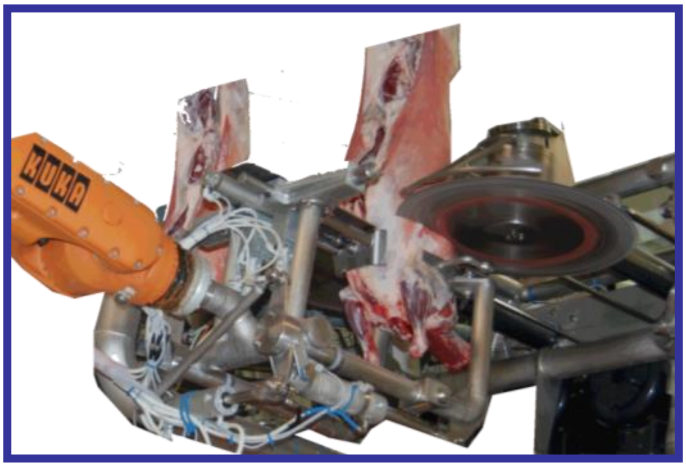

Figure 3: Primal forequarter cutting knives

In addition to circular cutting knives that eliminate most of the sawdust wastage of a bandsaw, the x-ray system ensures cutting between adjacent ribs, rather than through a rib bone as experienced with a significant number of manual bandsaw cuts.

There have been two of these systems installed; the first installation in New Zealand was used as the test site to establish performance benchmarks. The second system was installed in Australia and provides a performance comparison with the measures reported in this ex-post study. The systems have the same core technologies although additional cuts are operational on the Australian system along with software upgrades for cutting lines.

4 Data Collection and Calculations

The following costs and benefits shown in Table 2 were identified as being relevant financial drivers in the installation of the automated x-ray lamb primal cutting system.

Table 2: Costs & benefits associated with use of automated primal cutting equipment

Benefits		Costs
Accuracy of cutting lines	1.1. First cut (Forequarter : Loin)	1. Capital cost of the equipment
	1.2. Second cut (Rack : SLP)	2. Ongoing maintenance of the equipment
	1.3. Third cut (Loin : Hindquarter)	
Technical advantages of cutting technique.	1.4. Scallop cut	3. Service agreement
	1.5. Saw dust yield gains	4. Risk of plant down time caused by the primal cutting equipment
	1.6. Increased shelf life	
Benefits to the operation of the processing plant	2.1. Increased labour efficiency	
	2.2. OH&S savings	
	2.3. Labour savings	

In order to validate the value opportunity for automated primal cutting in the Australian processing plant, the same benchmarking methodology was used in this ex-post review as was applied to the results of the expected New Zealand and Australia automated cutting system. Further benchmarking measures were taken to ensure consistency across the different stages of data collection.

The data collection phase of the review focused on trial work to establish the accuracy of current cutting systems, the costs associated with inaccuracy, and survey work to asses other production and logistic components such as current staffing levels and number of head being processed.

This section explains the various methods used for data collection and calculations behind the value attributed to each of the 9 benefits and 4 costs highlighted in the table above.

4.1 Data Quality Control

There is always a range in accuracy and performance within manufacturing environments and particularly where a biological product like a carcase is involved. Manual processes will always show a range in variation as will automated processes (but hopefully to a lesser degree). This variation produces a range in value or cost and is reported in the cost/benefit and financial tables as the lower (left column) and upper (right column) confidence intervals for the data collected. The range in accuracy is also of interest with narrower variation increasing the ability to control and refine the process.

Manual baseline data and ex-post analysis of performance was conducted over 3 consecutive days of commercial production totally 6 days of data. Samples measured under manual conditions were collected out of sight from operators to reflect normal unobserved performance. Collection periods were spread evenly across the days production summarised in Table 3.

Over the 3 days of automated operation 14,030 carcases were processed in total with 2,748 samples being taken (19.6% of production). The range of carcases processed represents the full range in carcase weights expected across the Australian population. Figure 4 indicates the samples measured were representative of the total population.

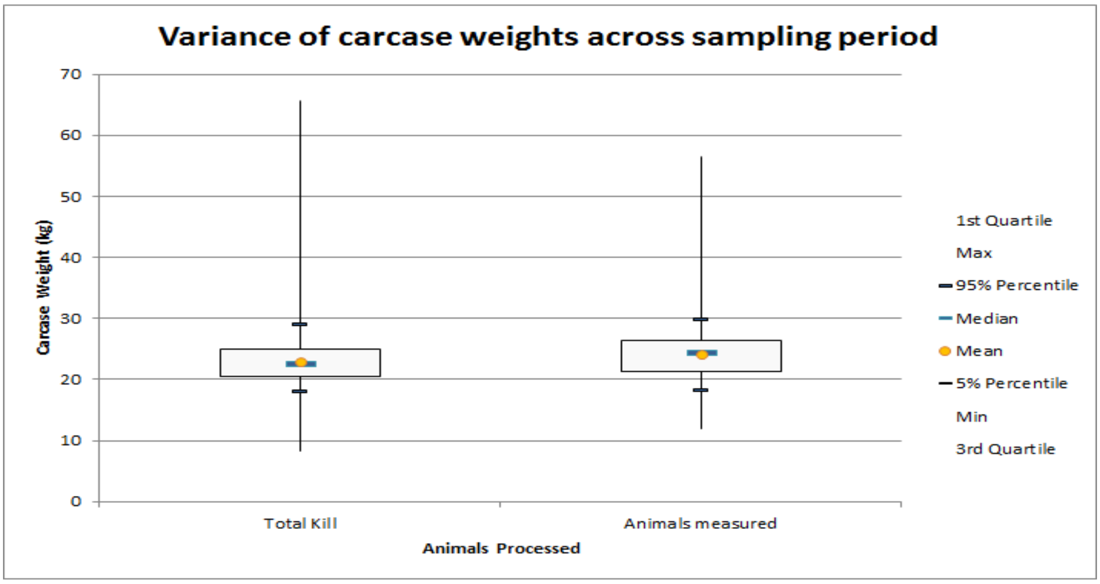

Figure 4: Carcase weights sampled are representative of the total population processed

The summary of data collected during the ex-ante and ex-post trials is included in Table 3. The results of the ANOVA tests show a significant difference (*p* < 0.001) between the means for manual and automated cutting accuracy for all three measurements taken reflecting the improvement in accuracy gained with the automated solution. The variation in yields observed throughout the trial and the increase in value generated from increased accuracy is explained in section **Error! Reference source not found.**.

Table 3: Summary statistics on data collected across ex-ante and ex-post trials

Data collection		
Measurement	**Manual**	**Ex-Post**
Start Date of collection	25/06/2013	17/11/2013
Finish Date of collection	27/06/2013	28/05/2014
Number of collection periods	7	5
Cut 1 (FQ-Mid)		
mm over from rack		
Number of samples	280	138
1st Quartile (mm)	2.5	2.3
Median (mm)	5.5	4.5
3rd Quartile (mm)	9.3	6.5
P-value		0.000
Number of ribs on shoulder		
Number of samples	280	138
1st Quartile (number of ribs)	4	4
Median (number of ribs)	4	4
3rd Quartile (number of ribs)	4	4
P-value		0.000
Cut 3 (Hind Leg)		
Number of samples	540	180
1st Quartile (mm from tip of cartilage)	0	-6
Median (mm from tip of cartilage)	3	-2
3rd Quartile (mm from tip of cartilage)	6	0
P-value		0.000

4.2 Statistical Analysis of Data Sets

There is always a range in accuracy and performance within manufacturing environments and particularly where a biological product like a carcase is involved. Manual processes will always show a range in variation as will automated process but hopefully to a lesser degree. This variation impacts on the level of value created or lost. The range in cost or benefit is also of interest and has been included in the summary results of this report.

4.3 Model Drivers Used for Calculations

The objective of the trial work was to establish the dollar per head value for each cost and benefit listed in Table 2. Calculations presented for these benefits use production numbers and sales prices discussed in the next section.

4.3.1 Fixed Model Drivers

To establish the dollar value of each of the listed costs and benefits as a per head number, the following production numbers were used for the calculations (Table 4). The table summarises manual performance (far left) as the base line, the ex-ante over one shift (middle) and the Ex-Post results (right) relative to manual operations.

These values are linked to adjustable drivers shown in the cost benefit summary section of the model.

Table 4: Calculation used for determining production volume base line

Processing room operation speeds			
	Manual	Ex-Ante	Ex-Post
Carcases / min	7.58	7.88	7.88
Carcases / Statn./hr	455	473	473
Carcases / day	5003	5002	5002
Annual days	240	240	240
Annual # of hd	1,200,672	1,200,534	1,200,534

Installation of an automated cutting system has shown in previous studies to have an immediate increase in productivity; the estimated increase in room throughput used through this report was 4% without increasing the number of labour units[1]. The key factor is the increased consistency at which product flows into the room. The manual method results in sporadic product flow from the bandsaws where operators would go fast for a while, then slow down and rest, or go slow when boners further down the line went slow and product built up.

4.3.2 Sales Prices

Values shown in Table 5 can be adjusted and the relevant prices will adjust all model results including summary financial drivers. Note average discount is a driver sourced from the summary page of the model and the relevance of this is explained in Table 13.

[1] This increase in productivity resulted in a greater volume of carcases processed per day. Livestock lairage, slaughter capacity, carcase chilling capacity, boning room capacity and finished product chilling and storage capacity all place different constraints on a plants overall daily production capacity. Every plant has a different combination of these constraints, most of which are dependent on the mix of livestock types, cutting specifications and market destinations. However, in most cases plants do not operate at maximum capacity and the productivity gains mentioned here will be realisable.

Table 5: Retail Sales values used for driving economic analysis

Value proposition for a LEAP III - Lamb X-ray Primal Cutter		
Average discount level		20%
Cut	$/kg	Discount Value
Whole Carcass	$ 7.50	$6.00
8 Rib Rack	$ 19.00	$15.20
7 Rib Rack (discount)	$ 17.00	$13.60
Shortloin	$ 11.10	$8.88
Trim 65CL	$ 2.70	$2.16
Leg price	$ 8.99	$7.19
Shoulders	$ 8.60	$6.88
Back strap	$ 22.00	$17.60
Shoulder Rack	$ 8.60	$6.88
Rendering	$ 0.16	$0.13

4.4 Benefits Achieved Through Cutting Accuracy

The market requirements determine the location of cutting lines for fabrication of lamb carcasses into primals. All other processing that occurs on the lamb carcases are based around these cutting lines. If the initial primal cutting lines are not accurate this will have an impact on the ability to process the product according to market specifications. Ultimately costs will be incurred through discounts if inaccuracies in the cutting lines don't allow product to meet the market specifications. As the accuracy of the cutting lines was an important part of the data collection phase the following section gives consideration to the measurement of accuracy levels observed with the manual cutting system, and the costs incurred because of these inaccuracies.

Figure 5 illustrates the 3 cutting lines that the automated primal cutting equipment can perform, and the various cuts associated with the different primals. Furthermore, Table 6 communicates the expected losses with the various inaccuracies of the cutting lines. Note the second cut between the rack and shortloin pair referred to in this section is not being done by this LEAP III installation as it will be done by a separate LEAP IV middle cutting system to be installed shortly.

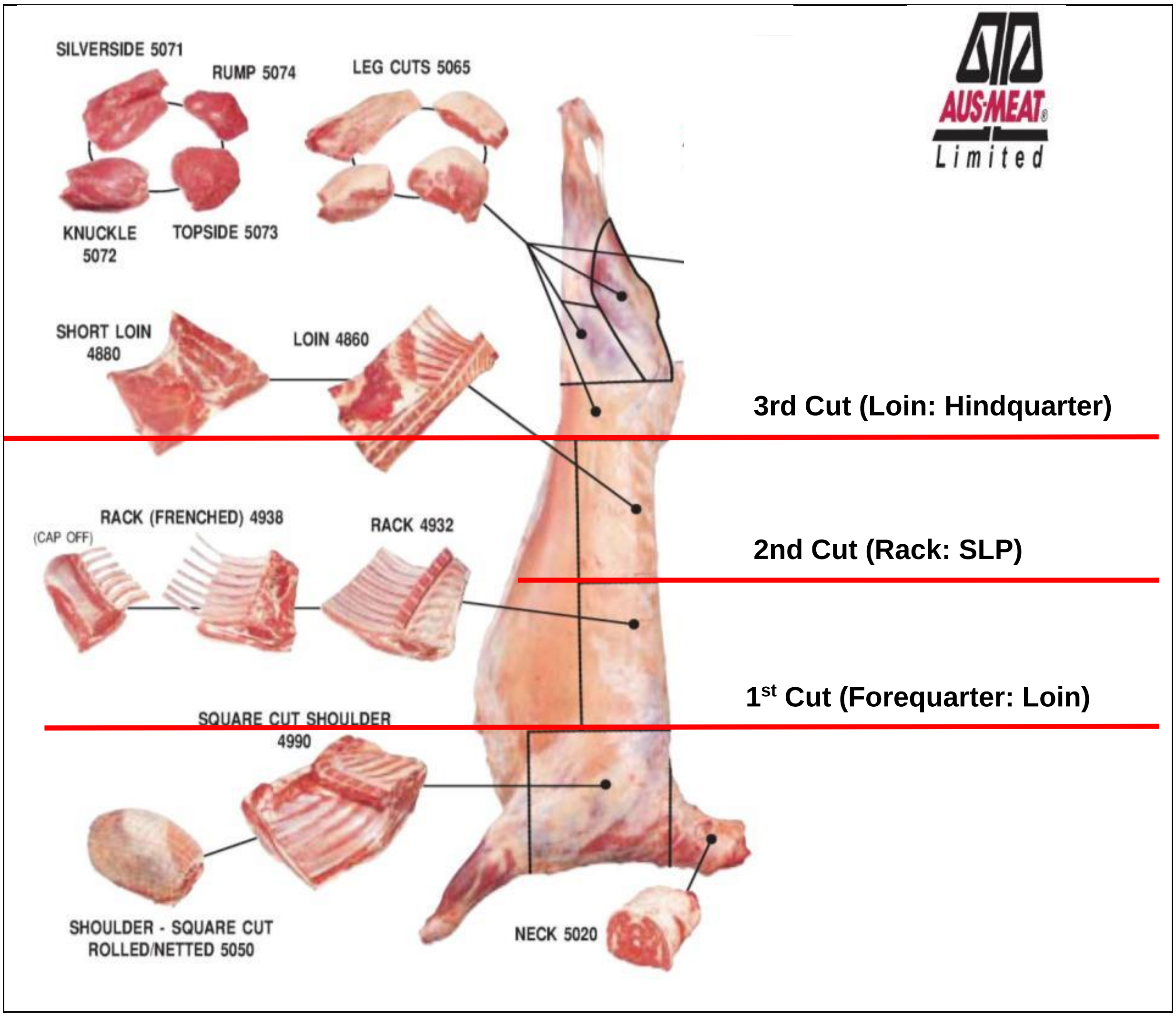

Figure 5: Cutting lines that the automated primal cutting system will perform on the lamb carcass (Source: Aus Meat 2003)

Figure 6 shows the carcase after primal cutting and the resultant four primals including forequarter, rack, short loin and leg or hindquarter.

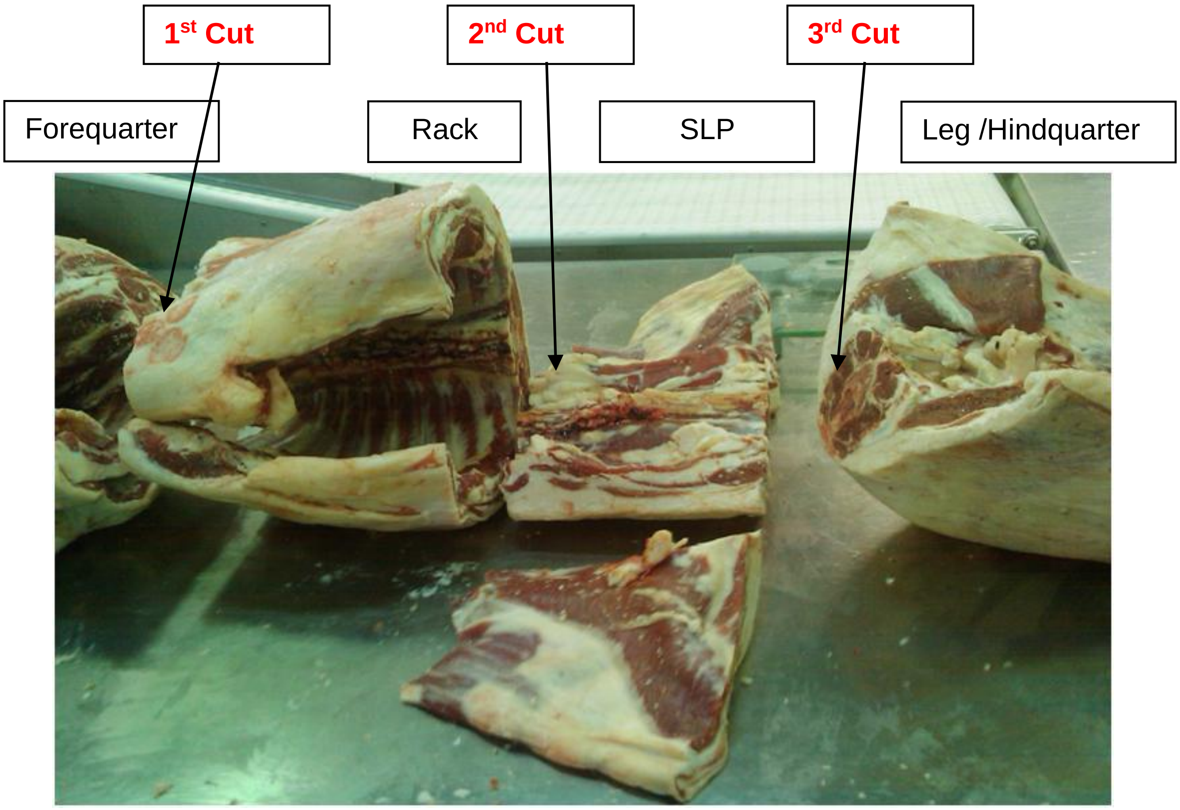

Figure 6: Three primal cuts, and the 4 respective primals

Table 6: Measurement points for determining cost of inaccurate cutting between primals in lamb processing

Cuts (Cranial to Caudal)	Impact on Primals either side of each cut		Resulting Loss
Cut 1	Shoulder Short	Rack Long	Possible shoulder trimmed off 8 rib rack, discounted racks that don't meet market specs
	Shoulder Long	Rack Short	Rack loin achieves lower value as shoulder rack Discounted racks if not able to meet market specs
Cut 2	Rack Short	Loin Long	Ribs cut short, discount because didn't achieve 8 rib rack for export
	Rack Long	Loin Short	Extra back strap on rack, may need to be lost to trim. Back strap discounted because they are too short Loss of TDR
Cut 3	Loin Long	Leg Short	Leg muscles remaining loin lost to trim, Aitch bone needs to be trimmed from loin
	Loin Short	HQ Long	Loss of back-strap and TDR to aitch bone and trimming or leg muscle depending cutting specification
Cut 3 (B) The operator of the primal cutting equipment can specify where cut 3 occurs.	Leg Long	Chump Short	The x-ray primal cutting equipment can also perform the 3rd cut higher than the chump (toward distal end of leg) This cut was not considered in this analysis
	Leg Short	Chump Long	

5 Measurement Results

5.1 Forequarter & Loin

5.1.1 Measurement

The accuracy of the shoulder cut was largely determined by the number of ribs required in the cutting specification.

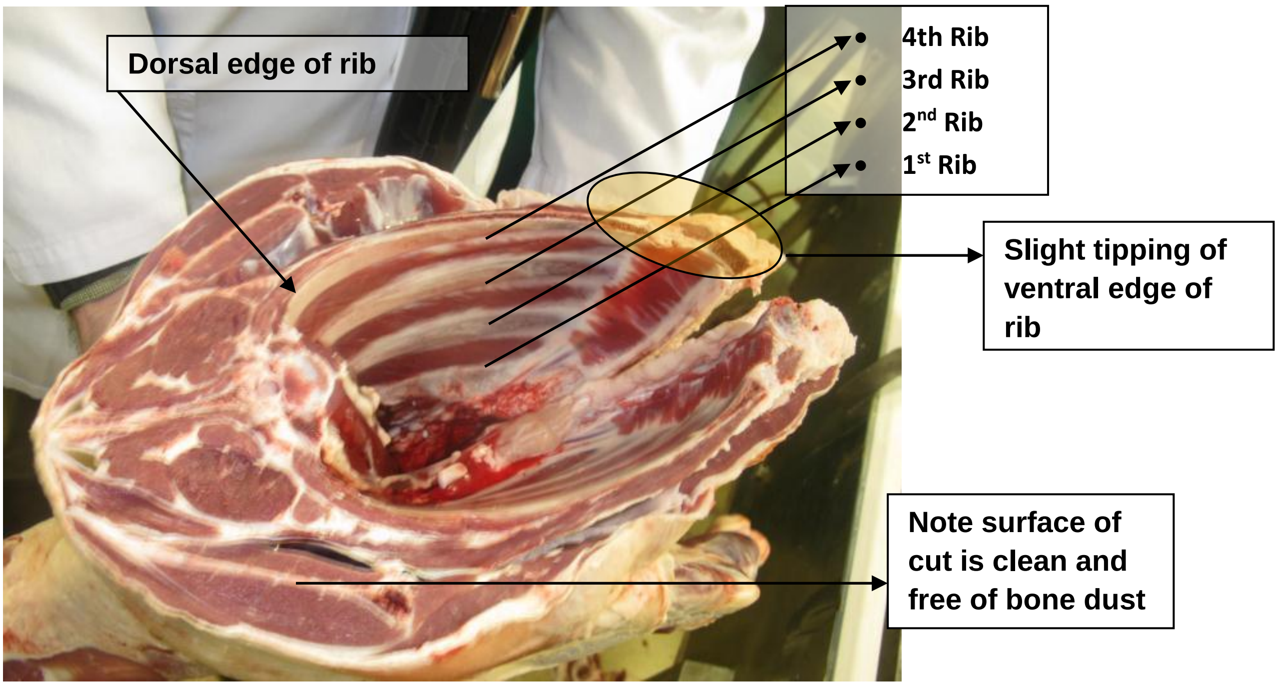

Figure 7: Measurement of cutting for forequarter rib.

While the main criteria of accuracy was measured by the ability of the equipment to cut at the selected rib number, another of the anticipated benefits of the x-ray primal cutting system was the ability to angle the cutting blade parallel to the rib angle.

Measurements were also taken to assess the amount of loin lost due to the inaccuracy of the cutting line relative to the rib.

5.1.2 Costing

Cutting inaccuracies that resulted in longer shoulder (5 ribs) were costed as the loss of higher value M. Longissimus dorsi lost to lower value shoulder (Figure 8, Figure 9 & Figure 10).

Figure 8: Impact of cutting one rib long, figure showing amount of loin lost

Figure 9: Correct cutting line between forequarter and loin for a four rib shoulder rack

Figure 10: Cutting line long for a four rib shoulder rack. Highlighted items represent value lost (Loin lost to trim and part rib lost to render).

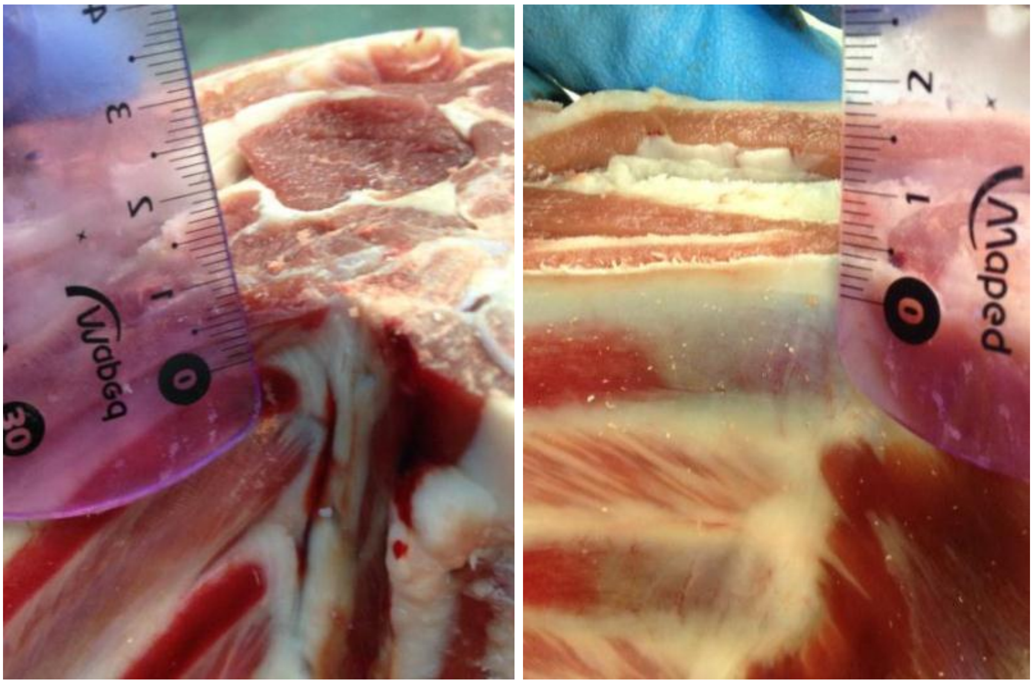

Figure 11: The number of millimetres above or below the 4th rib was measured at both the dorsal (left image) and ventral (right image) edges of the cutting line

5.1.3 Results – Impact of rib accuracy

Figure 12 shows that there was significant increase in the accuracy when comparing manual and automated cutting systems. In terms of achieving the correct rib number the ex-post automated x-ray primal cutting system was estimated to be 1.0% more accurate than the manual cutting system. It is also important to note that measurements taken under manual operation were best case scenario. Accuracy observed by plant supervisors in ad hoc sampling the week after we conducted the tests indicated less accuracy than that recorded during our data collection. Manual performance would likely not be achieved consistently across an entire day, or week, while the x-ray accuracy levels will remain consistent.

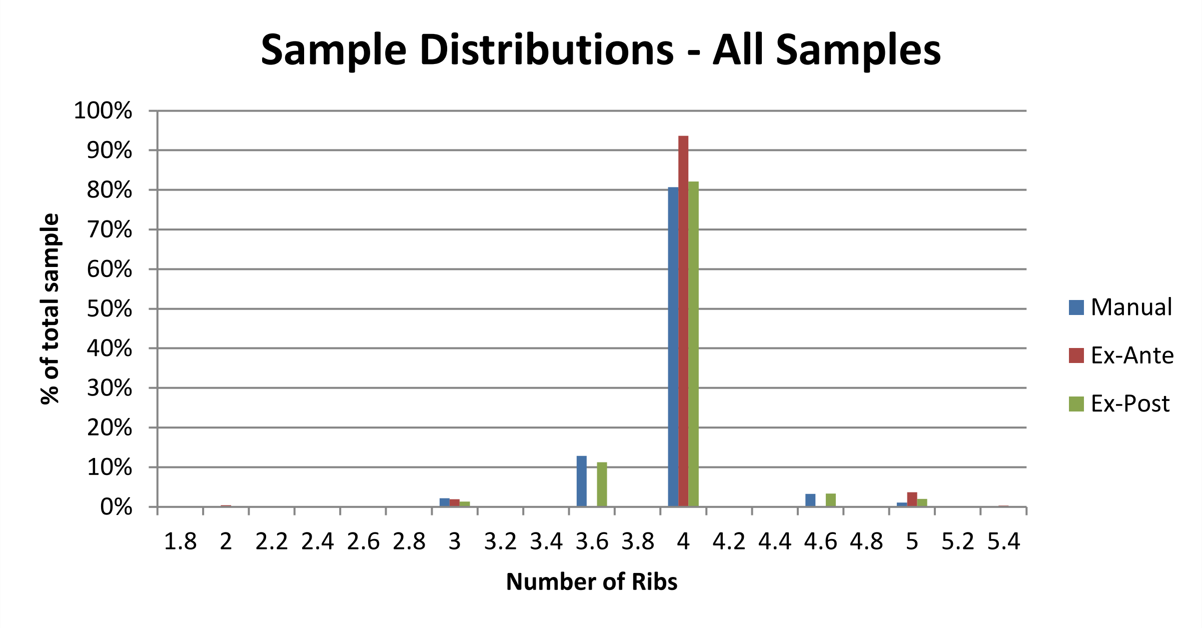

Figure 12: Shoulder cut accuracy observations for both manual and x-ray cutting systems

The methods used in the previous ex-ante & ex-post costings (Greenleaf, 2010) to establish the cost of various cutting inaccuracies were applied in the same way in this ex-post study. Figure 13 indicates the cost of inaccurate shoulder cutting similar to the manual system. This range of inaccuracy captures 95% of the sample population observed during the trials.

The cutting specifications on site required the slices to remove the fourth rib from the rack if there is a 3 rib shoulder cut. The analysis of the data was modified to account for the loss of weight being sold as render and trim rather than shoulder.

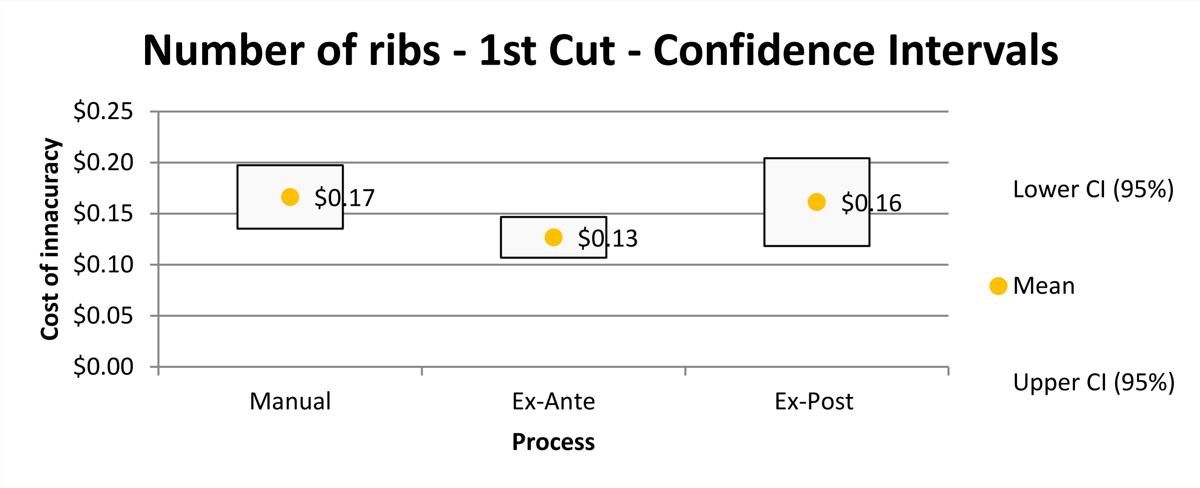

Figure 13: Cost of 1st cut inaccuracy due to incorrect number of ribs

In reality the true cost of these cutting inaccuracies will vary for every plant depending on existing markets, sales prices and many other drivers. Provision is made in the model for customized costings to be calculated and used in the cost benefit analysis (see "base line data" Table 4).

5.1.4 Impact of Cut Angle

The distance in millimetres that the shoulder cut was made above or below the 4th rib is summarised in Figure 14 for each cutting method observed. Negative values show where the cutting line has cut into the caudal edge of the 4th rib. Positive values show where the cutting line is located closer towards the cranial edge of the 5th rib, thus taking more loin from the rack and leaving it on the shoulder. The main point to note from this graph is the variation in distance away from the edge of rib was minimal in this case and there would only be a slight improvement with the Automation system.

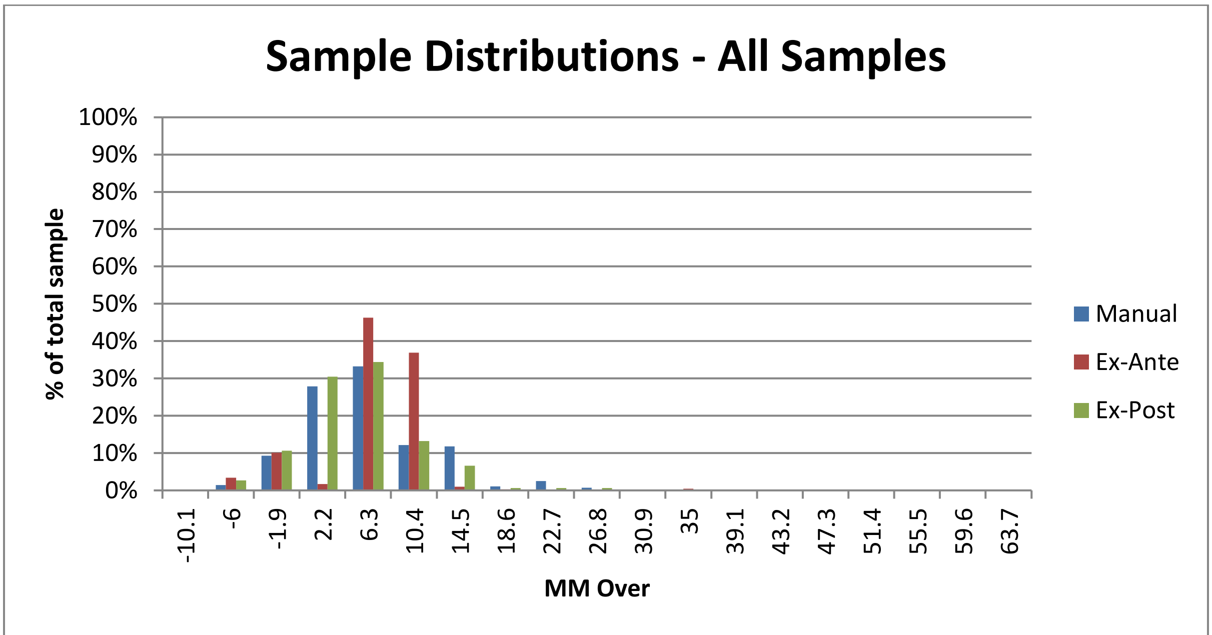

Figure 14: Distance of cutting lines from the edge of the 4th rib on a 4-rib shoulder cut.

When a shoulder is cut long (beyond the caudal edge of the 4th rib), loss occurs due to higher value rack loin muscle achieving only shoulder value. As shown in Figure 9 & Figure 10 lost loin was removed from the shoulder and weighed.

Figure 15 illustrates the relationship between the levels of cut accuracy as the weight of loin lost relative to the primal weight. The main point to note is that there is a very strong relationship between millimetres of inaccuracy and amount of loss that occurs relative to primal weights.

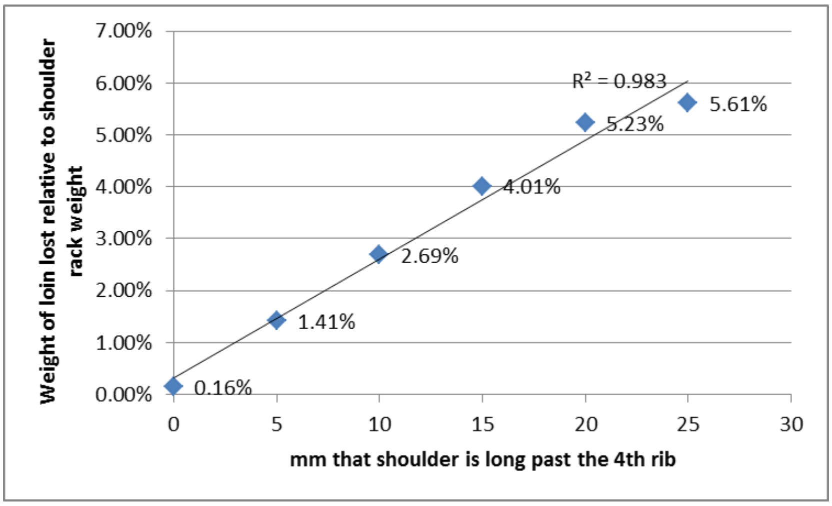

Figure 15: Scatter plot showing relationship between mm of inaccuracy and the loss of shoulder rack relative to its weight

Based on the level of accuracy observed in Figure 14, and Figure 15 is used to calculate the cost of inaccuracy to the plant. The current cutting system was resulting in a benefit of $0.01/hd or a benefit of $12,000 per annum for the plant.

Cost of cutting shoulder long (loss of loin muscle from higher value rack product at $19.00/kg to lower value shoulder rack at $8.60/kg) has just as big an impact on value as the number of ribs. Figure 16 shows the costs and accuracy of each system based on the millimeters of loin remaining on the shoulder above the fourth rib. Note the mean cost was greater in the automated system with increased throughput than in the manual system. However, the important focus is the variance in cutting accuracy which is much less for the automated system when compared to manual. Narrow variation allows much greater process control. So adjustment to the automated system's settings could be made to lower the cutting line closer to the fourth rib without risking cutting into the rib. The data collected demonstrates that the system should continue to be calibrated. These additional benefits were not included in the calculations.

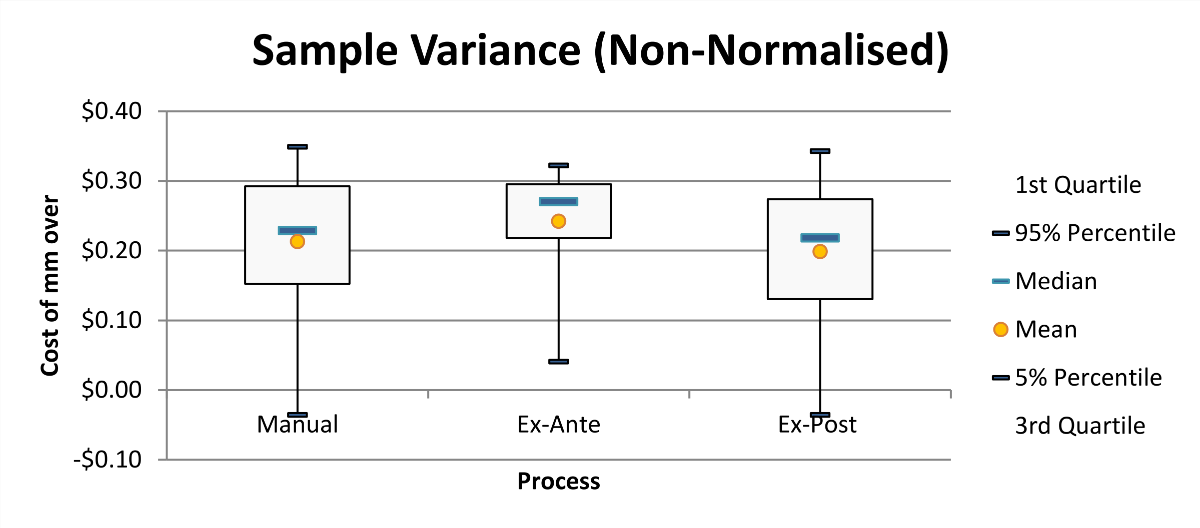

Figure 16: Range in cost of cutting accuracy above last shoulder rib for each cutting system

5.1.5 Total shoulder value

The combined cost of inaccuracy for number of shoulder ribs and for distance cut above the fourth rib is summarised in Figure 17. The difference in cost between the manual cut method on the left and x-ray system is the additional value created by the automated systems for this cut. When manual systems are running at their best they can generate as great a value as the automated system however this is not sustainable. Furthermore, if the bandsaw operator was to change accuracy would be affected. However, manual cutting has a wide variation and can be up to twice that of automation. There was a greater variation shown between the manual and automated system which allows greater control of cutting lines with the automated system. This allows adjustment to systems between plants to meet different plant and customer requirements.

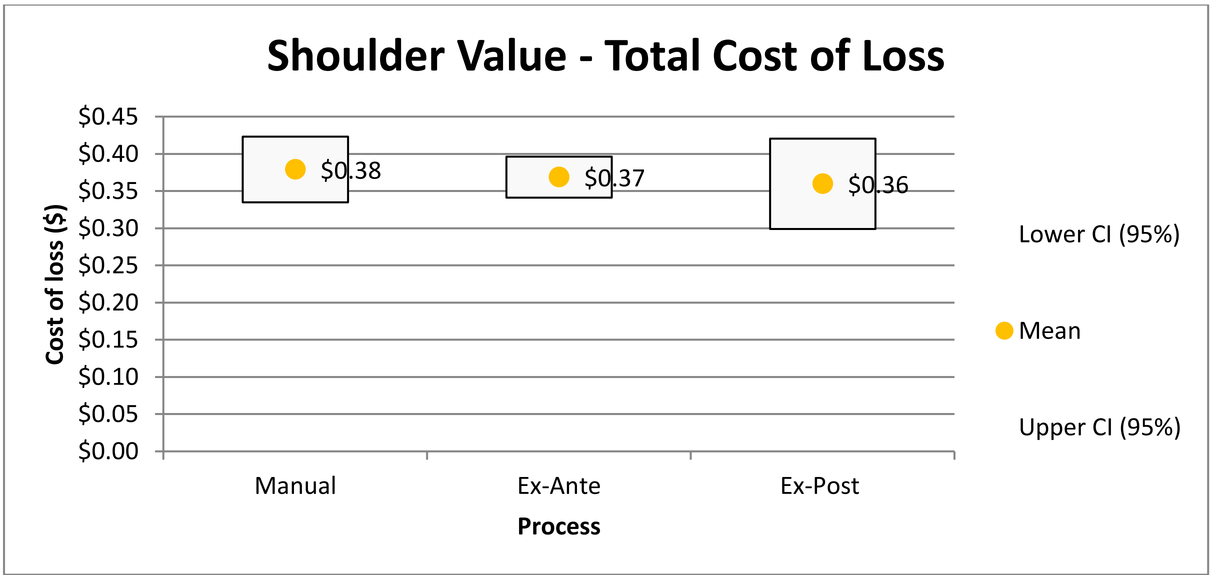

Figure **17: Combined value of loss on shoulder cut (rib # and mm's over last rib) for each cutting method**

5.2 Loin – Hindquarter cut

5.2.1 Measurement

Two major benefits were identified for the automated cutting system to provide value for the hindquarter cut. The first being related to accuracy of the cut, and the second being a technical advantage achieved by the angle of the double cutting blades on the automated primal cutter (scallop cut, see Figure 18).

Figure 18: Shape of scallop cut, when processing boneless back strap, note greater loin recovery from aitch bone.

Accuracy of the leg cut was largely assessed by observing the proximity of the cut to the ilium section of the pelvic bone. An accuracy of level “0” or 100% was considered to be a cut at the lumbosacral junction of the vertebrae and cutting through the cartilage located on top of the ilium bone. The ‘ideal’ cut was considered to be where the cut is made through the top of the cartilage found on the ilium bone (Figure 19). Figure 20 shows where the tip of the ilium bone cartilage is just visible on the cut surface of the leg.

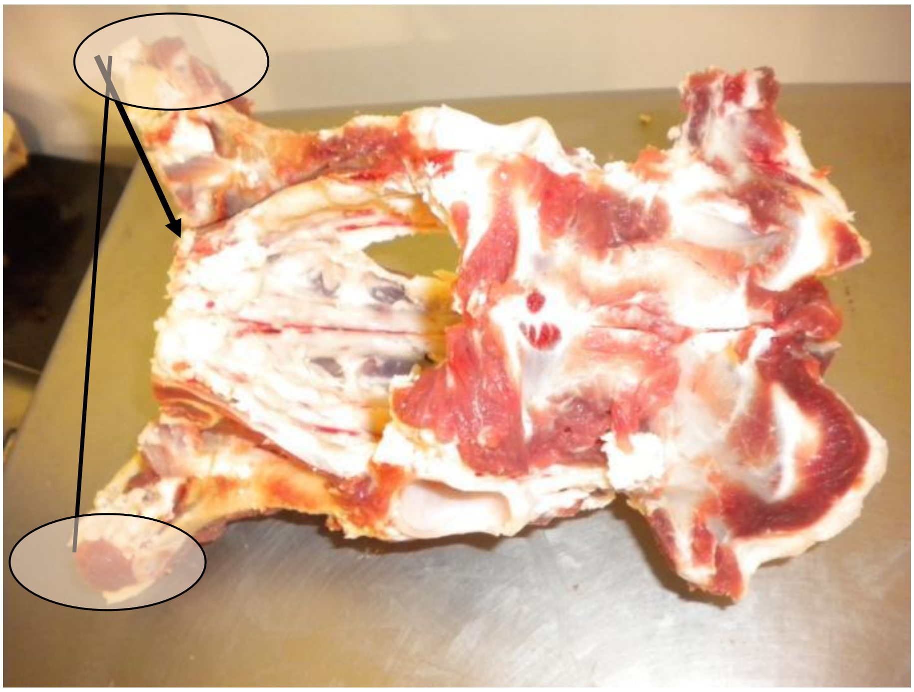

Figure 19: Correct cutting line between hindquarter and loin.

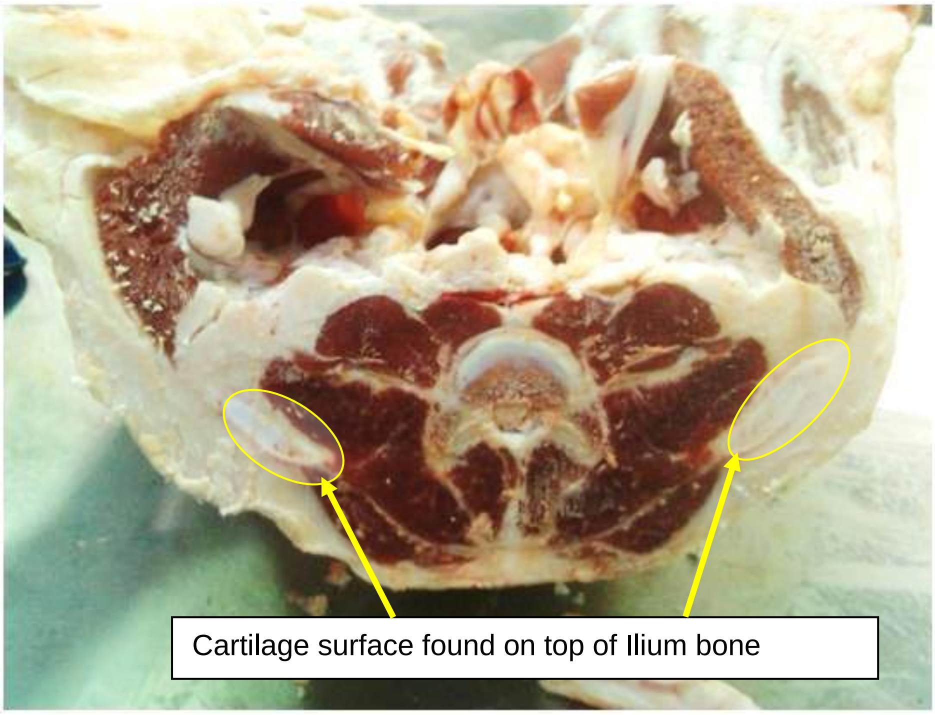

Figure 20: 100% accurate cutting line: Un-boned hindquarter with bone still remaining

Figure 21 illustrates a boneless back strap from the caudal edge. The section highlighted in the image shows here the some cartilage from the aitch bone remains on the boneless loin. The higher the negative value recorded for the hindquarter cut the higher the cutting line was on the aitch bone, resulting in increased bone left on the loin. While no cost has been applied to this as knife hands preparing the loin would remove this excess bone, however there would be an increased labour cost to trim the boneless loin.

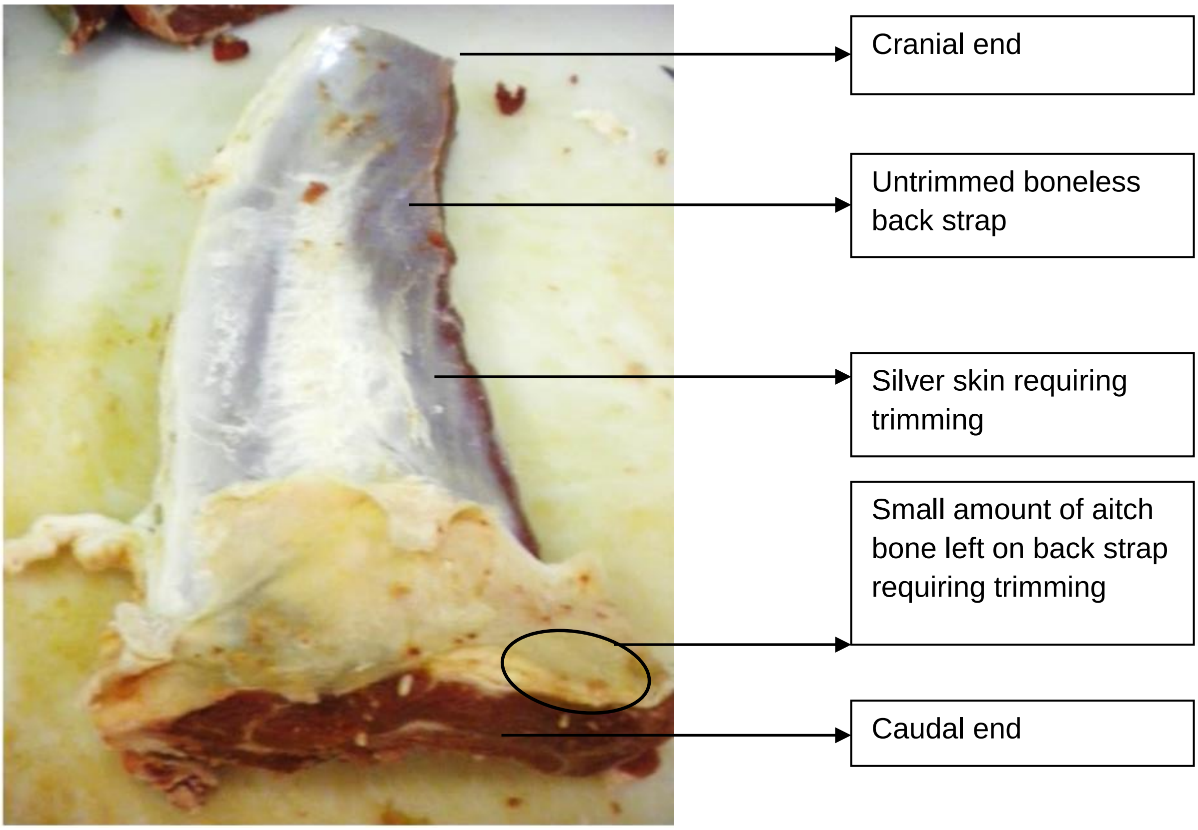

Figure 21: Boneless back strap showing small amount of aitch bone cartilage left on the surface of the muscle.

The following images (Figure 22, Figure 23 & Figure 24) illustrate the method used to calculate the cost of inaccuracies that occur on the leg cut. The images show an inaccurate leg cut where the cut occurs high on the leg, resulting in a long leg, and a shorter loin. Depending on the cutting specification, loin is lost to rendering with aitch bone. Aitch bones were selected randomly from the belt, the accuracy observed, and amount of trim (grams) relative to the accuracy recorded.

Figure 22: Aitch bone showing cut where leg is long, and loin would be short, knife edge marks correct cutting line.

Figure 23: Same aitch bone with trim removed.

Figure 24: Loin muscle recovered from the aitch bone after fat was trimmed.

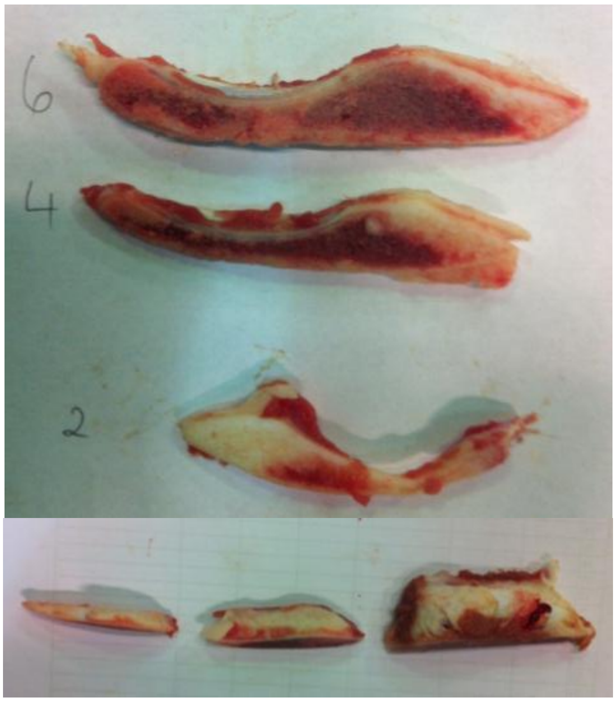

Figure 25: Calibration methods using ilium bone to establish mm's away from target cutting line.

5.2.2 Costing

The weight of the trim relative to the cutting accuracy level was averaged and an index was established to calculate the cost of inaccuracy.

Figure 26: Average weight of loin recovered from aitch bone based on mm of cutting line inaccuracy

Figure 26 is used to illustrate the cost of inaccuracies shown in Figure 27, when the leg primal is cut long. The average amount of trim lost at a given level of inaccuracy is determined. The difference in value of this trim at loin price compared to rendering price is used to calculate the cost of inaccuracy. The per cent occurrence where the leg was long with x-ray cutting systems was then subtracted from the manual per cent of inaccuracy. It was not possible to pick up 100% of inaccuracy observed under manual operating conditions with the installation of x-ray cutting system. The costs for the different levels of inaccuracy were then calculated for the total daily kill population based on the percentage difference between manual and x-ray operation.

5.2.3 Results

The automated process is expected to have a narrower variation in cutting accuracy than manual methods as seen in Figure 27. The Australian installation consistently cut shorter on the leg.

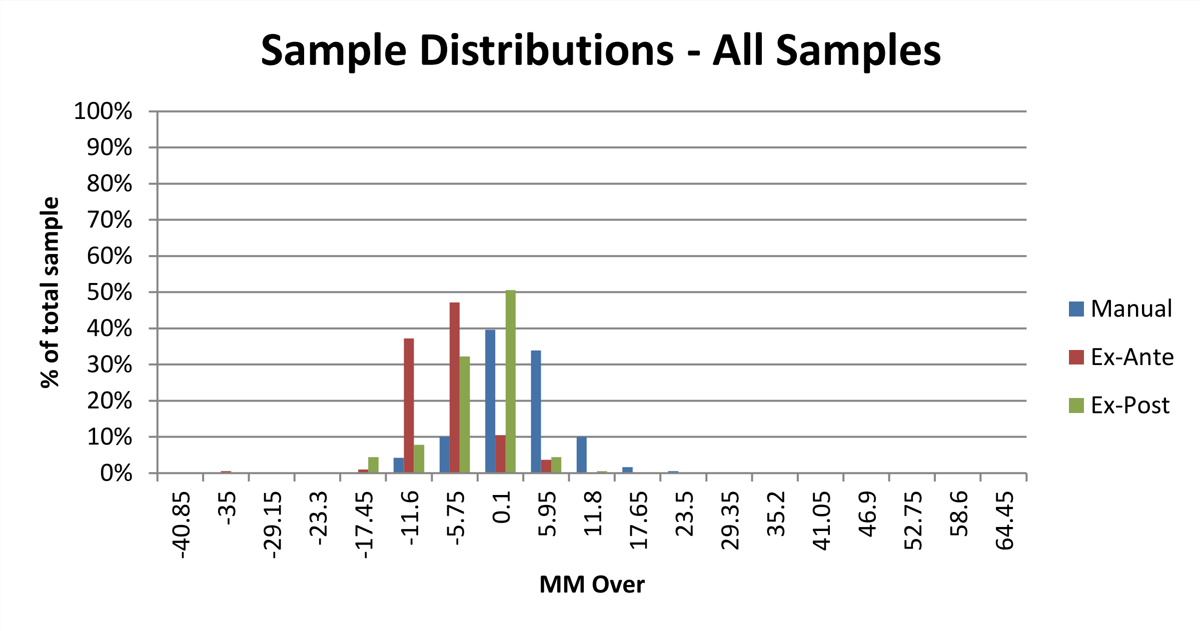

Figure 27: Survey results showing level of cutting accuracy for loin – leg cut for each cutting method

Given the tighter control of the cut with the automated system than the manual bandsaw, the plant was able to target the cutting line higher into the leg to maximise the value of loin without damaging the leg specification. If the cut was to proceed too far into the leg, more rump would remain on the loin and would be lost to trim.

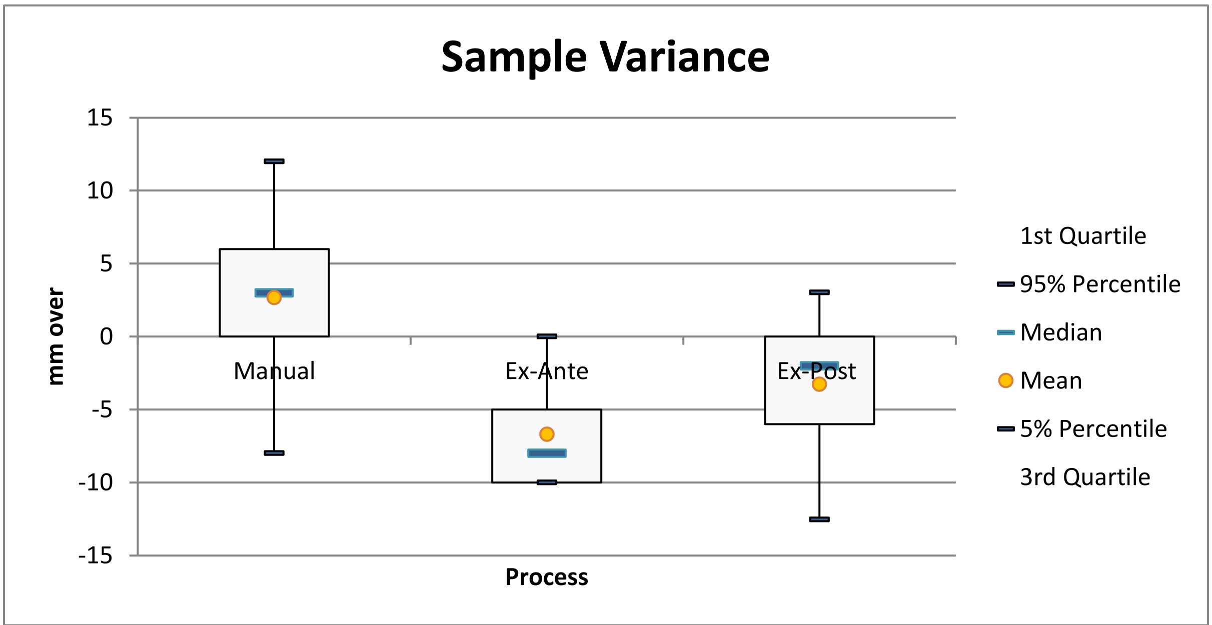

Figure 28: Leg cut sample variance between cutting processes

The variation in manual operations prevents this shift in cutting line to gain lost loin value. This additional control created value on the leg cut that had not been realised during previous ex-post studies. Figure 29 reflects this with significant difference in value for the automated system, expressed as a negative loss (Value gain) in the figure.

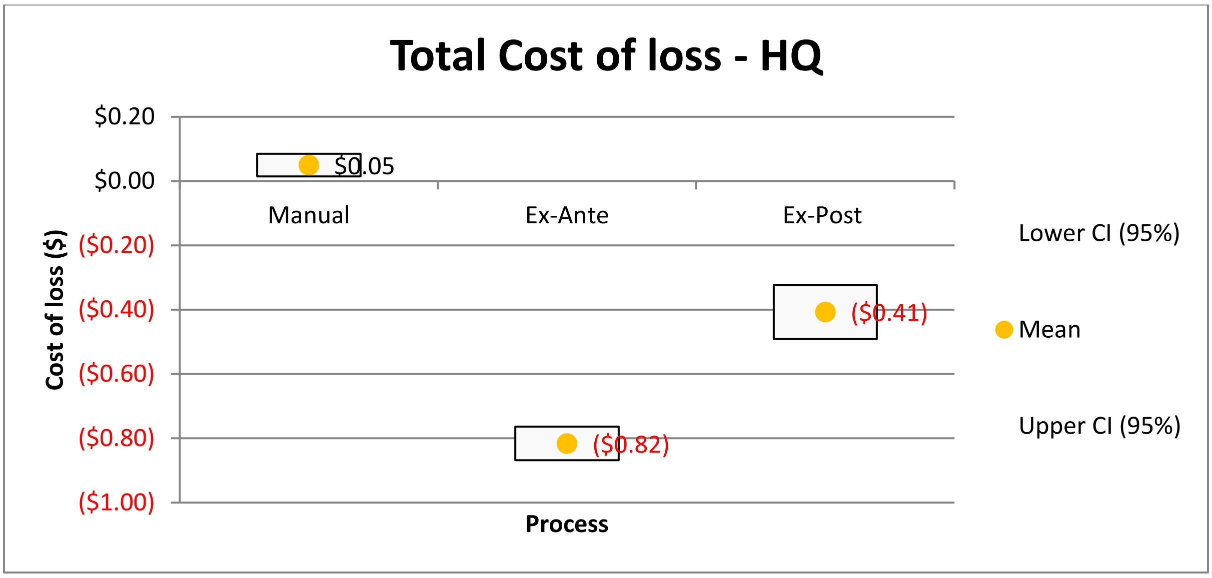

Figure 29: Cost of cut inaccuracy between leg and loin for each cutting method

5.3 Scallop cut

Figure 30 illustrates the two locations where loin can be recovered from the aitch bone with the use of the LEAP III automated primal cutting systems. The first point of recovery is due to improved cutting accuracy, the second aspect is a technical cutting advantage where the blades for the hindquarter cut are angled to follow the ilium aspect of the acetabulum bone, allowing for greater loin recovery from the aitch bone.

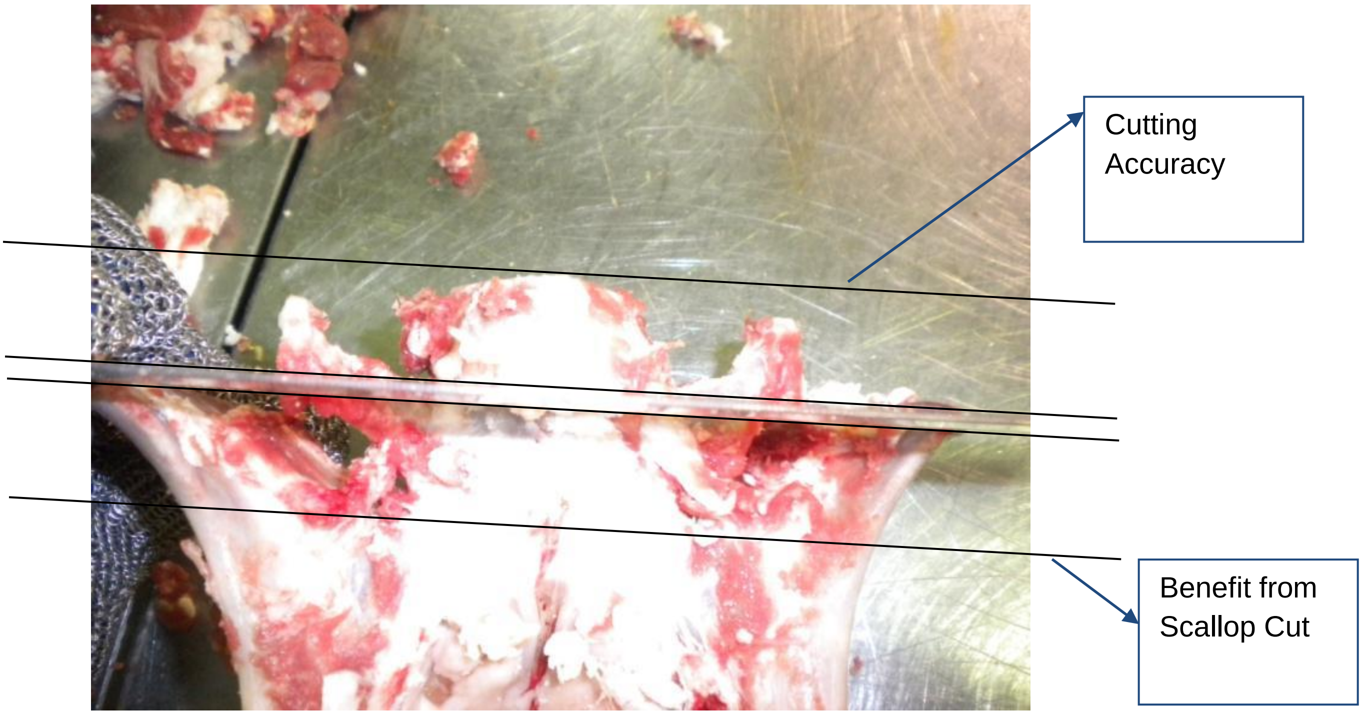

Figure 30: Aitch bone showing value opportunity for increased accuracy in cutting lines, and also value opportunity technical advantageous achievable with the scallop cut.

Figure 31: Difference between standard cut (far left), and Scallop cut (right). Note the increased visible loin remaining on standard hindquarter cut.

Note the large amount of muscle remaining on the aitch bone on the left hand side of Figure 31 is cut with a horizontal cut relative to amount of muscle left on the aitch bone seen on the right hand side of the image. The cost benefit of the scallop cut was established by removing remaining loin from aitch bones cut using the standard cutting method. Aitch bones were than assessed during the scallop cut and any remaining loin was removed. The average amount of loin remaining on the aitch bones after the scallop cut was 10 grams.

The scallop cut to be conducted allows for a varying angle as a result of the primal specifications. When primal are sold as shortloin pairs the scallop cut will only be a minor scallop cut (Figure 32) whereas when boneless back straps and tenderloins are being cut the angle is increase as seen in Figure 18 to increase the yield of saleable product.

These cuts have been costed individually as a result in the difference in yield loss. The costing were then applied to the portion to the portion of production being sold as either a striploin or boneless back straps.

Figure 32: Shape of scallop cut, when processing shortloin pair, the yellow circle identifies the yield benefit to the striploin pair

Provision in the model is made so that the amount of loin recovered can be adjusted for both the minor and major scallop cuts (see Table 7). For the current analysis a saving of 10 grams per side is assumed for the minor scallop cut.

Table 7: The gain in value attributed to the minor scallop cut.

Scallop Cut					
	Per Side	Per Head			
		Min		Max	
Loin Yield benefit achieved with Scallop Cut	0.01		0.02		0.02
Value as Render		$	0.00	$	0.00
Value as Boneless Back strap		$	0.53	$	0.53
Saving / hd		$	0.52	$	0.52
Percentage of animals scallop cut			92.6%		100%
Saving / hd Based on annual processing of Boneless Backstrap**		$	0.48	$	0.52
Daily		$	2,420	$	2,614
	Annual	$	580,830	$	627,246

** Less than 100% of saddles are cut into backstrap using the scallop cut reflected in average value per head of $0.48 to $0.52 per head with the maximum saving for the plant being $0.53/ hd.

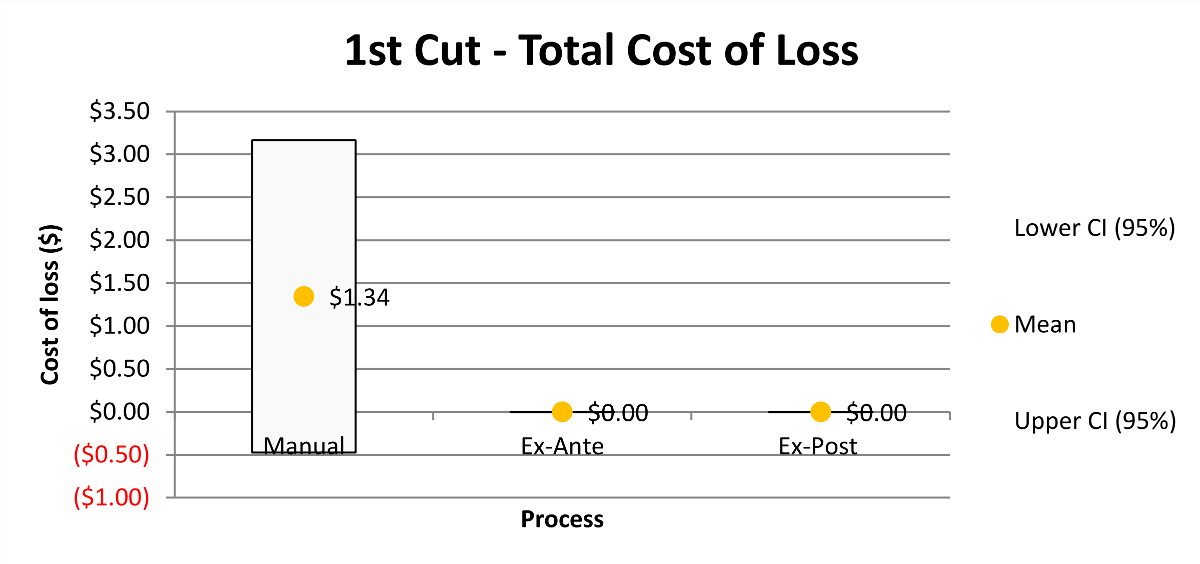

Figure 33: Value gained attributing to the major scallop cut product sold as Boneless back strap and tenderloin

The values presented in Figure 33 show the estimated benefit for conducting the major scallop cut on every carcase processed. However as a result of only 7% of carcases processed sold as boneless back straps and tenderloins the savings for the plant will be requested to $0.09 per head.

The total value attributed to the ability to conduct a scallop cut with the installation of the LEAP III system is calculated at $1.34/head.

5.4 Reduced bandsaw dust

The use of bandsaws for cutting lamb results in bandsaw dust. This has two negative impacts; a) yield loss from the carcass and b) negative visual impact from the residual saw dust left on the surface of the product. The average amount of bandsaw dust collected from the main bandsaw where lamb carcases were being broken into primals was 19.9 grams per carcass across two different manual processing plants (Table 8). An assumption was made that there would be a 90% reduction in sawdust with the different cutting system on the x-ray primal cutter. This returned a value of 36.83 kg/day (based on daily production of 5002 hd), which was costed at an approximate retail carcase value of $7.50/ kg. This resulted in an achievable saving of $0.06/hd based on the automated primal cutting equipment performing 3 cuts on the carcass. An assumed reduction in savings of one third is applied if the automated equipment is operating at only two cuts; this provides a benefit $0.04/hd.

Table 8: Value of band sawdust lost during manual cutting

Number of head for collection		5002
Weight (kg)	Tub weight	Dust weight
11.70	1.92	9.78
4.17	1.92	2.25
15.83	1.92	13.91
6.40	1.75	4.65
	Total dust weight	30.59
Dust from cut splitting chime bone		30.00%
Total dust that could be saved using equipment (kg)		21.41
Saw dust per cut (from 1500 hd)		10.71
Band saw dust / cut / hd (kg)		0.0021
Value of saw dust (retail value of whole lamb		$7.50
Cost / hd / Cut		$0.02

5.5 Increased shelf life

Increases in shelf life are expected with the use of the x-ray primal cutting equipment. This is largely due to;

a) Eliminating oxidized bone dust causing browning of meat surface. (Natural process of oxymyoglobin converting to metmyoglobin and causing browning will still occur).
b) Reduced biological loading
    a. Removal of bone dust from meat surface;
    b. Eliminating the use of water on bandsaw tables currently used during the cutting process;
    c. Reduced human handling of meat;

Figure 34: Lamb hindquarter cut with the LEAP III x-ray primal cutting system, note cut meat surface and lack of bone dust present.

Based on the assumptions the following reductions in discounts are estimated (Table 9) due to improved visual appearance of the product and increased shelf life. Increased shelf life is a benefit to the retail customer. Export chilled and domestic retail contracts place importance on shelf life, but given a number of other factors influence customer buying decisions, no benefit of increased shelf life has been captured in this report for the processor.

Table 9: Calculation used to value the increase in shelf life of lamb product via reduced retail discounts.

Increased Shelf Life (reduced level of discounting)			
	Shoulder (Boneless square cut shoulder)	Loin (Rack Standard)	Leg (Boneless leg chump on)
Average primal weight (kg)	2.57	2.80	5.20
Number of items in 1 year	2,401,068		
Current level of discounting	4.00%		
Number of items discounted	96,043	96,043	96,043
Weight of discounted (kg)	246,830	268,920	499,422
True Value	$2,122,736	$5,109,472	$4,489,804
Discount Value	$1,698,189	$4,087,577	$3,591,843
Current cost of discounting	$424,547	$1,021,894	$897,961
Reduction in level of discounting	10.00%		
New level of discounting	3.60%		
New number of items discounted	86,438	86,438	86,438
New quantity (kg)	222,147	242,028	449,480
New True value	$1,910,462	$4,598,525	$4,040,824
New Discount Value	$1,528,370	$3,678,820	$3,232,659
New cost	$382,092	$919,705	$808,165
SAVING	$42,455	$102,189	$89,796
Saving per head (leg reduced discounting)	$0.035	$0.085	$0.075
Number of cuts	2	$0.11	
	3	$0.20	
	4	$0.27	
Total Saving /hd	Total	$0.27	

**Average primal weights are based on results from industry bone out trials of 121 lamb carcases (average carcasses weight 24.58 kg)*

5.6 Increased Efficiencies on Existing Labour

The main driver behind increased efficiencies for existing labour is a more consistent throughput of product through the boning room. Manual processes rely on the bandsaw operator setting the speed at which the lamb carcasses enter the processing belt. While each bandsaw rotation processed the specified number of carcasses in a given time period, large variations in the processing speed occurred during the rotation. This led to labourers either operating at less than optimum speeds or build-up of product where operators were not able to keep up.

One of the main advantages of the automated primal cutting equipment identified by boning room managers during previous ex-post studies is a greater consistency of throughput through the room. The comment has been made that product flow through the room tends to be much more consistent, and has resulted in an increased boning capacity of the room using the same labour and infrastructure as previously used. This improvement in labour cost per kg is shown in the three scenarios in the right hand columns of Table 10 increased throughput of 4%, the room running at the equipment max for one shift and for two shifts.

Table 10: Manning of processing room[2]

Increased throughput through the room			Manual	Ex-Ante	Ex-Post
Average daily hd			5003	5002	5002
Hd/annum			1,200,672	1,200,534	1,200,534
Average kg			21.88	21.88	21.88
Total Kg boned per day			109,461	109,449	109,449
Boning room cost / hour			$3,076	$3,076	$3,076
Boning room cost / day			$33,834	$32,542	$32,542
Labour cost \ per kg to bone			$0.31	$0.30	$0.30
Labour cost \ per hd to bone			$6.76	$6.51	$6.51
Labour productivity savings/ head			**$0.00**	**$0.26**	**$0.26**
Task	**Rate / hour**	**WW Loading**	**Number labour units per shift- Manual Process (Note - this is gross of labour savings - based on No. of Head above)**		
		30%			
Supervisor	$35.00	$45.50	1	1	1
QA	$31.00	$40.30	0	0	0
Band Saw operator	$23.00	$29.90	6	6	6
Trimmers	$23.00	$29.90	24	24	24
Packer	$24.00	$31.20	41	41	41
General Labor	$23.00	$29.90	3	3	3
Boners	$26.00	$33.80	12	12	12
Slicers	$23.00	$29.90	12	12	12
		$0.00			
Total FTE's required			99	99	99

In the cost benefit results, no consideration is given to reduction in per head allocation of fixed costs by increasing the processing capacity of the plant due to increased cutting speed of the equipment.

5.7 Labour savings

The data displayed in Table 11 shows a saving of 3 labour units across band saw operators and bone scrapers. This resulted in labour savings of $0.19 per head using the automated primal cutting equipment.

Table 11: Labour savings achieved with automated x-ray primal cutting system.

Labour Savings per day			
	Number labour units required		
Task	Manual	Ex-Ante	Ex-Post
Supervisor	1	1	1
Band Saw operator	6	4	4
Trimmers	24	24	24
Packer	41	41	41
General Labor	3	2	2
Boners	12	12	12
Slicers	12	12	12
Total FTE's required	**99**	**96**	**96**
Total FTE's saved	**-**	**3**	**3**
Saving per head	**$0.00**	**$0.19**	**$0.19**

[2] Note table 9 is purely for the purposes of measuring changes in throughput and labour units required to achieve faster rates. No additional staff were required to achieve the faster throughputs. It does not take into account the savings in bandsaw operators or other staff as a result of the automation. These labour savings are covered in section 5.7.

5.8 OH&S savings

Two main areas are identified where the automated primal cutting system will provide OH&S benefits. These are reduced sprain and strain injuries through eliminating the need for bandsaw operators to be lifting carcass off the rail for cutting, and eliminating the need for any operator interaction with a saw blade for the cutting of lamb primals. Based on these assumptions the following frame work is presented to show OH&S Benefits (Table 12).

Table 12: OH&S Benefits of automated x-ray primal cutting system

OH&S					
	Band Saw cutting	Sprain and Strain from lifting			
Job Role Affected	Band Saw operator	3			
Claims in last 10 years	4.0	40.0	Manual	Ex-Ante	Ex-Post
Risk / FTE / Year	6.7%	66.7%			
Annual Premium	$19,200	$10,000			
Job Annual Hours			15,840	10,665	10,665
Limb Losses per year			0.40	0.28	0.28
Sprains and Strains per year			4.00	2.80	2.80
Annual Cost			$47,680	$33,376	$33,376
Annual Cost / Head			$0.04	$0.03	$0.03
Annual saving per head			$0.00	$0.01	$0.01

5.9 Equipment costs

Table 13 shows the total cost of the equipment Including both capital and operational costs. Real costs will be site specific to every application particularly installation costs. No major maintenance costs have been factored into the costings at this stage.

Table 13: Estimated capital and operating costs of automated x-ray primal cutting equipment

Capital Cost	Ex-Ante		Ex-Post	
	Cost	Life span	Cost	Life span
Capital Cost of the equipment	$1,980,000	10	$1,980,000	10
Other Capital install	$710,000	10	$710,000	10
Total	**$2,690,000**		**$2,690,000**	
Service maintenance	Ex-Ante		Ex-Post	
	Cost	Units	Cost	Units
Estimated - COSTS				
Electricity	6.00 KW	$0.33 /KWH	6.00 KW	$0.33 /KWH
Maintenance labour (Daily)		$9,242 /Yr		$9,242 /Yr
Maintenance labour (Preventative)		0 /Yr		0 /Yr
Maintenance labour (Breakdown)		$66,910 /Yr		$66,910 /Yr
Maintenance labour (Training)		$1,500 /Yr		$1,500 /Yr
Operational		**$14,469**		**$14,269**
Maintenance		**$68,410**		**$68,410**
Annual Sub Total (excluding major overhaul costs)		**$82,879**		**$82,679**
Combined Total: (cap ex + operating)				
Total Annual Estimated Expenses	Hours	Cost	Hours	Cost
Expected hours downtime per year	12	$36,910 /Yr	12	$36,910 /Yr

5.9.1 Capital Costs

Equipment purchase price is based on prices supplied by the manufacturer. Installation costs will be site specific, and will depend largely on the foot print available within the existing plant. Infrastructure upgrades may be required at some plants and allowance has been provided in the model for site specific numbers to be included. The capital cost per head processed will reduce as the total annual number of head processed increases.

5.9.2 Maintenance and Service Costs

Maintenance and service costs are also supplied by the equipment manufacturer. Maintenance costs are additional running costs that the plants will incur with the installation of the equipment and include components such as parts and labour. The service contract covers ongoing service and maintenance of the x-ray system. The assumption is made that these costs will be a “per head cost” and for this reason no reduction in these costs is seen with increasing production.

5.9.3 Risk of Down Time

Table 13 shows the conservative calculation used to estimate the cost of down time for an average installation across the wider industry. The allowance is made for 1 occurrence per week where the stoppages associated with the equipment would cause the entire room to be at a standstill for 15 minutes. The same labour cost used for calculating increases in labour efficiency (Table 10) is used to calculate the cost of down time. The amount of weekly down time is an adjustable figure found on the “Costs” sheet of the model.

5.10 Installation Adjustments

The installation of any system may have a number of adjustments required after the system is up and running. The adjustments on this system are detailed below and have been resolved:

- There have been a number of saw blades broken since it was in operation, which required a change in the type of blades being used.
- The left and right sides of the carcases were not cutting as accurately as expected due to the carcases hanging slightly off centre. The automated pelt removal on the slaughter floor had been pulling downward after the carcase passed the centre of the pulling action. As a result on side of the carcase was stretched more than the other and resulted in imbalance between the left and right ribs. As one side of the carcase is scanned during the x-ray, the other side was not cut true and cut at the wrong rib. The pelt removal process has been modified to reduce the variations between sides.

The LEAP III system in the plant has been highly successfully as everyone on the boning room floor is very happy with the system. Even bandsaw operators that previously did the manual cutting say the automated system is more accurate than they ever were.

6 Cost Benefit Results

The results reported in this section are based on the model drivers summarised in 4.3.1 on page 11. The total ex-post benefits observed were less than expected during the ex-ante review conducted previously by Greenleaf in 2013. The ex-post analysis demonstrated a benefit approximately 22% smaller than estimated in the ex-ante analysis due to benefits associated with the hind leg cut being less than expected. The actual benefit is currently between $0.34 and $0.46/hd less than estimated as a result of the following:

- The partial scallop cut, costed in the ex-ante study for all carcases is not yet implemented by the plant and is a decision on customer specification
- The target cutting line used for the ex-ante estimation assumed a cut further into the Aitch bone. Ex-post settings are slightly tipping the cartilage on the ilium bone. This is a customer specification and can be adjusted on the LEAP system.
- The combination of leg cuts caused a $0.38/hd to $0.44/hd variation in benefit

The methodologies used to analyse and present the data were constant between the ex-ante and ex-post reports. The detail summarised in Table 14 of this ex-post report reflects the range in values observed in the data collected.

The summary results in Table 14 demonstrate the performance of the ex-ante machine (left), and the ex-post review relative to manual operations.

Variance observed across the sample data reflects a range in values expected and is reported using the upper and lower 95% confidence intervals in the Table 14 as lower (From) and upper (To) value range for each piece of equipment.

The ex-post estimated net benefit of between $1.32/hd and $1.49/hd, compared with an ex-ante prediction of between $1.57/hd to $1.85/hd. This therefore delivers an estimated return on investment of between 1.39 and 1.55 years.

Part of the variation observed between plants is causes by the installation refinement and facilitated system improvements by the manufacturer to reduce cutting variation and increase value from improved cutting accuracy. In addition to these modifications some of the variation will be causes by plant specific drivers such as number of head killed per day.

Table 14: Summary of benefits for ex-ante, and ex-post analysis relative to manual cutting performance

SUMMARY PERFORMANCE MEASURES				
	Ex-Ante		Ex-Post	
Hd / annum	1,200,534		1,200,534	
Production increase with equipment	7.21%		7.21%	
	From	To	From	To
Capital cost (pmt option, upfront)	$2,690,000		$2,690,000	
Gross return Per head	$1.90	$2.18	$1.65	$1.82
Total costs Per head	$0.32		$0.32	
Net Benefit Per head	$1.57	$1.85	$1.32	$1.49
Annual Net Benefit for the plant	$1,886,970	$2,222,596	$1,586,706	$1,790,801
Annual Net Benefit for the ex cap	$2,036,181	$2,371,807	$1,735,917	$1,940,013
Pay back (years)	1.32	1.13	1.55	1.39
Net Present Value of investment	$12,452,628	$14,809,928	$10,343,700	$11,777,181

The benefits identified can be broadly summarised as either product value or process efficiency benefits with the larger portion of benefits being related to product value as in Figure 35.

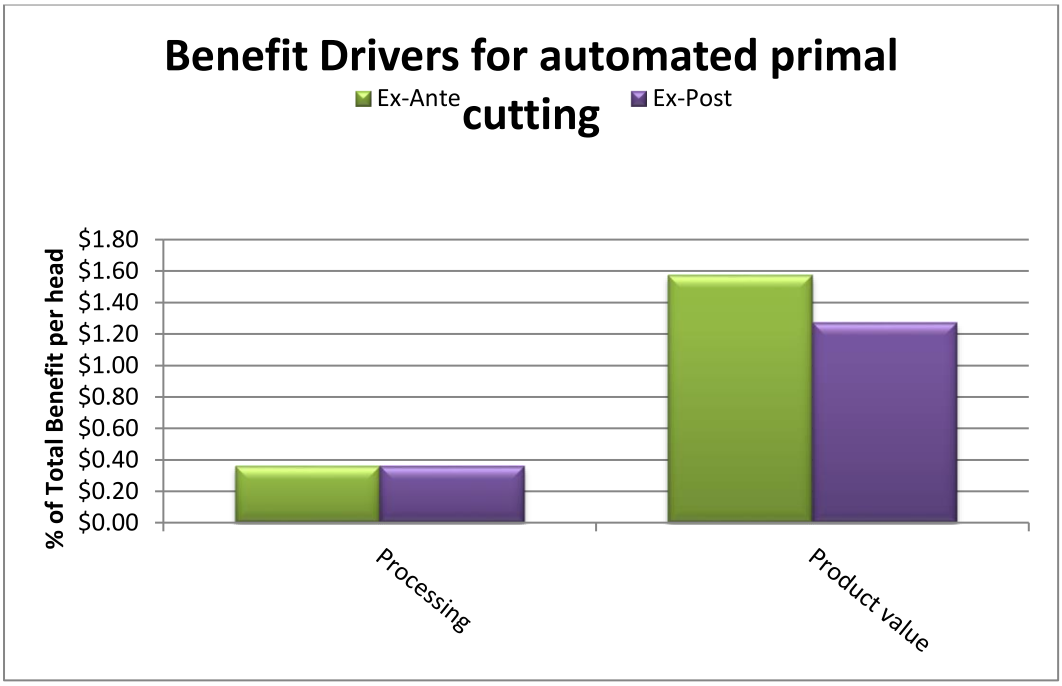

Figure 35: Broad grouping of benefits delivered by Scott's x-ray primal cutting solution

Scott's automated equipment improved accuracy of cutting lines as compared with manual methods and increased retail value of carcasses. Automated cutting technology delivered a technical cutting advantage over manual systems including scallop cutting for some product specifications, yield gains through reduced bandsaw dust and increased shelf life. Other benefits relating to process improvements included increased labour productivity as a result of more consistent product flows, as well as a reduction in labour units required. Occupational health and safety costs reduced as a result of reduced safety risks.

The overall contribution of each individual benefit and its associated dollar value is summarised in Figure 36.

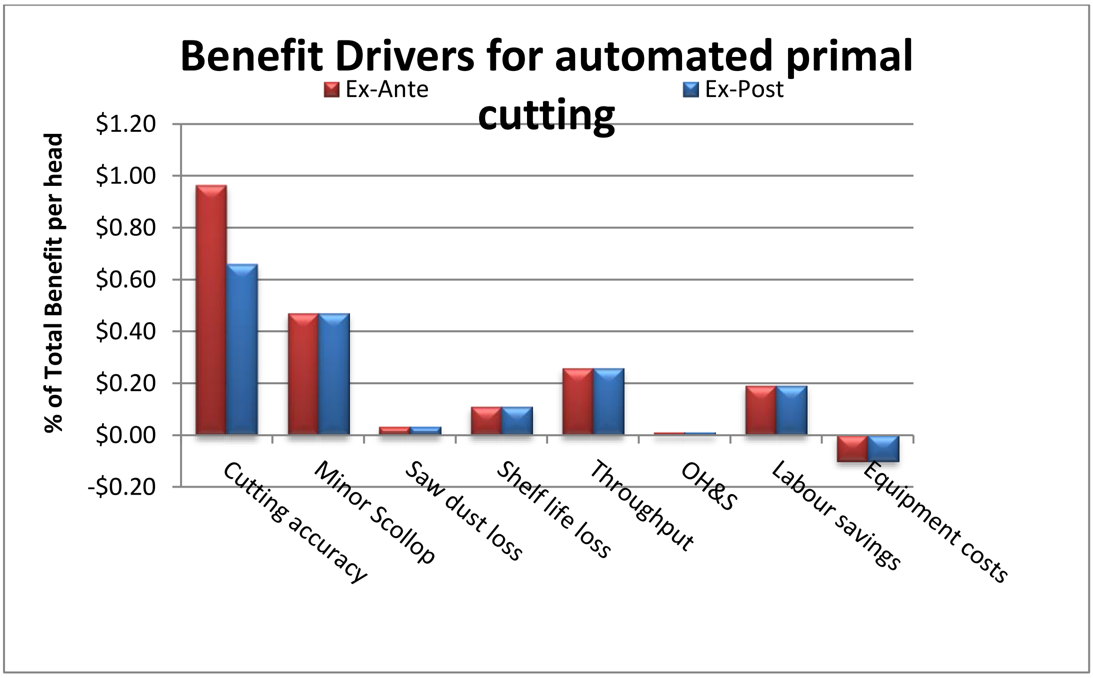

Figure 36: Summary of benefits delivered from Scott's x-ray primal cutting solution

6.1 Calculating Value of Benefit

Target performance levels for manual and automated systems alike relate back to product cutting specifications, operational targets and what the customer is willing to pay for each piece of meat. There is an ideal mix of performance across the range of variables that could produce optimum value for the company. The Australian LEAP III systems are compared back to manual operations but these systems need to be compared back to the optimum value that could be obtained. The target cutting lines between the leg and loin are a prime example in section 5.2. Deviation away from the target cutting line created more value in the Australian LEAP III system, but only while the variance was small enough to ensure no cuts exceeded a limit that would have caused loss.

Table 15 summarises the amount of benefit relative to the manual operation by area the benefit for the LEAP III installed is between $1.55 and $1.72/hd when compared to the manual system.

Table 15: Summary results of individual benefits associated with automated x-ray primal cutting of lamb carcasses

TOTAL BENEFIT					
		Ex-Ante		Ex-Post	
Benefit Summary		$/hd From	$/hd To	$/hd From	$/hd To
1.1 Accuracy Benefit	Cut 1 (FQ-Mid)	-$0.01	$0.03	$0.12	$0.11
	Cut 3 (Hind Leg)	$0.88	$0.85	$0.51	$0.41
	Full Scallop Cut	-$0.03	$0.21	-$0.03	$0.21
1.2 Cutting Technique	Cut 4 (SLP)	$0.45	$0.49	$0.45	$0.49
	Saw dust loss	$0.03	$0.03	$0.03	$0.03
	Shelf life loss	$0.11	$0.11	$0.11	$0.11
2. Throughput		$0.26	$0.26	$0.26	$0.26
3. OH&S Benefit		$0.01	$0.01	$0.01	$0.01
4. Labour Benefit		$0.19	$0.19	$0.19	$0.19
Equipment costs	**Maintenance**	-$0.06	-$0.06	-$0.06	-$0.06
	Operation	-$0.01	-$0.01	-$0.01	-$0.01
	Risk of failure	-$0.03	-$0.03	-$0.03	-$0.03
	$ Benefit per head	**$1.80**	**$2.08**	**$1.55**	**$1.72**
$ Annual Benefit overall plant		**$2,155,970**	**$2,491,596**	**$1,855,706**	**$2,059,801**

Presenting the figures this way in the detailed section of the model demonstrates the total costs involved and highlights areas that future savings could be generated.

The Figure 37 shows the difference in cost between the systems. Thickness of the box in the graph represents the upper and lower variation in value expected based on performance variation captured in the data.

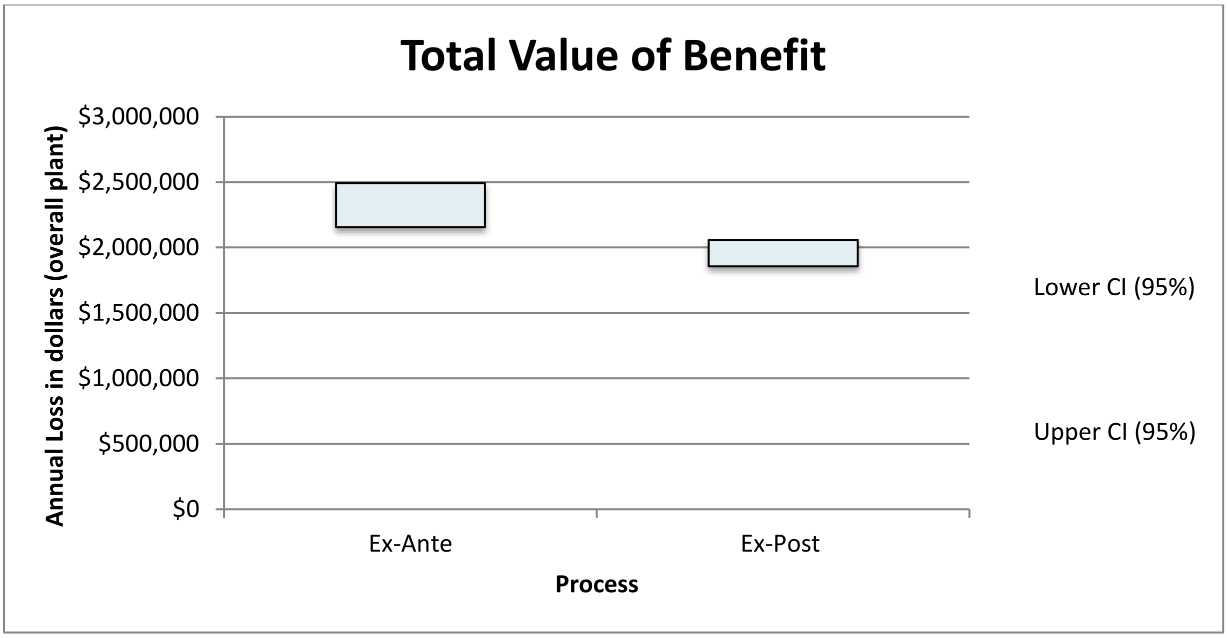

Figure 37: Improvement in benefits over manual operation from Table 15

More detailed breakdown of the costs and benefits are included in Table 16 and Table 17 below.

6.2 Breakdown of costs and benefits

Table 16: Summary of forecast and actual benefits for the LEAP III system

SUMMARY PERFORMANCE MEASURES				
	Ex-Ante		Ex-Post	
Hd / annum	1,200,534		1,200,534	
Production increase with equipment	7.21%		7.21%	
COST - BENEFIT ANALYSIS OF ROBOTIC PRIMAL CUTTING EQUIPMENT				
** Cost is reported as the inaccuracy from target specification OR as the difference between Manual vs. Auto costs*				
Benefit summary	$/hd		$/hd	
	From	To	From	To
$ Accuracy Benefit per head	$0.84	$1.09	$0.59	$0.73
$ Technique Benefit per head	$0.59	$0.63	$0.59	$0.63
$ Labour Benefit per head	$0.46	$0.46	$0.46	$0.46
$ Automation Costs	($0.10)	($0.10)	($0.10)	($0.10)
$ Overall Benefit per head	**$1.80**	**$2.08**	**$1.55**	**$1.72**

COST ASSOCIATED WITH THE EQUIPMENT		
	$/hd	$/hd
Capital cost	$0.22	$0.22
Maintenance	$0.06	$0.06
Operation	$0.01	$0.01
Risk of mechanical failure	$0.03	$0.03
Total cost per head	$0.32	$0.32
Total cost per head (EX CAP)	$0.10	$0.10

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Table 17: Costs and benefits breakdown for the LEAP III installation at 7.88hd/minute

Benefit Drivers for automated primal cutting				
	Ex-Ante		Ex-Post	
	$/ hd	$/ annum	$/ hd	$/ annum
Processing	$0.36	$432,410	$0.36	$432,609
Product value	$1.58	$1,891,373	$1.27	$1,525,144
	$1.94	**$2,323,783**	**$1.63**	**$1,957,753**
Cutting accuracy	$0.96	$1,157,076	$0.66	$790,847
Minor Scollop	$0.47	$563,503	$0.47	$563,503
Saw dust loss	$0.03	$38,543	$0.03	$38,543
Shelf life loss	$0.11	$132,251	$0.11	$132,251
Throughput	$0.26	$309,106	$0.26	$309,106
OH&S	$0.01	$14,299	$0.01	$14,299
Labour savings	$0.19	$228,794	$0.19	$228,794
Equipment costs	-$0.10	-$119,789	-$0.10	-$119,589
	$1.94	**$2,323,783**	**$1.63**	**$1,957,753**

6.3 Financial viability of equipment

Value of this equipment will vary between plants dependant on market specifications and processing speeds. However based on the drivers show in Table 17 the following analysis provides a net annual return of conservatively $1,730,000 per annum. Considering an initial total cost of investment of $2,690,000 this delivers a payback period of between 1.39 and 1.55 years at current processing rates. Based on a 10 year life expectancy of the investment and discount rate of 7% (and all other factors being equal) the Net Present Value of investment is estimated between $10.3 million and $11.8 million.

6.4 Additional benefits not captured

The benefit of reducing direct labour cost per head through increased production per man hour has been accounted for in section 5.6. An additional benefit of larger production volumes is the allocation of fixed overhead costs like administration, marketing and land and building costs across a larger volume of product as a result of faster processing speeds. This benefit is real for the installation reviewed but will not apply to all plants as other volume limiting processes (including livestock supply) may limit increased production volumes.

Current manual primal cutting speed is approximately 7.88 hd / minute; however the automated equipment can run at a speed of 10 hd/minute. Increasing the processing capacity to 7.88 hd per minute (79% of expected equipment operational capacity) a 7.21% increase in the overall production capacity of the existing plant is expected to be achieved through the installation of the LEAP III system. This helps to lower the average fixed cost per head, resulting in an increased net benefit not yet captured in the benefits or in the payback period for the investment. Obviously other processing plants would need to have the existing capacity to increase overall production (trimming – packaging – chill/ freeze – load out).

Lamb supply is often the biggest limiting factor. However, livestock supply fluctuates throughout the year and at times increased seasonal lamb turn-off reduces that supply bottleneck. The boning room is the next largest bottleneck for a number of lamb processing plants. In these situations increased production (enabled by reducing the boning room bottleneck with LEAP III) would reduce allocation of overhead costs. Given the lack of knowledge about the various processors situations and variability of this benefit across processors, it has not been included in this report.

7 References

Aus Meat (2003) "Sheep meat Language" (Sheep Meat Primal Cuts) sourced on line at Aus Meat, viewed 14 July 2010, http://www.ausmeat.com.au/media/3413/sheep%20meat%20language%20brochure.pdf

Greenleaf. (2010). *LEAP 3 Generic Report V2.6.* North Sydney: MLA.

8 Appendices

8.1 List of Tables

8.2 List of Figures