# final report

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# Ex Ante NZ Ex Post General LEAP III CBA Report

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# Ex-Post value proposition for automated Ovine x-ray Primal Cutting Systems

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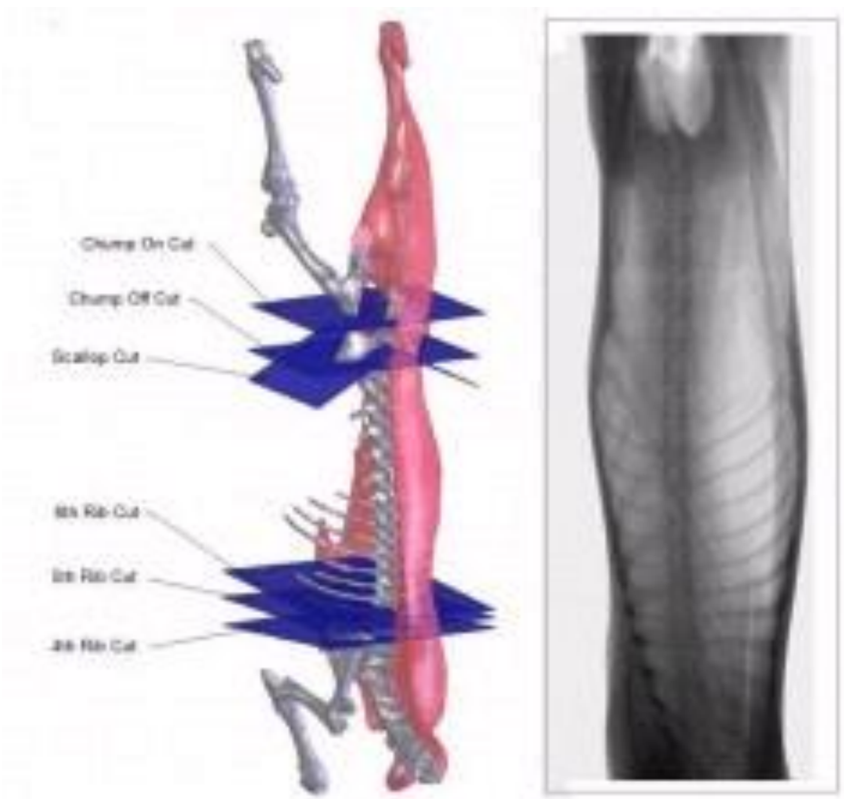



**Prepared by Greenleaf Enterprises: November 2012**

## Executive Summary

Scott Technology in conjunction with stakeholders including MLA and a New Zealand lamb processing company have developed automated lamb primal cutting equipment guided with the use of x-ray Technology (LEAP III). An ex-ante cost benefit analysis was conducted in an Australian lamb processing company (2010) to estimate the likely benefit from installation of a commercial system. The review identified the costs associated with the current manual cutting systems and compared this against the improvements in accuracy and safety demonstrated by the automated system in the New Zealand processing plant. A LEAP III primal cutting system has since been installed in the Australian plant. A comparison between the performance of previous manual methods, the ex-ante New Zealand automation system and the ex-post installation in this Australian plant was conducted and is the basis of this report.

The total ex-post benefits observed were consistent with the ex-ante review but the magnitude of benefits changed with a higher total realised ex-post value relative to the ex-ante prediction. The summary results in Table 1 demonstrate the performance of the ex-ante machine (left), the ex-post Australian installation (middle) and theoretical maximum capacity of the machine (right) 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 1 as lower (From) and upper (To) value range for each piece of equipment.

The ex-post net benefit was $2.03/hd, compared with an ex-ante prediction of $1.87/hd. This represents an 8% improvement on the original increase in value, delivering an estimated return on investment of 1.63 years. Part of the improvement from the ex-ante to ex-post reviews was attributed to information collected during the ex-ante study that facilitated system improvements by the manufacturer to reduce cutting variation and increase value from improved cutting accuracy.

**Table 1: Summary of benefits for ex-ante, ex-post and maximum machine speed relative to manual cutting performance[1]**

[1] Note the modelling and calculations used in this ex-post analysis involve a higher degree of statistical analysis of the base data than used in the original ex-ante modelling. This has been done to improve the level of insights arising from these studies. To allow easy comparison this improved method has been applied back against the ex-ante data set. Detail of the analysis is explained in section 4.1

| SUMMARY PERFORMANCE MEASURES | | | | | | |
|---|---|---|---|---|---|---|
| | NZ-Xray (Ex-Ante) | | AUS-Xray (Ex-Post) | | EQUIP. MAX hd/min | |
| | Hd/ annum | 723,450 | Hd/ annum | 723,450 | Hd/ annum | 1,113,000 |
| Production increase with equipment | 24.05% | | 24.05% | | 90.84% | |
| | From | To | From | To | From | To |
| Capital cost (pmtt option, upfront) | $2,690,000 | | $2,690,000 | | $2,690,000 | |
| Gross return Per head | $2.16 | $2.38 | $2.32 | $2.52 | $2.66 | $2.86 |
| Total costs Per head | $0.48 | | $0.48 | | $0.32 | |
| Net Benefit Per head | $1.67 | $1.90 | $1.83 | $2.03 | $2.35 | $2.55 |
| Annual Net Benefit for the plant | $1,209,967 | $1,371,466 | $1,326,667 | $1,469,486 | $2,614,450 | $2,834,173 |
| Annual Net Benefit for the ex cap | $1,397,233 | $1,558,732 | $1,513,933 | $1,656,752 | $2,757,706 | $2,977,429 |
| Pay back (years) | 1.93 | 1.73 | 1.78 | 1.62 | 0.98 | 0.90 |
| Net Present Value of investment | $7,299,563 | $8,433,862 | $8,119,210 | $9,122,317 | $16,854,952 | $18,398,194 |

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 1.

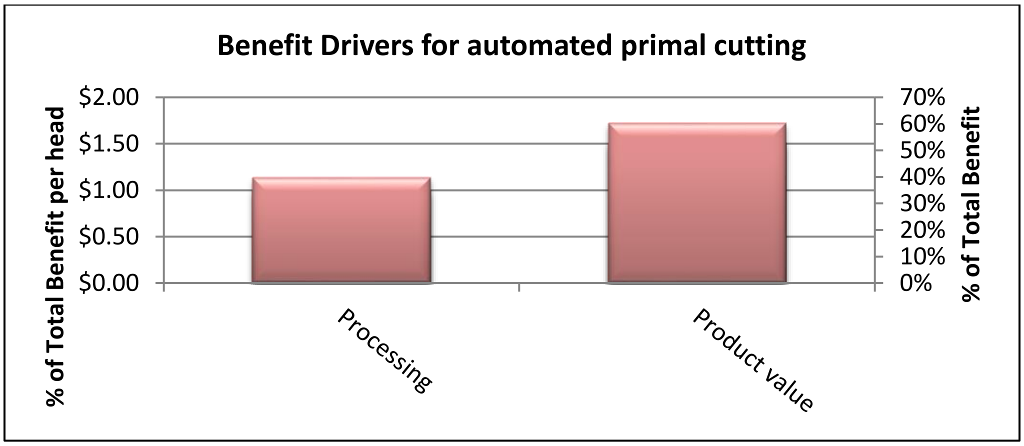



**Figure 1: Broad grouping of benefits delivered by Scott's x-ray primal cutting solution**

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 2.

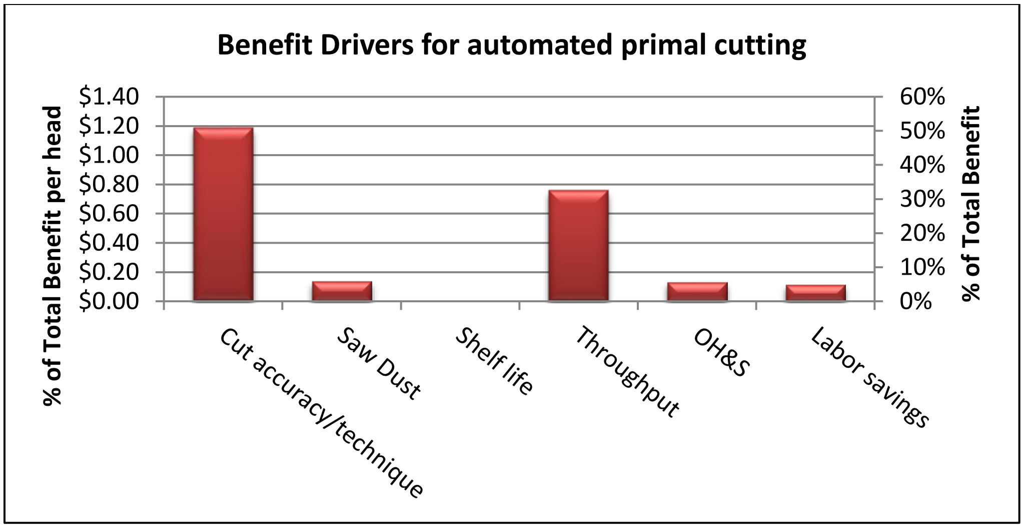



Figure 2: Summary of benefits delivered from Scott's x-ray primal cutting solution

## 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) |
| 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) |

# 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 following ex-post report measures the actual benefit delivered by this system after 12 months of commercial operation. The report is designed to build on the methods used for data collection and analysis in the ex-ante study to enable comparison of both ex-post and ex-ante 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-ante study, measure the real value opportunity demonstrated by the equipment 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. The first installation in New Zealand was used as the test site to establish performance benchmarks for the ex-ante study. A second system has been installed in Australia and underpins the performance measures reported in this ex-post study. The systems have the same core technologies although additional cuts are operational on the ex-post system along with software upgrades for cutting lines.

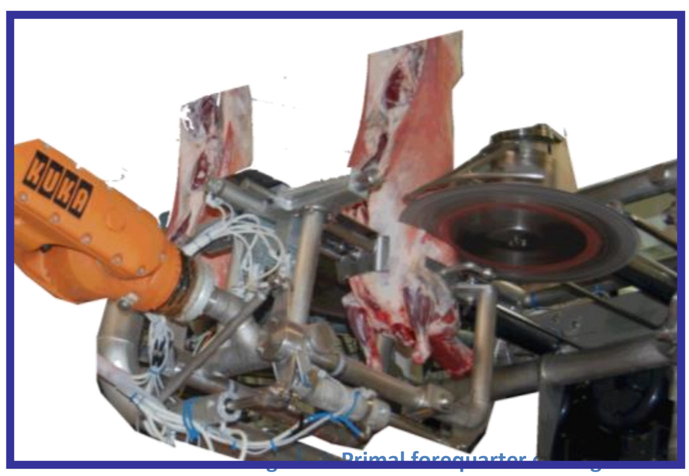
## 3.1 Whole carcase x-ray system

The first tasks 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.


## 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.




Primal forequarter

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.

# 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 an 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 used in the ex-ante review was applied with the results compared back to the manual process and to the New Zealand automated cutting system. Further benchmarking measures were taken to ensure consistency between the ex-ante and ex-post data collection processes and to enable to ex-ante and ex-post comparisons.

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

A range of statistical hypothesis tests were used in the analysis to determine robustness of correlations between data collected in ex-ante and ex-post studies. Due to the fact that we have different data collectors and data analysts across different processing sites which compared manual and NZ x-ray processes and AUS x-ray process to ex-ante results, we have reanalysed previous data as well to ensure consistency across the analysis.

## 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 previous ex-ante study reported average costs and benefits. The range in cost or benefit is also of interest and has been included in the summary results of this report.

Re-analysis of the ex-ante data has been done in addition to this projects deliverables to reflect ex-ante variation and to compare the ex-ante range in value with ex-post results.

## 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 are calculated using 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 calculation (Table 3). The table summarises manual performance (far left) as the base line which the ex-ante machine (left), the ex-post Australian installation (middle) and theoretical maximum capacity of the machine (right) relative to manual operations are compared against.

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

**Table 3: Calculation used for determining production volume base line**

| Processing room operation speeds | | | | |
|---|---|---|---|---|
| | Manual | NZ-Xray (Ex-Ante) | AUS-Xray (Ex-Post) | EQUIP. MAX hd/min |
| Carcases / min | 5.24 | 6.50 | 6.50 | 10.00 |
| Carcases / Statn./hr | 314 | 390 | 390 | 600 |
| Room speed | 314 | 390 | 390 | 600 |
| Shifts / day | 1 | 1 | 1 | 1 |
| Saw Hrs / Shift 1 | 7.0 | 7.00 | 7.00 | 7.00 |
| Saw Hrs / Shift 2 | 0.0 | 0.00 | 0.00 | 0.00 |
| Carcases / day | 2201 | 2730 | 2730 | 4200 |
| Annual days | 265 | 265 | 265 | 265 |
| Annual # of hd | 583,212 | 723,450 | 723,450 | 1,113,000 |

Installation of the automated cutting system gave an immediate increase in productivity, increasing room throughput by 24% without increasing the number of labour units[2]. The key factor is the increased consistency at which product flows into the room. Previous manual methods resulted in

[2] 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.

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 light green in Table 4 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 12.

**Table 4: Retail Sales values used for driving economic analysis in the driver**

| Average discount level | | 20% |
|---|---|---|
| Cut | $/kg | Discount Value |
| Shoulder Rack | $8.60 | $6.88 |
| 8 Rib Rack | $19.00 | $15.20 |
| 7 Rib Rack (discount) | $17.00 | $13.60 |
| Back strap | $22.00 | $17.60 |
| Trim 65CL | $2.70 | $2.16 |
| Leg price | $8.99 | $7.19 |
| Whole lamb retail price | $7.50 | |
| Rendering | $0.16 | |

## 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 will perform, and the various the cuts associated with the different primals. Furthermore, Table 5 communicates the expected losses with the various inaccuracies of the cutting lines.

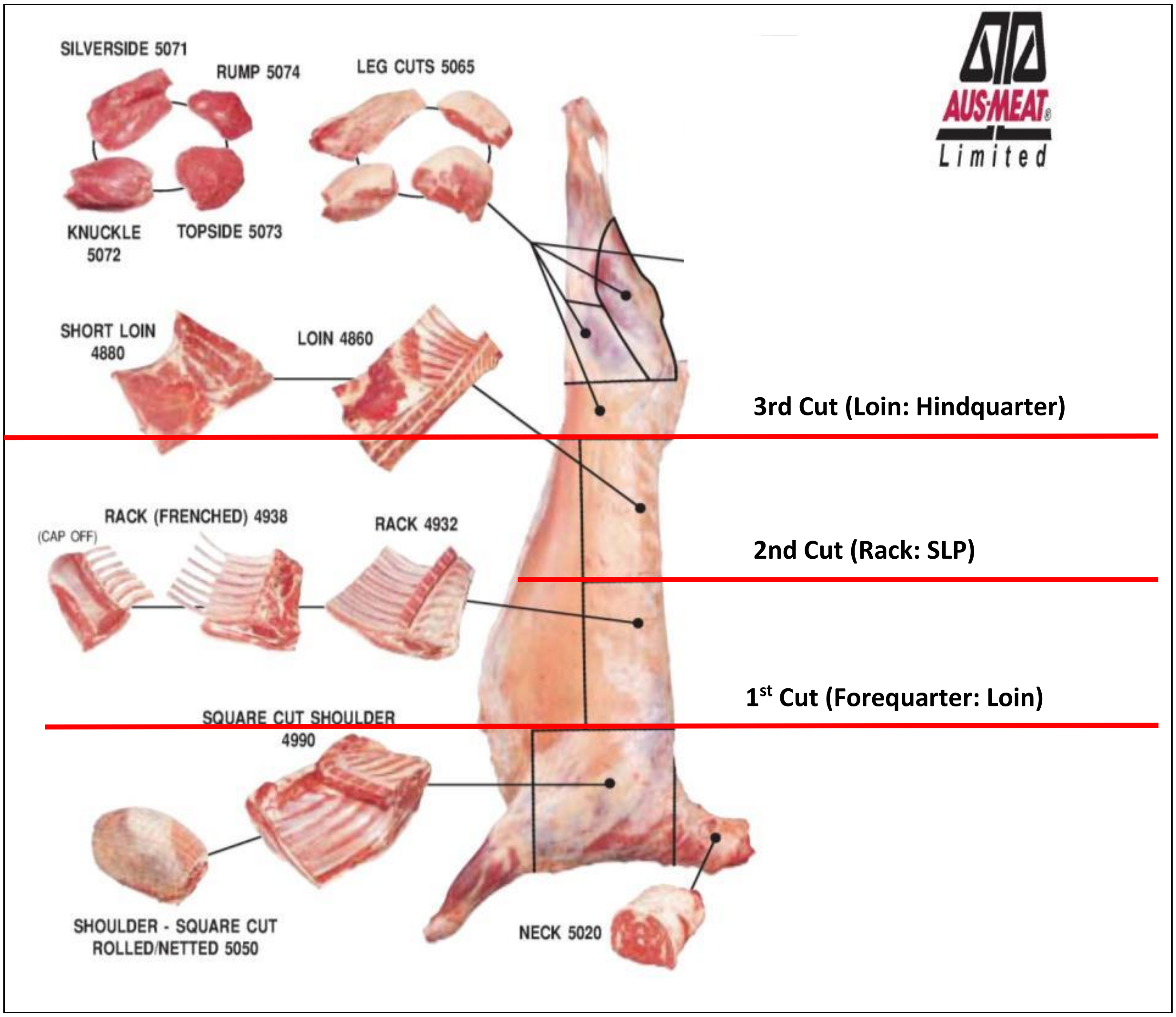



Figure 5: Cutting lines that the automated primal cutting system will perform on the lamb carcass (Source: Aus Meat 2003)

Figure 6 shows the carcase after primal cutting and the resultant four primals including Forequarter, Rack, short loin and Leg or hindquarter.

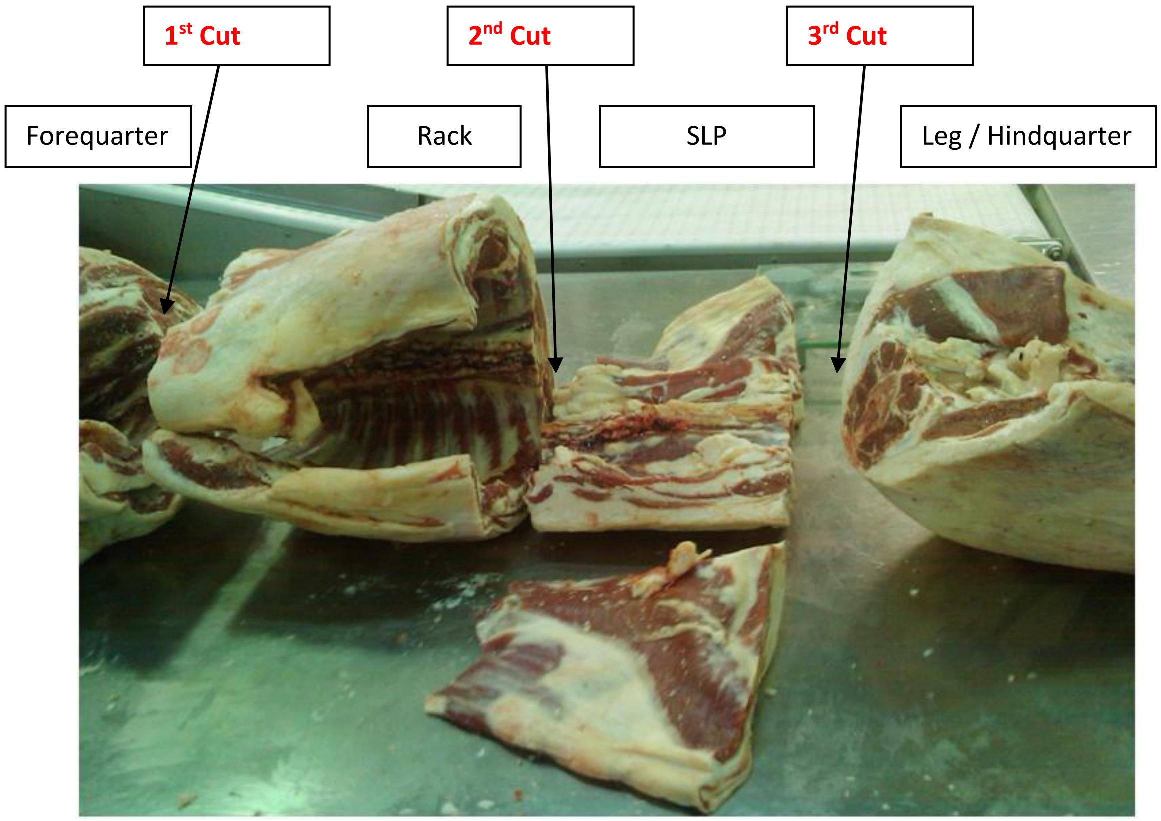



Figure 6: Three primal cuts, and the 4 respective primals

**Table 5:** 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<br>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)<br>This cut was not considered in this analysis |
| | Leg Short | Chump Long | |

# 5 Measurement Results

## 5.1 1st Cut, Forequarter & loin (measurement and results)

### 5.1.1 Measurement

The accuracy of the shoulder cut was largely determined by the number of ribs required in the cutting specification. For plant 1 the cutting specification remained consistent with a 4 rib shoulder, 8 rib rack and 1 rib short loin. Counts were conducted to assess the number of ribs relative to the cutting specification for both the left and right side of the carcass, zero = correct number of ribs (Figure 7), and inaccuracies were measured plus or minus the correct rib number. Observations were also taken to assess the angle of the cut in relation the rib. This was important because the cut may have been made at the correct rib number, but if the angle was wrong – this may result in a rib tail length that was too short to meet market specifications.

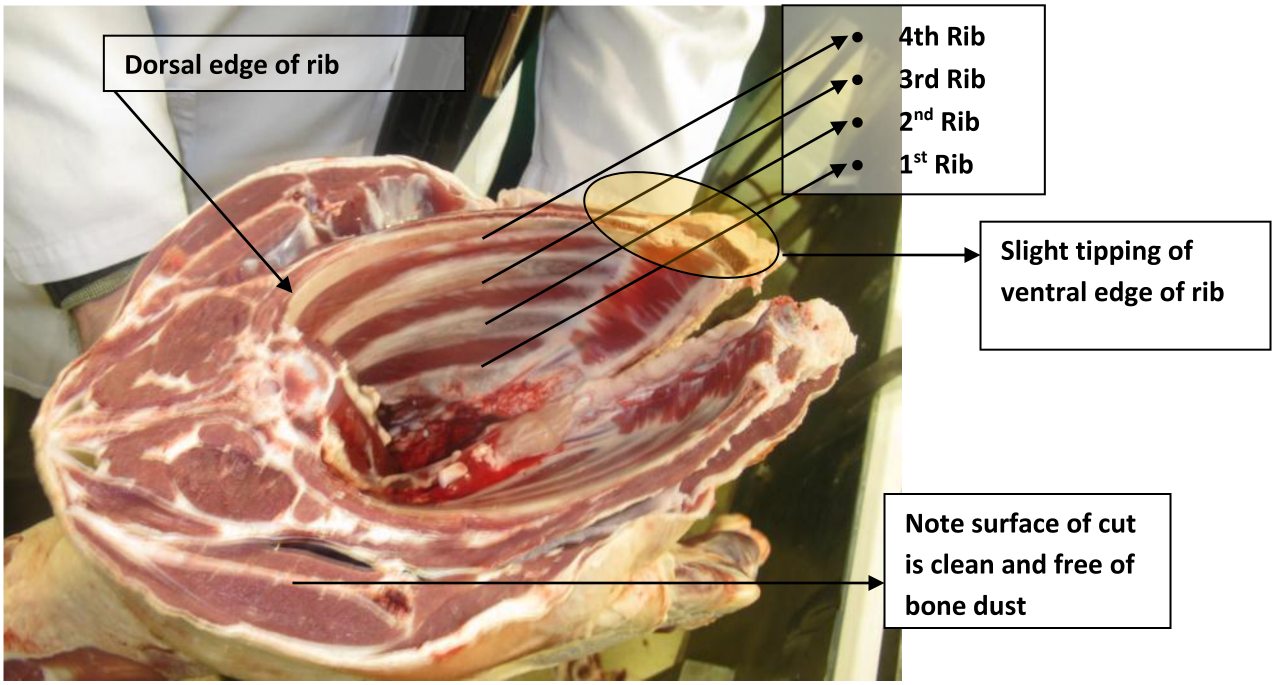



Figure 7: Measurement of cutting for forequarter rib.

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 the rib angle.

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

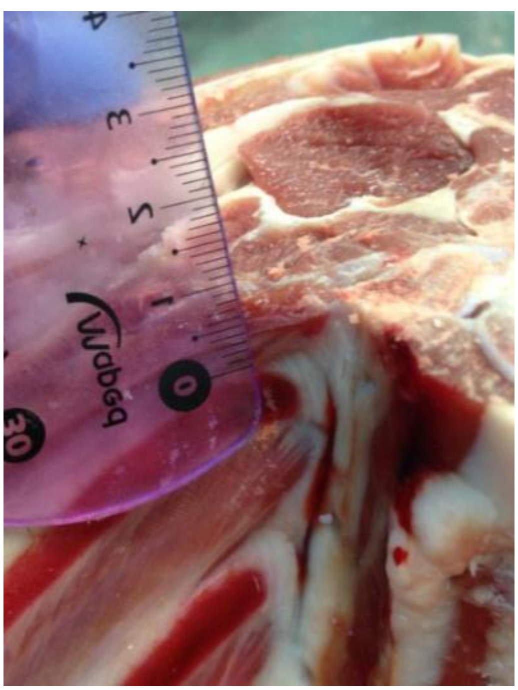
### 5.1.2 Costing

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).



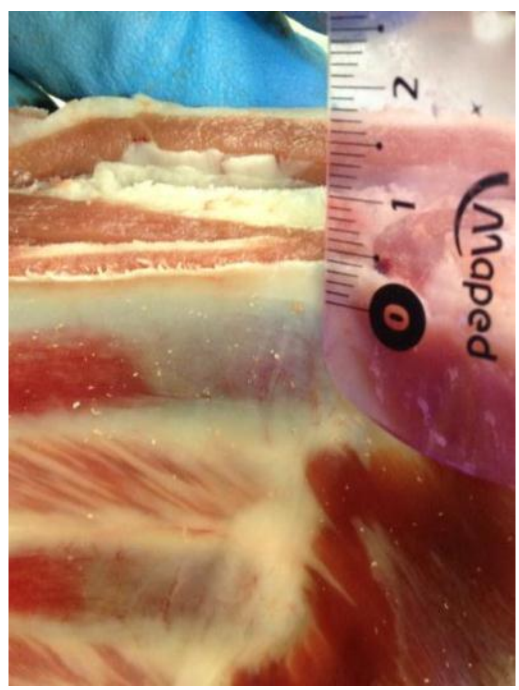


Figure 11: The number of millimetres above or below the 4th rib was measured at both the dorsal (left image) and ventral (right image) edges of the cutting line

### 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 12.9% more accurate than the manual cutting system at 93.7% and 80.8% respectively. It should be noted that accuracy levels of 86.4% on the New Zealand ex-ante review (Greenleaf, 2010) caused Scott Technology to go back and review their measurement process. The reported accuracy was confirmed and helped Scott's identify areas for improvement in cutting accuracy. Improvement in accuracy since those changes has not been reviewed by Greenleaf but the numbers reported here indicate the performance of the system has been improved and we expect the New Zealand accuracies would more closely reflect the Australian ex-post figures if they were to be reviewed again. It is also important to note that measurements taken under manual operation were likely best case scenario, and would likely not be achieved consistently across an entire day, or week, while the x-ray accuracy levels will remain consistent.

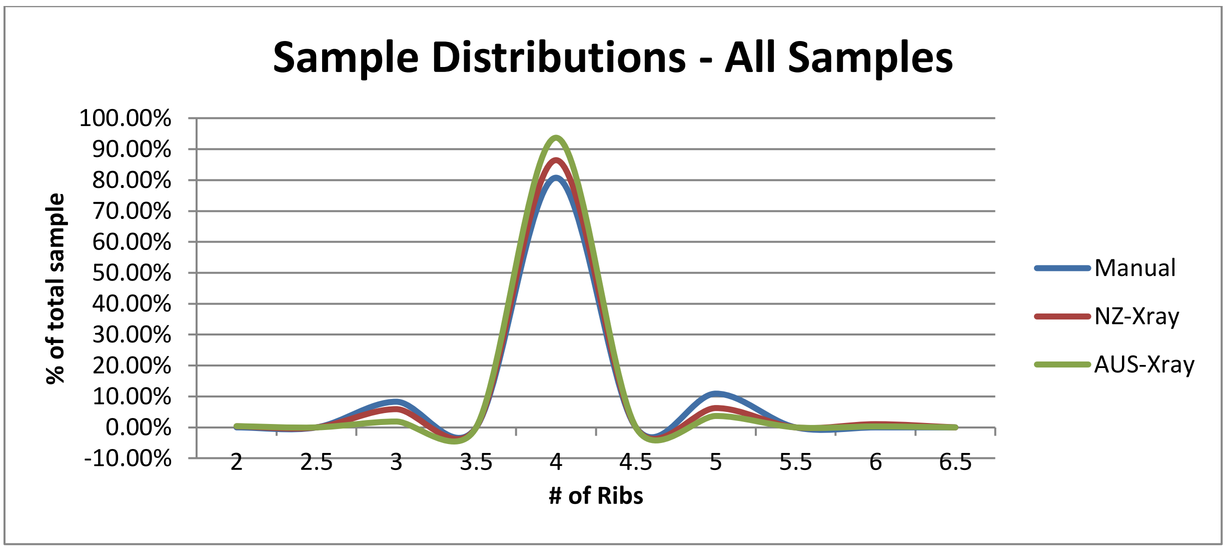



**Figure 12: Shoulder cut accuracy observations for both manual and x-ray cutting systems**

The methods used in the ex-ante costings (Greenleaf, 2010) to establish the cost of various cutting inaccuracies were applied in the same way in the ex-post studies. Figure 13 indicates the cost of inaccurate shoulder cutting lines to be double that of the ex-post automated system. This range of inaccuracy captures 95% of the sample population observed during the trials. Not only is the cost lower for the ex-post system but the variation is also reduced.

Note the Australian LEAP III system is showing a marked improvement over the NZ system. The original ex-ante study highlighted shoulder cutting inaccuracies in the automated system that exceeded Scott Technologies targeted performance levels. Scott focussed on improving the accuracy of the x-ray image analysis and integration with the shoulder cutting robot after the study was completed. Although Greenleaf was not involved in any review of that process improvement the results observed in the second generation Australian system indicate the improvements were successful.

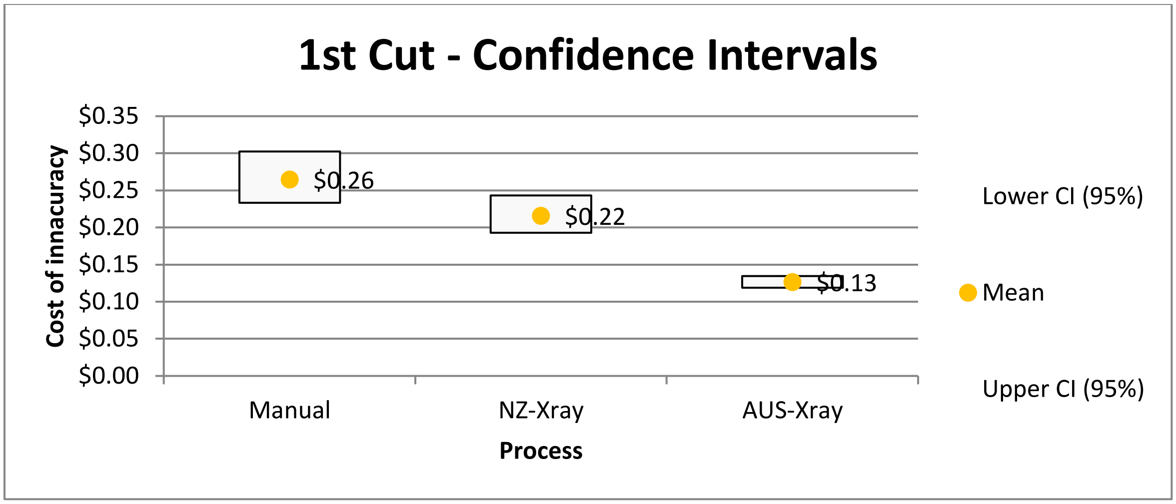



Figure 13: Cost of 1st cut inaccuracy due to incorrect number of ribs

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 3 section 1).

#### 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 under manual cutting conditions with a large proportion of cuts over 15mm or more.

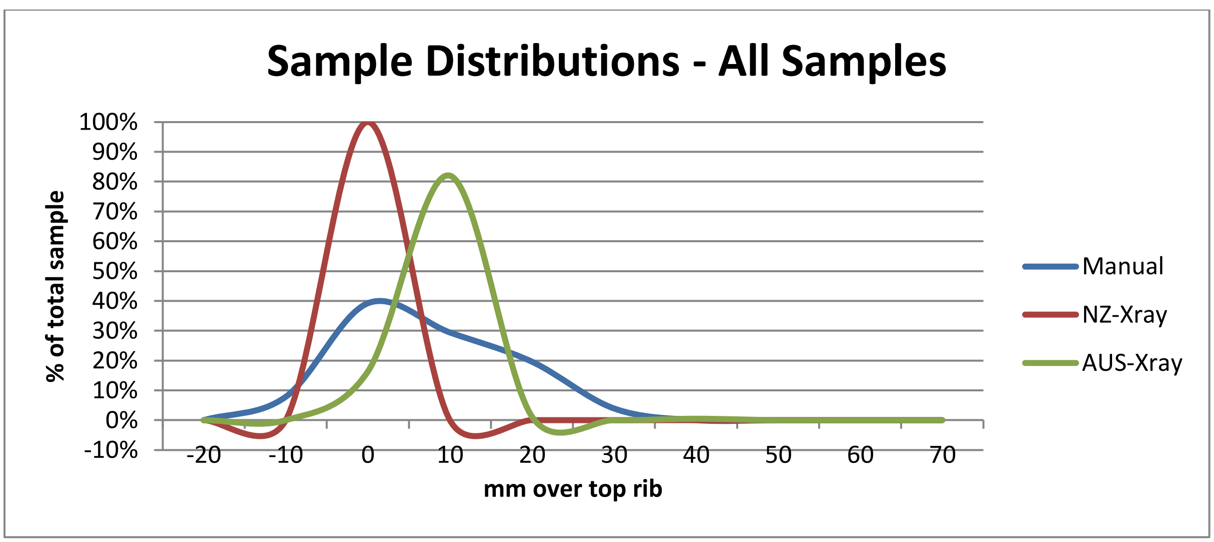



Figure 14: Distance of cutting lines from the edge of the 4th rib on a 4-rib shoulder cut.

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.

Note the Australian x-ray installation left more meat above the shoulder cut than the New Zealand installation and impacted negatively on the costings in the model. The distribution of accuracy between the systems was almost the same considering differences in the sample population observed during the trials. In practice the Australian systems settings minimised the times the cut broke into the top of the last shoulder rib, giving a cleaner cut all the time. This improvement has not been reflected in the values used for comparison.

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.

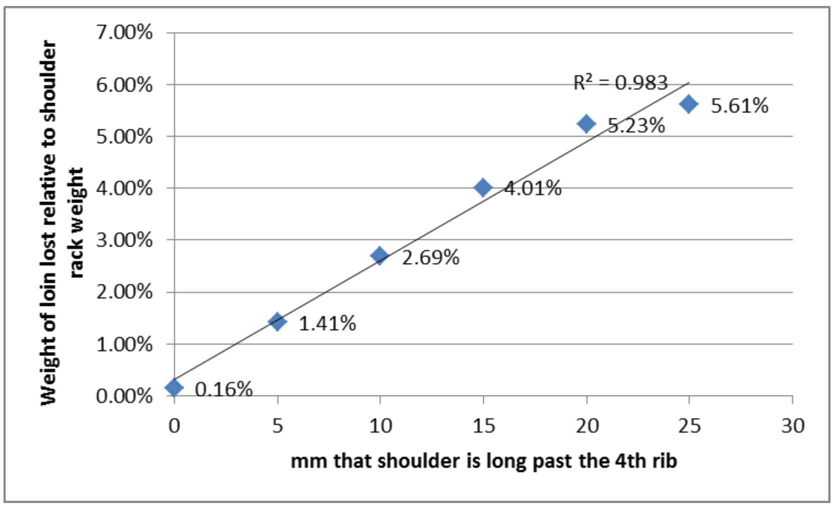



**Figure 15: Scatter plot showing relationship between mm of inaccuracy and the loss of shoulder rack relative to its weight**

Based on the level of accuracy observed in Figure 14, Figure 15 is used to calculate the cost of inaccuracy to the plant. The current cutting system was resulting in a loss of $0.13/hd, or $94,000 per annum for the plant.

Cost of cutting shoulder long (loss of loin muscle from higher value rack product at $14/kg to lower value shoulder rack at $9/kg) has just as big an impact on value as the number of ribs. Figure 16 costs the accuracy of each system based on the millimeters of loin remaining on the shoulder above the fourth rib. Note the cost was greater in the Aus-xray system than in the manual system. However, the important focus is the variance in cutting accuracy which is much less for the Aus-xray as compared to manual. Narrow variation allows much greater process control. So adjustment to the Aus-xray settings could be made to lower the cutting line closer to the fourth rib without risking cutting into the rib than manual processes. The data collected demonstrates this should be done. These additional benefits were not included in the calculations.

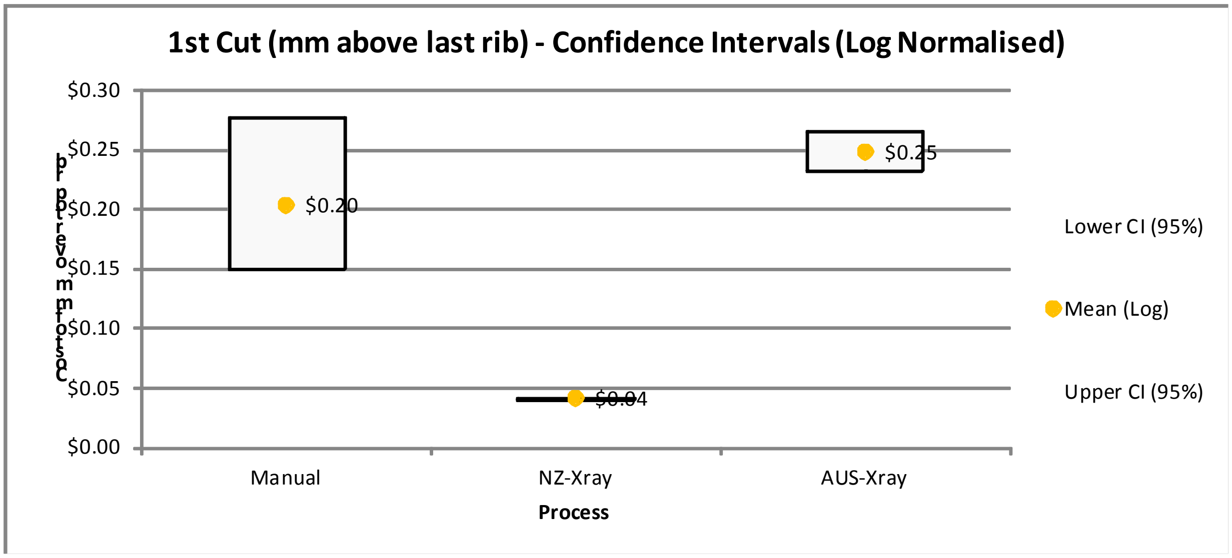



Figure 16: Range in cost of cutting accuracy above last shoulder rib for each cutting system

### 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 the two x-ray installations is the additional value created by the automated systems for this cut. When manual systems are running at their best they come close to the value generated in the Australian installation. However, manual cutting has a wide variation and can be up to twice that of automation. The same tight range in variation was observed between the two automated systems which allows greater control of cutting lines. This allows adjustment to systems between plants to meet different plant and customer requirements.

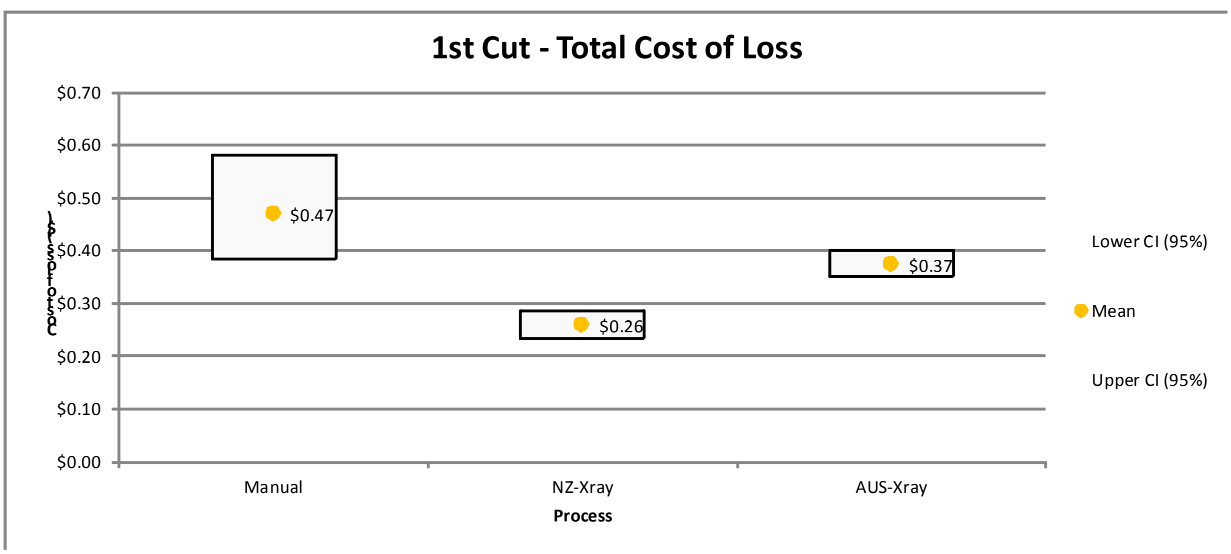



Figure 17: Combined value of loss on shoulder cut (rib # and mm's over last rib) for each cutting method

## 5.2 Second Cut (Rack & Short Loin Pair)

The cut between the rack and short loin pair was not being done by the automated primal cutting equipment when the ex-ante study was undertaken. Manual measures were taken at the time to create a base line. The ex-ante modelling assumed 100% accuracy for the automated system to quantify the value opportunity available for improvement over manual cutting systems. Part of this ex-post study has been to measure the accuracy of the second cut in commercial use.

### 5.2.1 Measurement

Measurement of cutting accuracy consisted of selecting random racks from the belt, counting the number of ribs relative to the cutting specification, and making sure the tail of caudal ribs was long enough to meet the required cutting specification. For example when a 25mm tail was required as opposed to a 100m tail the rib length did not need to be as long to meet specifications. The angle of the cut on both cranial and caudal edges of the rack was also observed.

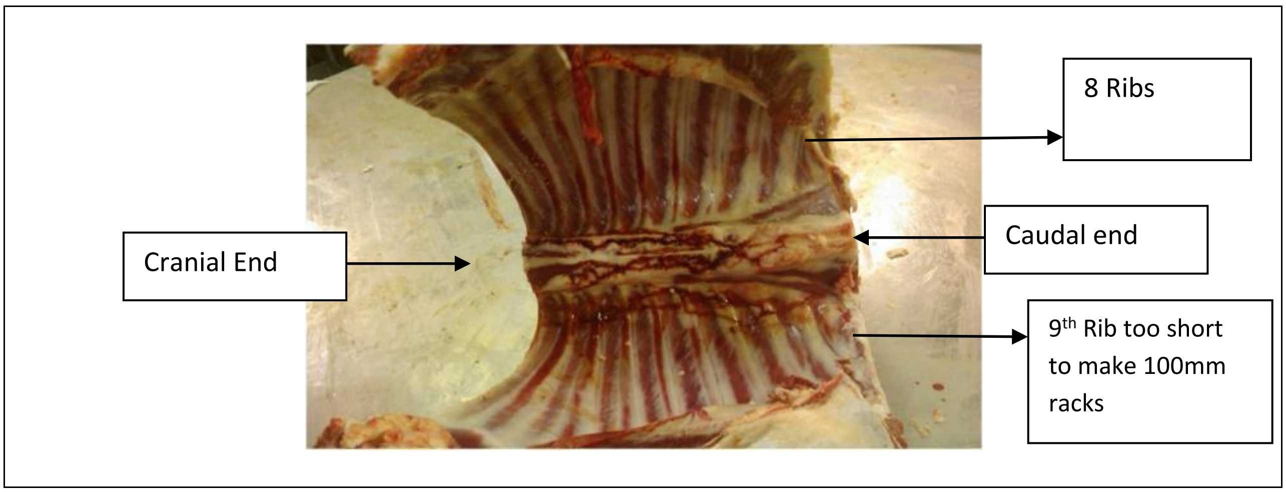



**Figure 18: 8 rib rack cut with manual bandsaw.**

Short loin pairs (SLP) were also observed prior to splitting to determine the number of bones left in. In most cases when the specification was a bone in SLP only two ribs were allowed to remain. Additional ribs (either as a result of the cutting inaccuracy on the first cut, or the number of ribs in the carcass) were removed and placed in rendering (Figure 19).

**Figure 19: Bones removed from SLP as only two ribs may remain in bone in short loin.**

### 5.2.2 Costing

Costing methodologies were developed in the ex-ante study (Greenleaf, 2010) and this same method was applied during ex-post data capture. Previous findings indicated different levels of benefit occurred for each product specification. Carcase specification does change from month to month depending on customer orders as will the associated benefits. The same average pricing and break down of specifications applied in the ex-ante study were used here. Provision is made in the model to customize costings on an individual plant basis.

### 5.2.3 Results

As mentioned previously the automated cutting system that was observed during the ex-ante study (NZ LEAP III system) did not have this cut operational. The observations taken during the ex-post study (Australian LEAP III system) have been applied to both the ex-post and ex-ante studies to enable comparison. Figure 20 summarises the results and shows a reduction in accuracy of the automated process from 100% used in the ex-ante results to less than the manual process. When the primal cutter was installed in Australia the bandsaw cuts were reduced. This gave the bandsaw operator twice as much time to make the Rack: Loin bandsaw cut so the accuracy was much greater.

Although the accuracy is less than manual, note the manual system cuts short more frequently than the automated systems resulting in loss of value. When cutting long the additional rib length on rack increases the weight and value of rack relative to cheaper shortloin.

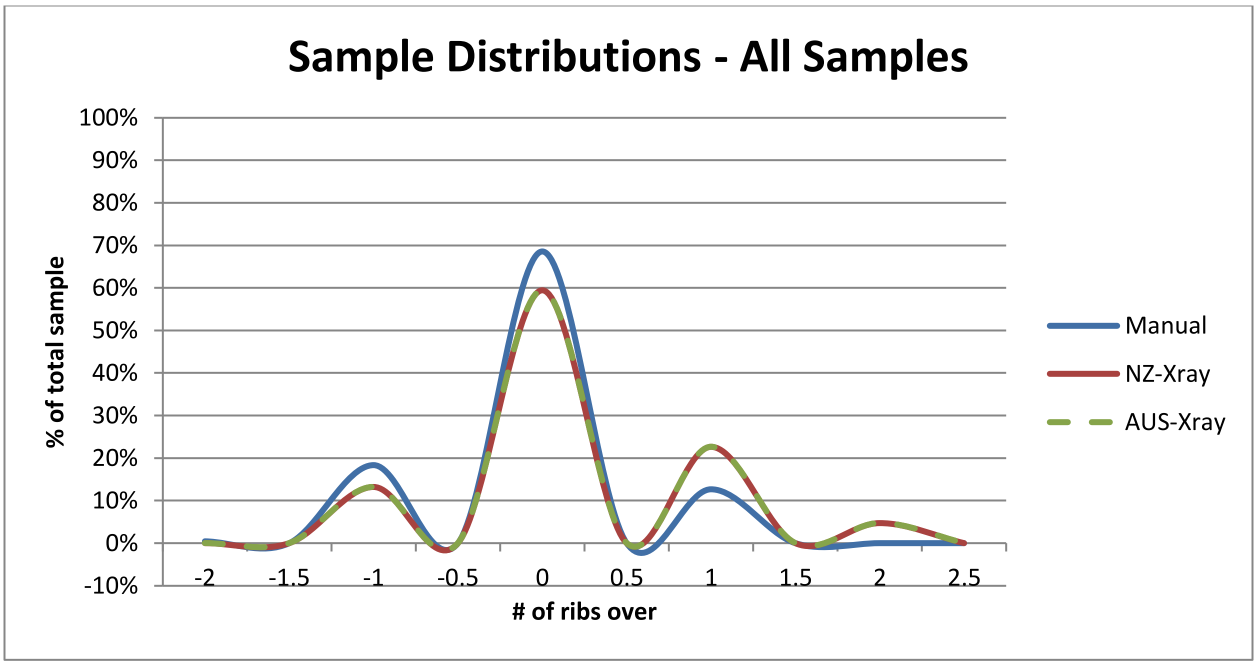



**Figure 20: Observed cutting accuracies between rack and short loin pair (NZ ex-ante data not available, uses AUS in model)**

Figure 21 shows the value opportunity that was observed for increasing the length of the cut between the rack and the short loin pair. Of the 335 observations across manual and automated processes the mean value opportunity was $0.23/hd. Some customer specifications don't require this cut (full loins) so the value benefit has been reduced accordingly in the model.

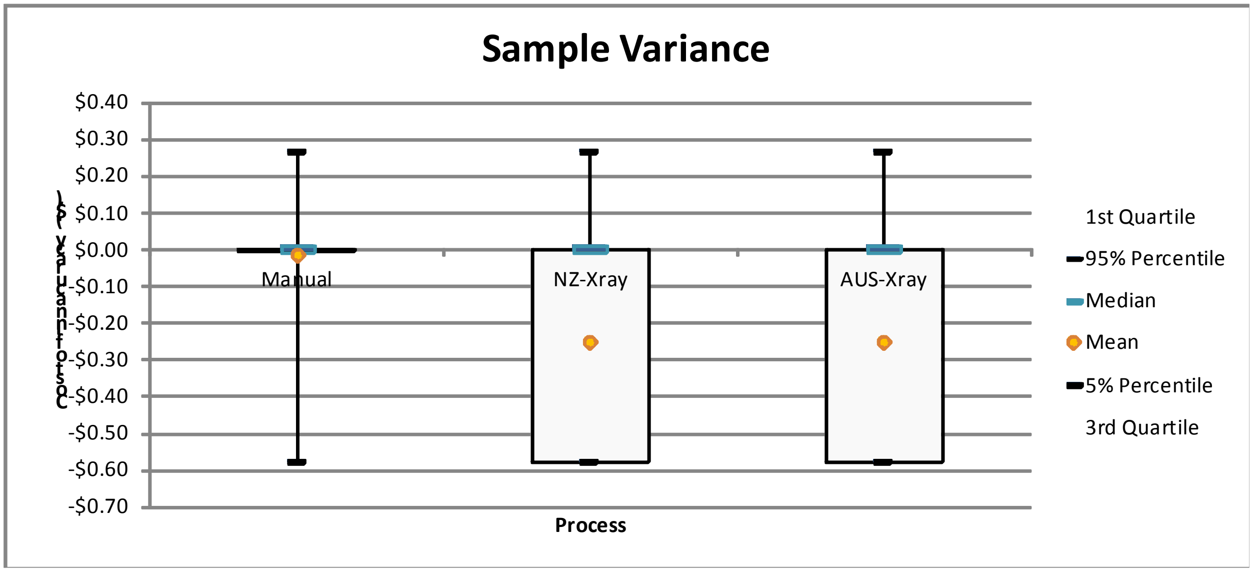



Figure 21: Current cost of cutting inaccuracies between rack and short loin pair

## 5.3 Third cut (Loin – Hindquarter cut)

### 5.3.1 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).

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 22). Figure 23 shows where the tip of the ilium bone cartilage is just visible on the cut surface of the leg.

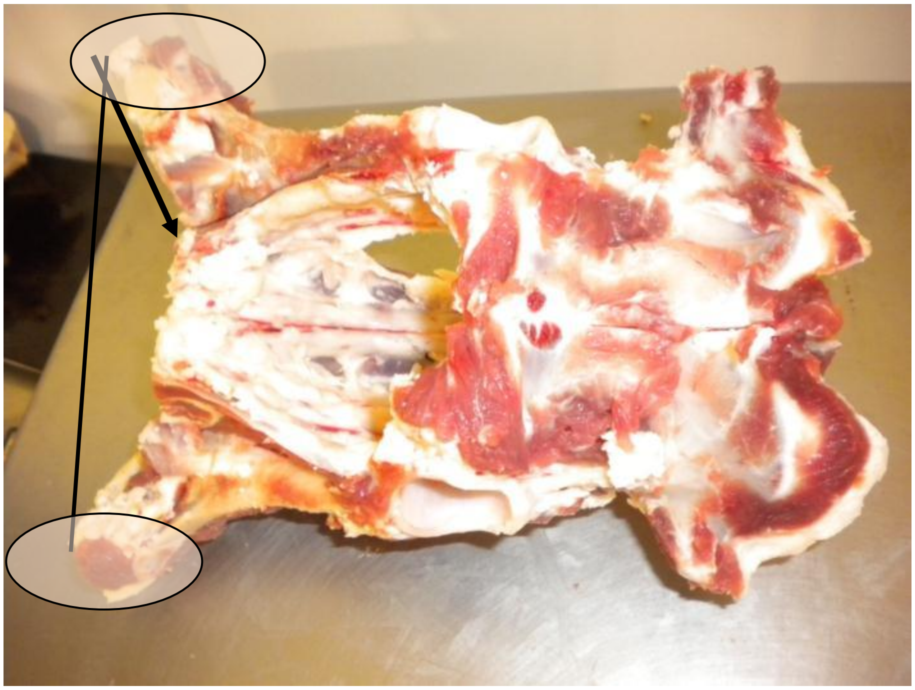


Figure 22: Correct cutting line between hindquarter and loin.

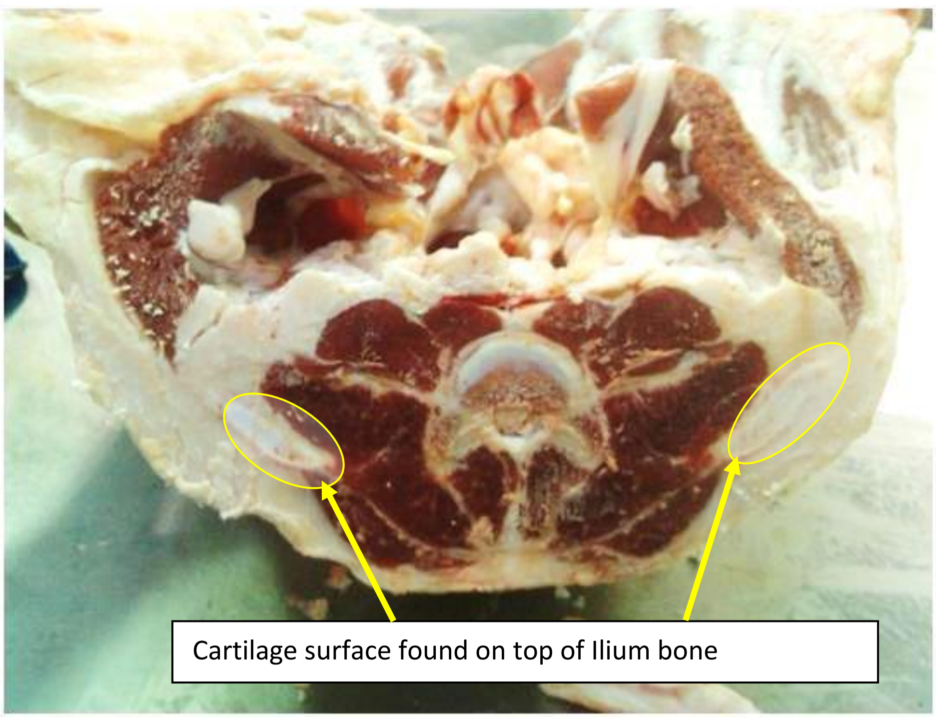



Figure 23: 100% accurate cutting line: Un-boned hindquarter with bone still remaining

Figure 24 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.

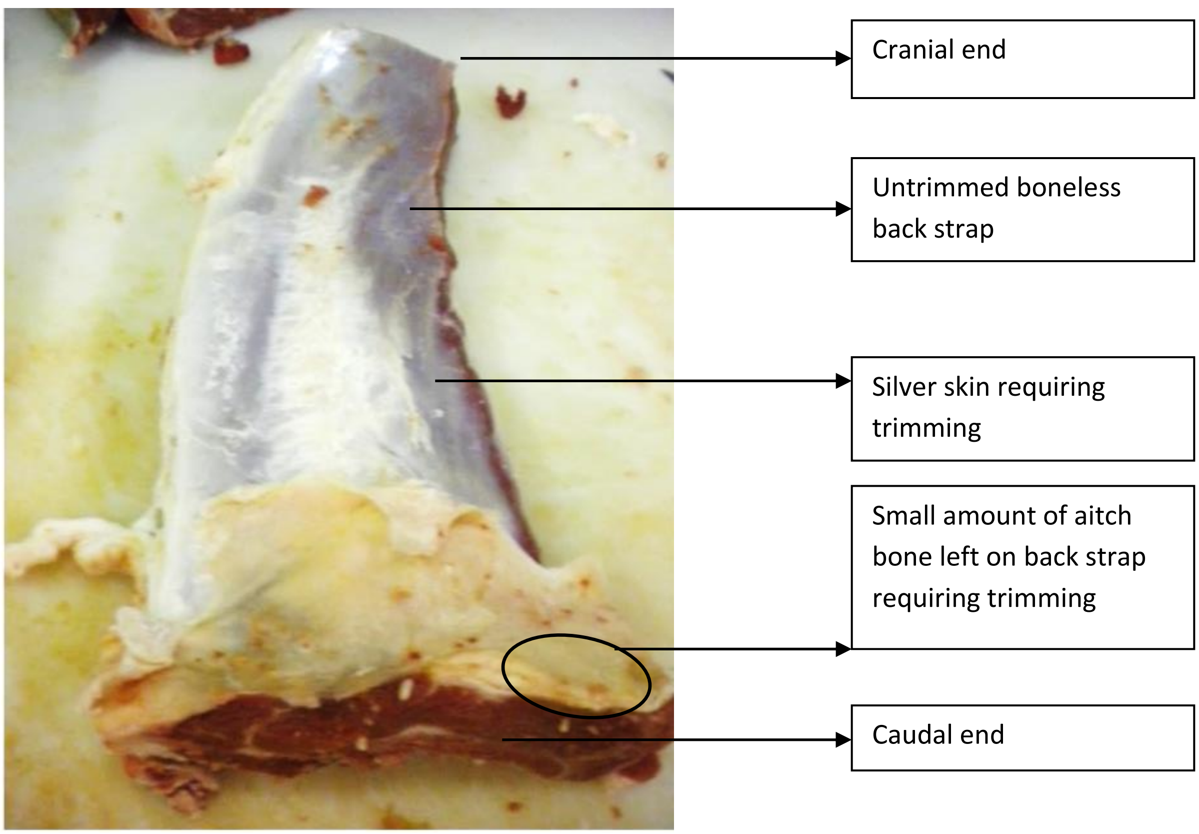



**Figure 24: Boneless back strap showing small amount of aitch bone cartilage left on the surface of the muscle.**

The following images (Figure 25, Figure 26 & Figure 27) 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 25: Aitch bone showing cut where leg is long, and loin would be short, knife edge marks correct cutting line

Figure 26: Same aitch bone with trim removed


Figure 27: Loin muscle recovered from the aitch bone after fat was trimmed.

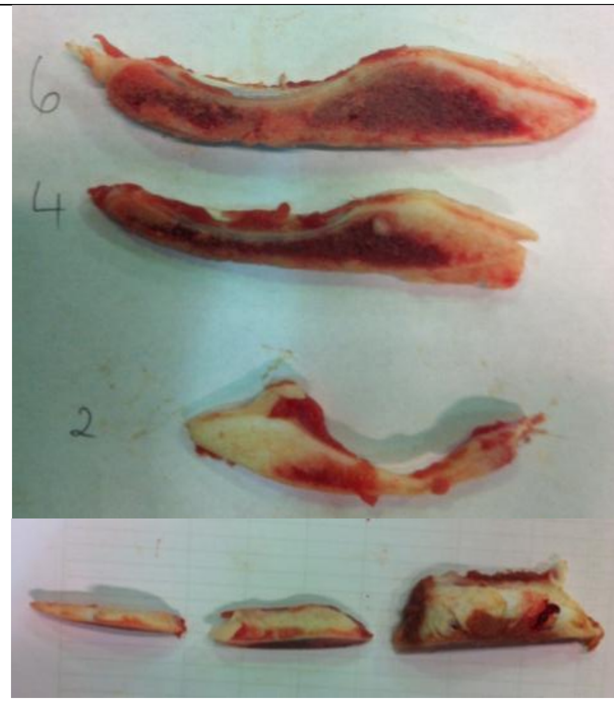



Figure 28: Calibration methods using ilium bone to establish mm's away from target cutting line

### 5.3.2 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.

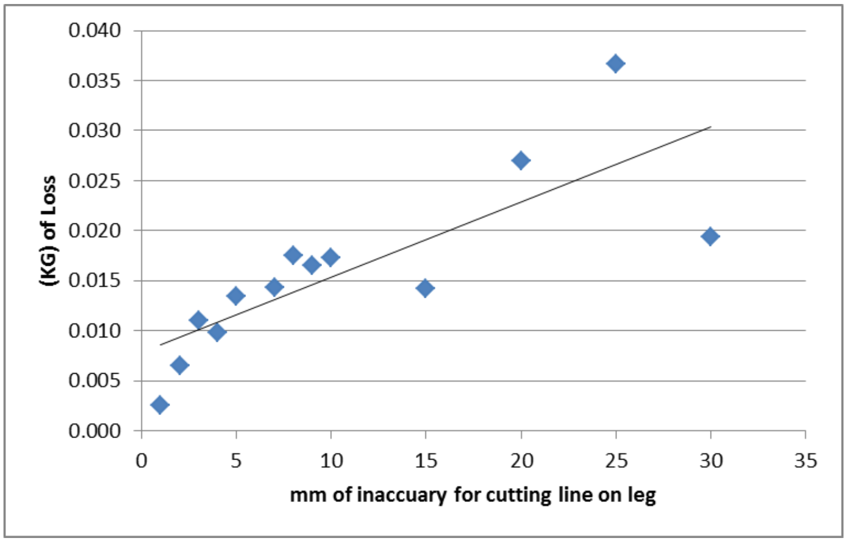



Figure 29: Average weight of loin recovered from aitch bone based on mm of cutting line inaccuracy

Figure 29 is used to illustrate the cost of inaccuracies shown in Figure 30, 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.

### 5.3.3 Results

The automated process had a narrower variation in cutting accuracy than manual methods as seen in Figure 30 which is expected. The Australian installation consistently cut shorter on the leg.

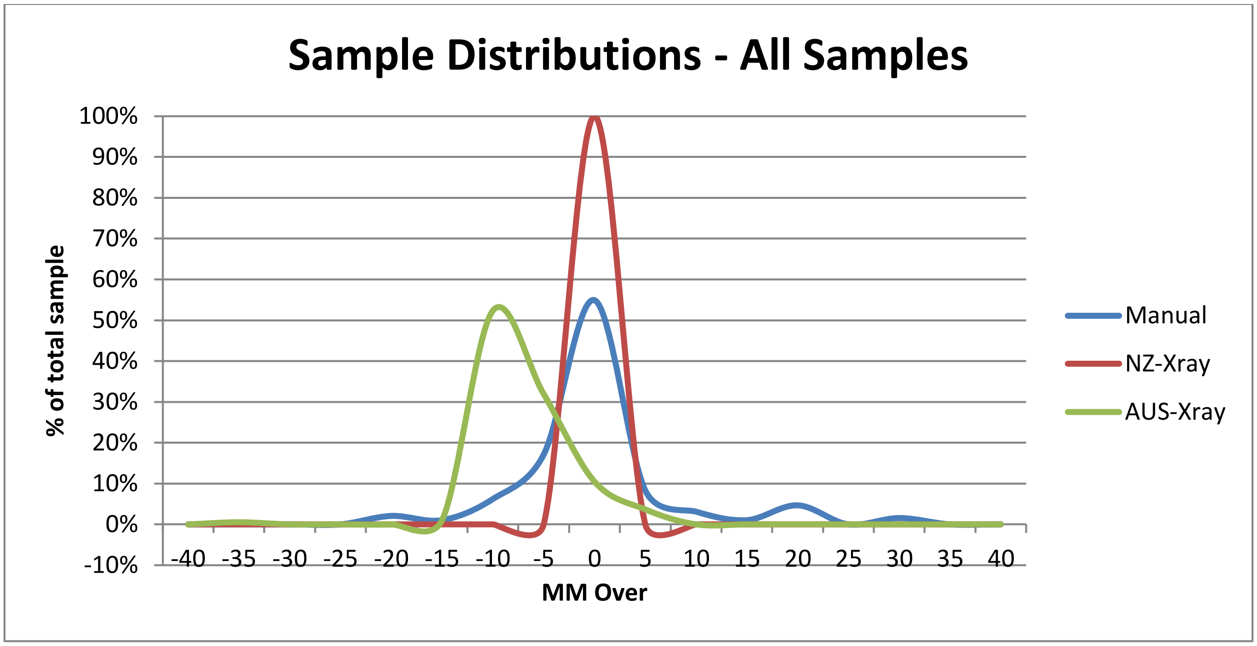



Figure 30: Survey results showing level of cutting accuracy for Loin – Leg cut for each cutting method

Given the tighter control of the cut than manual bandsaw (Figure 32), 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.

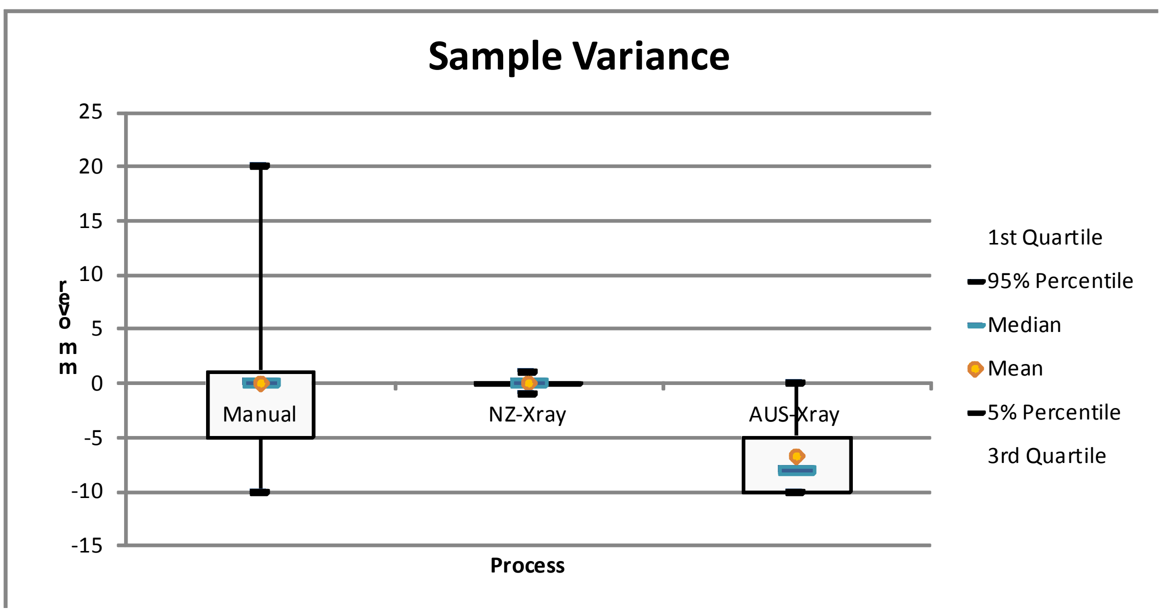



Figure 31: Leg cut sample variance between cutting processes

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 the ex-ante study.

Figure 32 reflects this with significant difference in value for the Australian system, expressed as a negative loss (Value gain) in the figure.

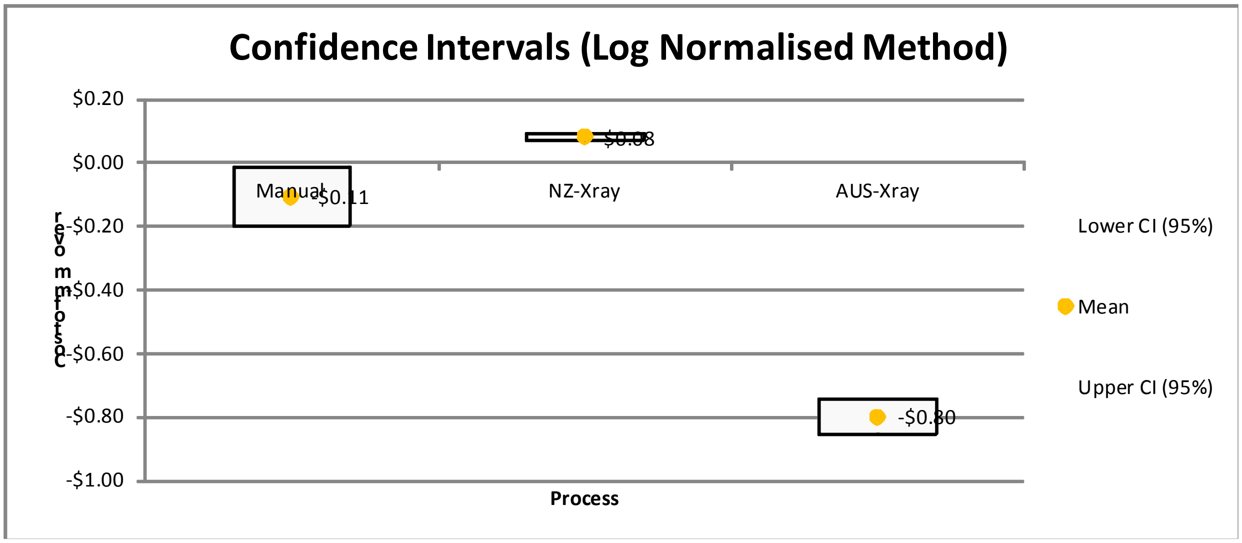



Figure 32: Cost of cut inaccuracy between leg and loin for each cutting method

## 5.4 Scallop cut

Figure 33 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.

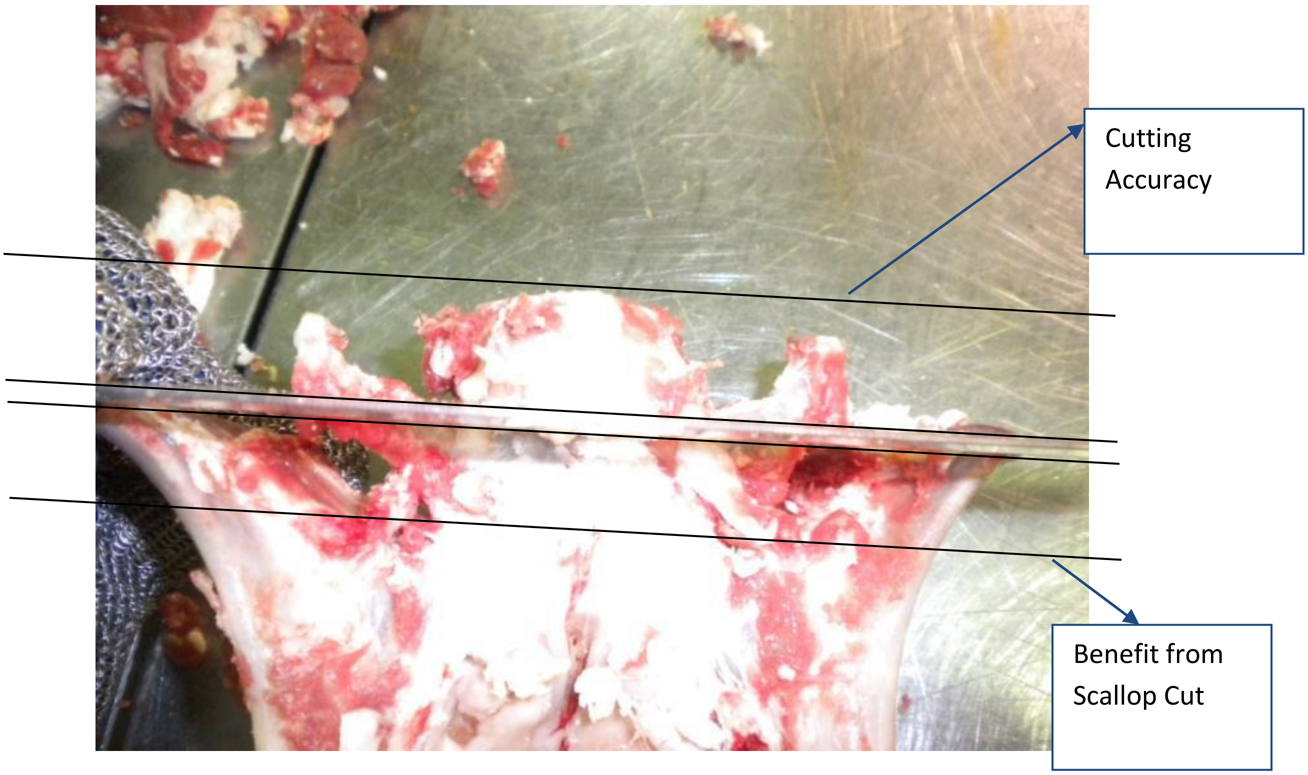



**Figure 33: Aitch bone showing value opportunity for increased accuracy in cutting lines, and also value opportunity technical advantageous achievable with the scallop cut.**

**Figure 34: Shape of scallop cut, note greater loin recovery from aitch bone.**

**Figure 35: 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 35 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. Recovery averaged 74 grams per aitch bone. 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 20 grams.

Provision in the model is made so that the amount of loin recovered can be adjusted (see Table 6). For the current analysis a saving of 20grams per side is assumed.

**Table 6: Calculation of gains for scallop cut**

| Scallop Cut | | |
|---|---|---|
| | | |
| | Per Side | Per Head |
| Loin Yield benefit achieved with Scallop Cut | 0.020 | 0.040 |
| Value as Render | | $0.01 |
| Value as Boneless Back strap | | $0.88 |
| Saving / hd | | $0.87 |
| Saving / hd Based on annual processing of Boneless Backstrap** | | $0.79 |
| Daily | | 1,730 |
| | Annual | 458,544 |

** Less than 100% of saddles are cut into backstrap using the scallop cut reflected in average value per head of $0.79 per head and not $0.87/ hd. For further explanation see heading "Market Specification" in Table 19 on page 50.

## 5.5 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 / carcass across two different manual processing plants (Table 7). 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 39.45 kg/ day (based on production of 2200 hd), which was costed at an approximate retail carcase value of $7.5/ kg. This resulted in an achievable saving of $0.13/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 $0.09/hd.

**Table 7 Value of band sawdust lost during manual cutting**

| Yield Savings through reduced Band Saw Dust | | |
|---|---|---|
| Number of head processed | | 2,201 |
| Time | | Net amount |
| Band saw dust per head (kg) | | 0.0199 |
| **TOTAL Collected for 3 cuts (kg)** | | **43.83** |
| reduction with automated | | 90.00% |
| % reduction with automated (Kg) | | 39.45 |
| Retail value of carcasses | | $7.50 |
| Value of recovered saw dust that was salable | | $295 |
| Value per annum | | $78,400 |
| | 2 cuts | $0.09 |
| Value per hd | 3 cuts | $0.13 |

## 5.6 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 current used during the cutting process
    c. Reduced human handling of meat

Figure 36: 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 8) 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 8: Calculation used to value the increase in shelf life of lamb product via reduced retail discounts.

| Increased Shelf Life (reduced level of discounting) | | Annual hd | 583,212 |
|---|---|---|---|
| | 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 | 1,166,424 | | |
| Current level of discounting | 4.00% | | |
| Number of items discounted | 46,657 | 46,657 | 46,657 |
| Weight of discounted (kg) | 119,908 | 130,639 | 242,616 |
| True Value | $1,031,212 | $2,482,150 | $2,181,120 |
| Discount Value | $824,970 | $1,985,720 | $1,744,896 |
| Current cost of discounting | $206,242 | $496,430 | $436,224 |
| Reduction in level of discounting | 10.00% | | |
| New level of discounting | 3.60% | | |
| New number of items discounted | 41,991 | 41,991 | 41,991 |
| New quantity (kg) | 107,918 | 117,576 | 218,355 |
| New True value | $928,091 | $2,233,935 | $1,963,008 |
| New Discount Value | $742,473 | $1,787,148 | $1,570,406 |
| New cost | $185,618 | $446,787 | $392,602 |
| SAVING | $20,624 | $49,643 | $43,622 |
| Saving per head (leg reduced discounting) | $0.04 | $0.09 | $0.07 |
| Total Saving /hd | $0.20 | | |

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

## 5.7 Increased efficiencies on existing labour

The area of improved productivity had the greatest difference between ex-ante and ex-post reviews. There had been an allowance for improved productivity in the earlier study but the observed improvement post installation was greater than expected.

The main driver behind increased efficiencies for existing labour is 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 labours 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 the boning room manager was the consistency of throughput through the room. The comment was made that product flow through the room is now much more consistent, and has resulted in 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 middle row of Table 9 and represents a productivity increase of 24% compared with the ex-ante prediction of 4% labour efficiency gains.

Table 9: Manning of processing room[3]

| Increased boning room throughput | Manual | NZ-Xray (Ex-Ante) | AUS-Xray (Ex-Post) | EQUIP. MAX hd/min |
|---|---|---|---|---|
| Average daily hd | 2201 | 2730 | 2730 | 4200 |
| Average kg | 21.88 | 21.88 | 21.88 | 21.88 |
| Average Kg boned per day | 48,154 | 59,732 | 59,732 | 91,896 |
| Boning room cost / hour | $1,066 | $1,066 | $1,066 | $1,459 |
| Boning room cost / day | $8,528 | $8,528 | $8,528 | $11,669 |
| Labor cost \ per kg to bone | $0.18 | $0.14 | $0.14 | $0.13 |
| Labor cost \ per hd to bone | $3.87 | $3.12 | $3.12 | $2.78 |
| Labour productivity savings/ head | $0.00 | $0.75 | $0.75 | $1.10 |
| Task | Number labor units | | | |
| Supervisor | 1 | 1 | 1 | 1 |
| QA | 1 | 1 | 1 | 1 |
| Admin | 2 | 2 | 2 | 2 |
| Band Saw operator | 3 | 3 | 3 | 4 |
| Ticketing | 2 | 2 | 2 | 3 |
| Knife hand | 8 | 8 | 8 | 12 |
| Trimmers | 7 | 7 | 7 | 10 |
| Packer | 4 | 4 | 4 | 6 |
| General Labor | 6 | 6 | 6 | 8 |
| Maintenance | 1 | 1 | 1 | 1 |
| Total FTE's required | 33.5 | 33.5 | 33.5 | 46.5 |

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.

## 5.8 Labour Savings

The data displayed in Table 10 shows a saving of 3 labour units across band saw operators and bone scrapers. This data would need to be customized for each different plant context. This resulted in labour savings of $0.23 per head using the automated primal cutting equipment.

[3] 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 5.8.

Table 10: Labour savings achieved with automated x-ray primal cutting system

| Labor | Hd / annum | 588,000 |
|---|---|---|
| Number band saw labor units saved | | 1.8 |
| Hourly cost | | $26.00 |
| Plus overheads (35%) | | $7.80 |
| Total hourly rate | | $33.80 |
| Total Annual Bandsaw labour saving | | $126,547.20 |
| Saving in bone scrapers | | 1.2 |
| Hourly cost | | $23.0 |
| Plus overheads (35%) | | $6.9 |
| Total hourly rate | | $29.9 |
| Annual cost of Bone Scraper | | $62,192.00 |
| $ Saved bone scraping | | $74,630.40 |
| Total | | $201,177.60 |
| Number of cuts required | 2 | $0.11 |
| | 3 | $0.23 |
| | 4 | $0.34 |
| Saving per head | | $0.34 |

## 5.9 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 11).

Table 11: OH&S Benefits of automated x-ray primal cutting system

| OH&S Savings with automated primal cutting | | |
|---|---|---|
| Band Saw cutting | | |
| Number of laceration claims in last 3 years | | 10 |
| Avg number of claims per year | | 3.33 |
| Avg cost per claim | | $3,000 |
| Annual Cost | | $10,000 |
| Average cost per hd | | $0.02 |
| Sprain and Strain from lifting | | |
| Number of occurrences per year | | 5 |
| (real) Cost of light duties claim, loss of operator | | $3,000 |
| Annual Cost | | $15,000 |
| Annual Saving per head | | $0.03 |
| TOTAL OH&S Benefit | | $0.04 |

## 5.10 Equipment Costs

Table 12 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.

**Table 12: Estimated capital, and operational costs of automated x-ray primal cutting equipment**

| CAPITAL COSTS | | |
|---|---|---|
| Based on annual product of | 588,000 | 723,450 |
| Item | Price | Price |
| Equipment purchase | $1,980,000 | |
| Shipping, insurance, install, commission | $350,000 | |
| Integration (lighting, drains, water, conveyors) | $150,000 | |
| Guarding, safety curtains, control interface | $100,000 | |
| Air Cond. Room for electrical controls | $50,000 | |
| Recommended spares and 12 months service | $60,000 | |
| Total Equipment and Installation | $2,690,000 | |
| Infrastructure upgrade | $0 | |
| Total | $2,690,000 | |
| Annual Deprecation | $269,000 | |
| Cost per head | $0.46 | $0.37 |

| Annual Costs | Item | Cost / yr | Cost / hd | |
|---|---|---|---|---|
| | Based on annual # hd | | 588,000 | 723,450 |
| Operational | Cleaning | $2,500 | $0.00 | $0.00 |
| | Power | $5,300 | $0.01 | $0.01 |
| | Service Contract | $30,000 | $0.05 | $0.04 |
| | Ongoing Training | $1,500 | $0.00 | $0.00 |
| | Risk of down time | $12,792 | $0.02 | $0.02 |
| Sub Total (operational) | | $52,092 | $0.09 | $0.07 |
| Maintenance | Blades | $10,000 | $0.02 | $0.01 |
| | Maintenance | $4,850 | $0.01 | $0.01 |
| | Materials | $2,000 | $0.00 | $0.00 |
| Sub Total (maintenance) | | $16,850 | $0.03 | $0.02 |
| Total | | $68,942 | $0.12 | $0.10 |

### 5.10.1 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.

### 5.10.2 Maintenance & 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.

***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 9) 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.

**Table 13: Estimated cost of down time across wider industry**

| Risk of down time | | |
|---|---|---|
| Weekly down-time (hours) | | 0.25 |
| Hourly labor cost for boning room | $ | 1,066 |
| Weekly Cost | $ | 267 |
| Annual Cost | $ | 12,792 |
| Cost per head | $ | 0.022 |

The actual downtime recorded from the downtime log over an 18 month period in the Australian installation is summarised in Table 14. One downtime incident (Item #2) involved the system being down for 1 week while a spare part was sourced from overseas. Given this is the first installation of its kind in Australia the range of spare parts not easily sourced that need to be carried was still being established. The downtime required manual operation. So no cost of downtime occurred, although the benefits of the automatic system were lost for 40 hours. Cost of carrying additional spare parts in future has been costed in Item #3. Given the actual costs are less than those used in the model, Table 13 is considered a conservative estimate for the wider industry.

Table 14: Eighteen month run –time figures for the Australian installation

| Item # | Actual stoppages per year | Time/hours | Avg hrs/week | $/hd |
|---|---|---|---|---|
| #1 | 5 | 1 | 0.10417 | $ 0.009 |
| #2 | 1 x Manual operation | 40 | 0.83333 | $ - |
| | | | | $ 0.01 |
| | | | | |
| | Value of spares in stock | Interest rate | Spares holding cost | $/hd |
| #3 | $ 50,000 | 7% | $ 3,500 | $ 0.0048 |
| | | | | |
| Total Cost of 18 months performance at Commercial rates | | | | $ 0.014 |

# 6 Cost Benefit Results

The results reported in this section are based on the model drivers summarised in the Table 19 on page 50.

The total ex-post benefits observed were consistent with the ex-ante review but the magnitude of benefits changed with a higher total realised ex-post value relative to the ex-ante prediction. The methodology used to analyse and present the data differed between the ex-ante and ex-post studies as described earlier in this report. The increased level of detail presented in the summaries in this ex-post report, including Table 15, captures the range in vales observed in the data captured for each system.

The summary results in Table 15 demonstrate the performance of the ex-ante machine (left), the ex-post Australian installation (middle) and theoretical maximum capacity of the machine (right) 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 1 as lower (From) and upper (To) value range for each piece of equipment.

The ex-post net benefit was $1.93/hd, compared with an ex-ante prediction of $1.78/hd. This represents an 8% improvement on the original increase in value, delivering an estimated return on investment of 1.7 years. Part of the improvement from the ex-ante to ex-post reviews was attributed to information collected during the ex-ante study that facilitated system improvements by the manufacturer to reduce cutting variation and increase value from improved cutting accuracy.

Table 15: Summary of benefits for ex-ante, ex-post and maximum machine speed relative to manual cutting performance

| SUMMARY PERFORMANCE MEASURES | | | | | | |
|---|---|---|---|---|---|---|
| | NZ-Xray (Ex-Ante) | | AUS-Xray (Ex-Post) | | EQUIP. MAX hd/min | |
| | Hd/ annum | 723,450 | Hd/ annum | 723,450 | Hd/ annum | 1,113,000 |
| Production increase with equipment | 24.05% | | 24.05% | | 90.84% | |
| | From | To | From | To | From | To |
| Capital cost (pmtt option, upfront) | $2,690,000 | | $2,690,000 | | $2,690,000 | |
| Gross return Per head | $2.16 | $2.38 | $2.32 | $2.52 | $2.66 | $2.86 |
| Total costs Per head | $0.48 | | $0.48 | | $0.32 | |
| Net Benefit Per head | $1.67 | $1.90 | $1.83 | $2.03 | $2.35 | $2.55 |
| Annual Net Benefit for the plant | $1,209,967 | $1,371,466 | $1,326,667 | $1,469,486 | $2,614,450 | $2,834,173 |
| Annual Net Benefit for the ex cap | $1,397,233 | $1,558,732 | $1,513,933 | $1,656,752 | $2,757,706 | $2,977,429 |
| Pay back (years) | 1.93 | 1.73 | 1.78 | 1.62 | 0.98 | 0.90 |
| Net Present Value of investment | $7,299,563 | $8,433,862 | $8,119,210 | $9,122,317 | $16,854,952 | $18,398,194 |

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 1.

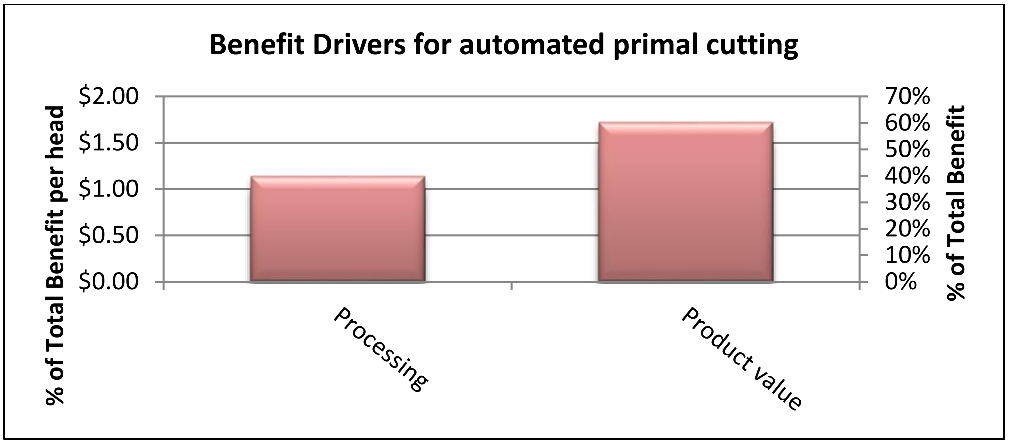



Figure 37: Broad grouping of benefits delivered by Scott's x-ray primal cutting solution

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 2.

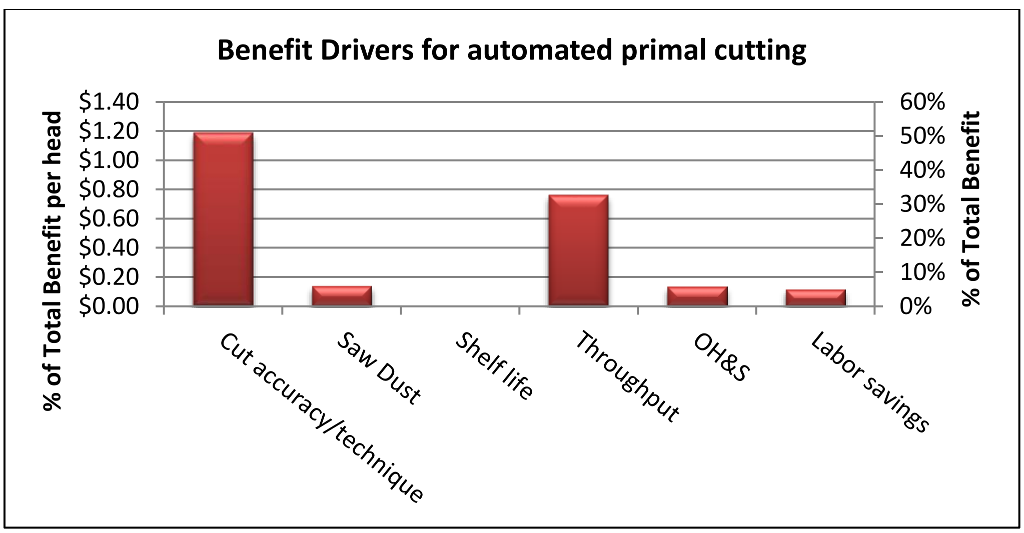



Figure 38: Summary of benefits delivered from Scott's x-ray primal cutting solution

## 6.1 Calculating cost of loss

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 New Zealand and Australian LEAP III systems are compared back to manual operations but all three 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 5.3. 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 16 summarises the amount of loss relative to an optimum, by area for each technology. For example, the cost of inaccurate cutting on the Cut 1 (FQ-Mid) in section "1.1 Accuracy" ranges from between $0.38/hd to $0.58/hd for manual cutting. For the New Zaland LEAP III the loss is much less at between $0.23-$0.29/hd which also has a smaller variation in cost. The difference between the two systems ($0.15-$0.29/hd) is the improved value generated for the NZ LEAP III over the manual system for that particular attribute. In Section 2 "Throughput Cost", $3.87/hd represents the total cost of labour for processing at the manual rate of carcases per hour. The processing rate for the New Zealand and Australian LEAP III systems costs $3.12/hd in processing labour cost. The saving generated by the automated system is the difference, representing a saving of $0.75/hd.

**Table 16: Summary results of individual costs associated with automated x-ray primal cutting of lamb carcasses**

| VALUE OF LOSSES DUE TO INACCURACIES AND MANUAL INTERVENTION* | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | Manual | | NZ-Xray (Ex-Ante) | | AUS-Xray (Ex-Post) | |
| Loss summary | | $/hd From | $/hd To | $/hd From | $/hd To | $/hd From | $/hd To |
| 1.1 Accuracy | Cut 1 (FQ-Mid) | $0.38 | $0.58 | $0.23 | $0.29 | $0.35 | $0.40 |
| | Cut 2 (Rack) | ($0.00) | ($0.01) | ($0.06) | ($0.09) | ($0.06) | ($0.09) |
| | Cut 3 (Hind Leg) | ($0.06) | ($0.00) | $0.02 | $0.03 | ($0.26) | ($0.22) |
| 1.2 Cutting Technique | Cut 4 (Scallop Leg) | $0.79 | $0.79 | $0.00 | $0.00 | $0.00 | $0.00 |
| | Saw dust loss | $0.13 | $0.13 | $0.00 | $0.00 | $0.00 | $0.00 |
| | Shelf life loss | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 |
| **2. Throughput Cost** | | $3.87 | $3.87 | $3.12 | $3.12 | $3.12 | $3.12 |
| **3. OH&S Cost** | | $0.13 | $0.13 | $0.00 | $0.00 | $0.00 | $0.00 |
| **4. Labor Cost** | | $0.23 | $0.23 | $0.00 | $0.00 | $0.00 | $0.00 |
| **Automation costs** | **Maintenance** | $0.00 | $0.00 | $0.02 | $0.02 | $0.02 | $0.02 |
| | **Operation** | $0.00 | $0.00 | $0.07 | $0.07 | $0.07 | $0.07 |
| | **Risk of failure** | $0.00 | $0.00 | $0.02 | $0.02 | $0.02 | $0.02 |
| **$ Losses per head** | | **$5.47** | **$5.72** | **$3.43** | **$3.46** | **$3.27** | **$3.32** |
| **$ Annual Losses overall plant** | | **$3,959,525** | **$4,141,434** | **$2,480,558** | **$2,500,968** | **$2,363,859** | **$2,402,947** |

** Cost is reported as the inaccuracy from target specification OR as the difference between Manual vs. Auto costs*

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 from.

The Figure 39 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.

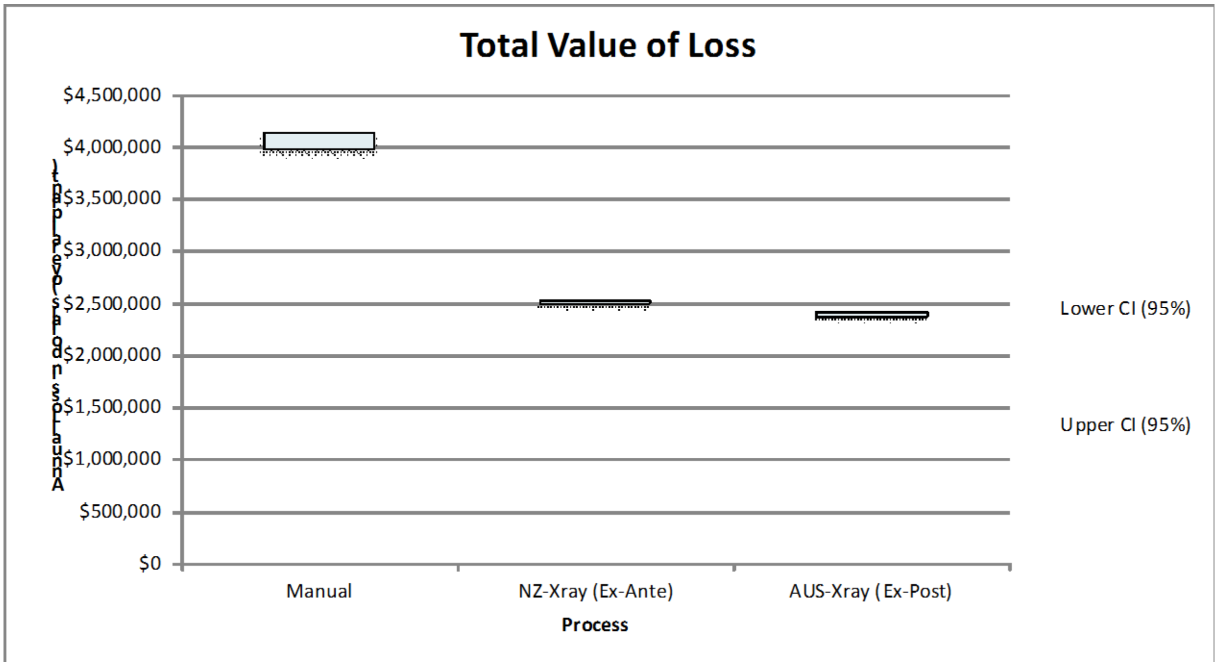



Figure 39: Graphical representation of losses captured in Table 16 showing reduction in loss using the automated systems

More detailed breakdown of the costs and benefits are included in Table 17 and Table 18 below.

## 6.2 Breakdown of Costs and Benefits

**Table 17: Summary of benefits for the installation of RTL Automated x-ray primal cutting system.**

| | NZ-Xray (Ex-Ante) | | AUS-Xray (Ex-Post) | | EQUIP. MAX hd/min | |
|---|---|---|---|---|---|---|
| | Hd/ annum | 723,450 | Hd/ annum | 723,450 | Hd/ annum | 1,113,000 |
| Production increase with equipment | 24.05% | | 24.05% | | 90.84% | |

**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 | | $/hd | |
|---|---|---|---|---|---|---|
| | From | To | From | To | From | To |
| $ Accuracy Benefit per head | $0.13 | $0.35 | $0.29 | $0.49 | $0.29 | $0.49 |
| $ Technique Benefit per head | $0.92 | $0.92 | $0.92 | $0.92 | $0.92 | $0.92 |
| $ Labour Benefit per head | $1.11 | $1.11 | $1.11 | $1.11 | $1.45 | $1.45 |
| $ Automation Costs | ($0.11) | ($0.11) | ($0.11) | ($0.11) | ($0.11) | ($0.11) |
| **$ Overall Benefit per head** | **$2.04** | **$2.27** | **$2.21** | **$2.40** | **$2.55** | **$2.75** |

**COST ASSOCIATED WITH EQUIPMENT**

| | $/hd | $/hd | $/hd |
|---|---|---|---|
| Capital cost | $0.37 | $0.37 | $0.24 |
| Maintenance | $0.02 | $0.02 | $0.02 |
| Operation | $0.07 | $0.07 | $0.05 |
| Risk of mechanical failure | $0.02 | $0.02 | $0.01 |
| Total cost per head | $0.48 | $0.48 | $0.32 |
| Total cost per head (EX CAP) | $0.11 | $0.11 | $0.07 |

**Table 18: Ex-ante costs and benefits breakdown for the Australian LEAP III installation at 6.4hd/minute**

| Benefit Drivers for automated primal cutting | | | 723,450 |
|---|---|---|---|
| Sector | % of total | $/ hd | $/ annum |
| **Processing** | 43.2% | $0.99 | $719,537 |
| **Product value** | 56.8% | $1.31 | $947,540 |
| **Total Benefit - Summary** | **100.00%** | **$2.30** | **$1,667,077** |
| **Cut accuracy/technique** | 51.0% | $1.18 | $850,351 |
| **Saw Dust** | 5.8% | $0.13 | $97,189 |
| **Shelf life** | 0.0% | $0.00 | $0 |
| **Throughput** | 32.6% | $0.75 | $543,416 |
| **OH&S** | 5.7% | $0.13 | $94,491 |
| **Labor savings** | 4.9% | $0.11 | $81,629 |
| **Total Benefit - Detail** | **100.00%** | **$2.30** | **$1,667,077** |
| Capital cost | 76.70% | $0.37 | $269,000 |
| Maintenance | 4.80% | $0.02 | $16,850 |
| Operation | 14.85% | $0.07 | $52,092 |
| Break Down | 3.65% | $0.02 | $12,792 |
| Total Cost | 100.00% | $0.48 | $350,734 |

## 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 19 the following analysis provides a net annual return of conservatively $1,400,000 per annum. Considering an initial total cost of investment of $2,690,000, this delivers a payback period of 1.7 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 at $8.6 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 5.7. 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 5.24 hd / minute, however the automated equipment can run at a speed of 10 hd/ minute. Increasing the processing capacity to 6.5 hd per minute (86% of expected equipment operational capacity) a 24% increase in the overall production capacity of the existing plant was achieved. 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>

# 8 Appendices

## 8.1 List of Tables

## 8.2 List of Figures

# 9 Model Drivers

The calculations used in the modelling within this report are based on the drivers and assumptions included in the Table 19. These drivers are configurable within the associated excel model and can be adjusted easily to different plants and scenarios.

Table 19: Summary of drivers used in modelling assumptions

| PLANT SPECIFIC DRIVERS | |
|---|---|
| **Finance** | |
| Discount rate | 7.00% |
| Include Cap ex as expenses in first year? | YES |
| Life expectancy (yrs) | 10 |
| Cost of investment | $2,690,000 |
| Infrastructure costs for robot install | $0 |
| Total investment | $2,690,000 |
| **Cutting system** | |
| Existing cutting system | BandSaw |
| No of stations | 1 |
| No of band saw operators saved | 1.80 |
| No of bone scrapers saved | 1.20 |
| Increase in Labor efficiency | 24.05% |
| **Product quality** | |
| Retail Discounting | 4.00% |
| Reduction in discount because of new cut system | 0.00% |
| New portion of production discounted | 4.00% |
| Average price of discount | 20% |
| Average Carcasses weight | 21.88 |
| **Product quality** | |
| % of Annual production requiring 3rd cut | 30.00% |
| **Market Specification** | |
| Expected kg yield gain for scallop cut /SIDE based on markets | 1.50% |
| % of Annual Kill processed Rack & Loin | 100.00% |
| % of Annual Kill as Full Loin (B/in & B/Less) | 0.00% |
| % of Racks frenched | 90.00% |
| % of Short loins as Backstrap | 59.00% |

# 10 Statistical Results

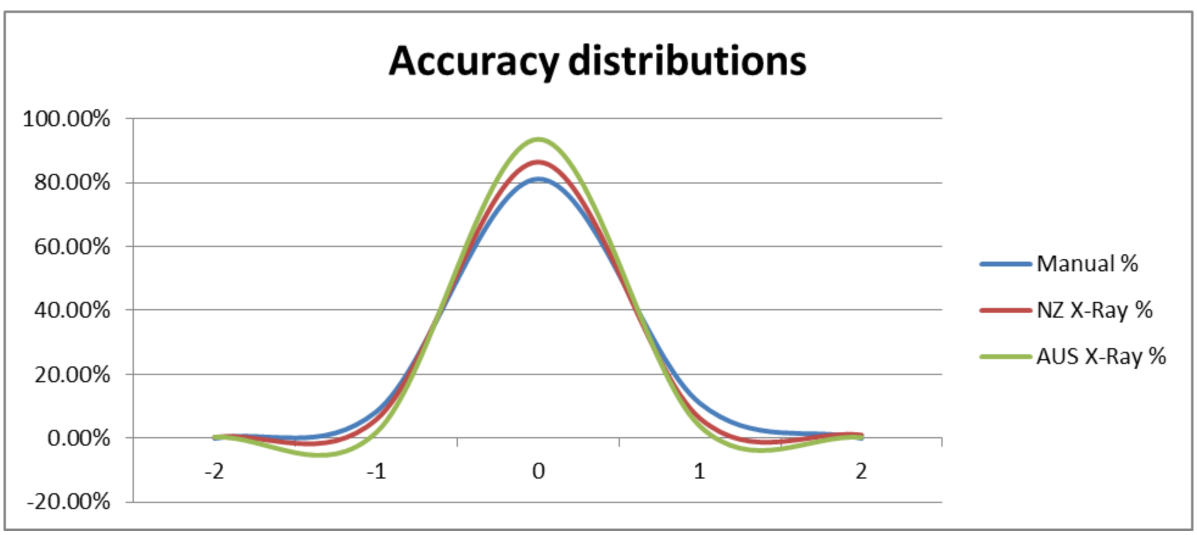
## 10.1 Cut 1 – FQ Mid

### 10.1.1 Number of Ribs

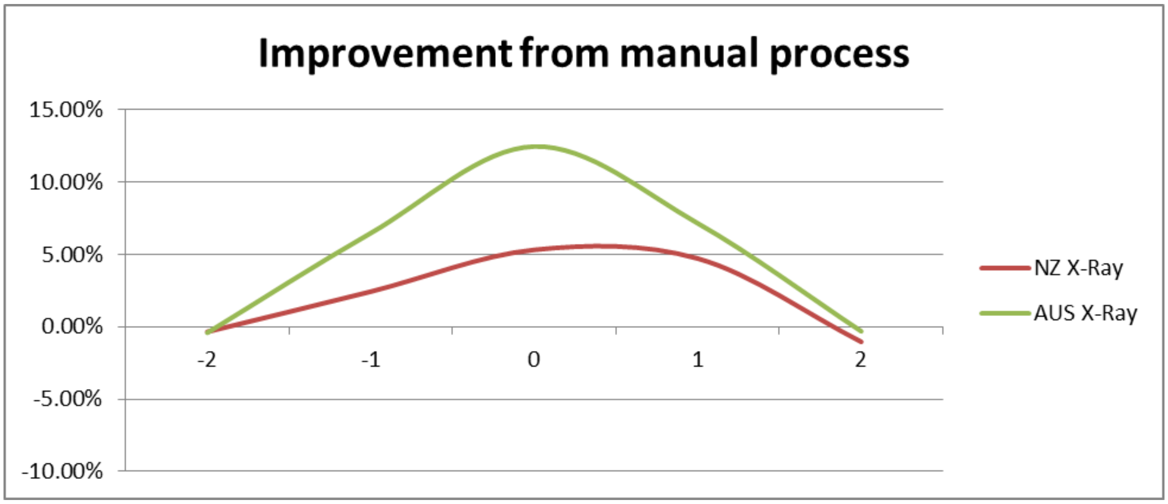
Graph 20 shows the distributions of the 3 methods which clearly shows that the progressive improvement from the manual process to the NZ x-ray to the AUS x-ray LEAP III systems. The fact that both x-ray machines show better performance is clear but we would like to be able to quantify the difference. We can see by the graph that all 3 methods follow a normal distribution around a zero mean – i.e. a bell curve which peaks at zero and falls away on both side roughly symmetrically then petering out to 2 away from the mean on each side. Having anecdotally identified that the measurements distributions are normal, we can then begin to conduct some statistically significant tests comparing those distributions.

Initial observation of the distributions would suggest that the improvement of the AUS to the NZ x-ray LEAP III systems is similar to the improvement of the manual process to the NZ LEAP III. This makes it difficult to quantify the difference between the manual process and the LEAP III machine.

Graph 21 below shows the improvement from the manual process for both the NZ and AUS machines. This is calculated by the measurements 'x-ray minus Manual' for the zero metric and 'Manual minus x-ray' for all other measurements. As can be seen in the graph, the x-ray machine showed a slight decrease in performance at 2 and -2 but was superior at all other measurements for both the AUS and N-Z machines. We do notice however that the NZ machine improvement distribution is skewed towards 0.5 whereas the AUS improvement is more normally distributed around a mean of zero. This would anecdotally suggest that the AUS LEAP III improvement over the manual process was linear i.e. the improvement across the board was consistent whereas the NZ x-ray process was significantly more improved at ribs over 4 and less improved at ribs under 4.

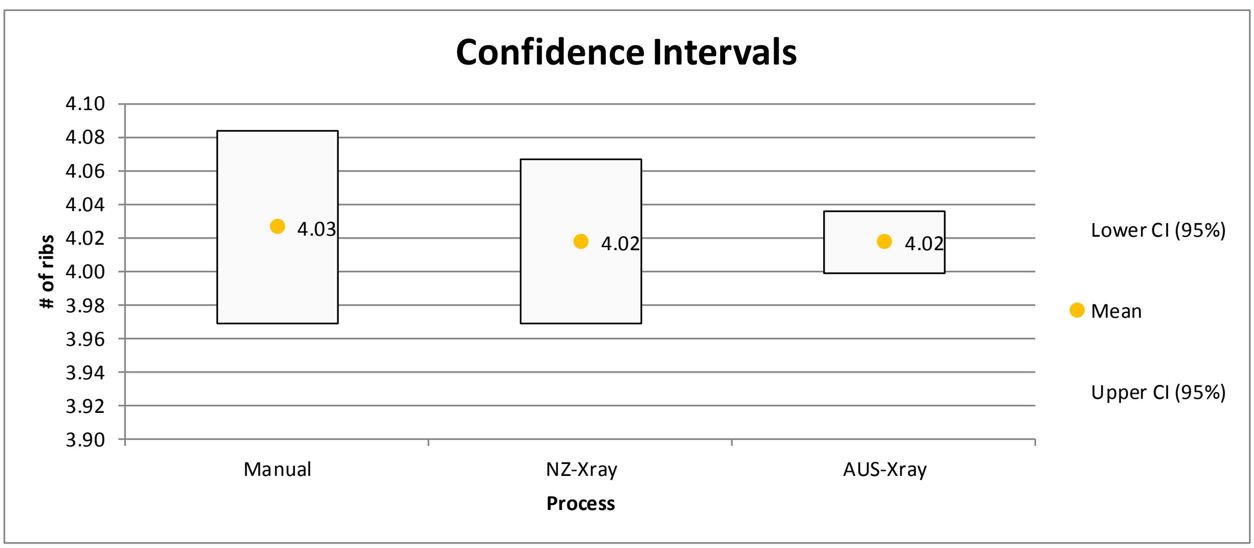



Graph 20: Accuracy distributions

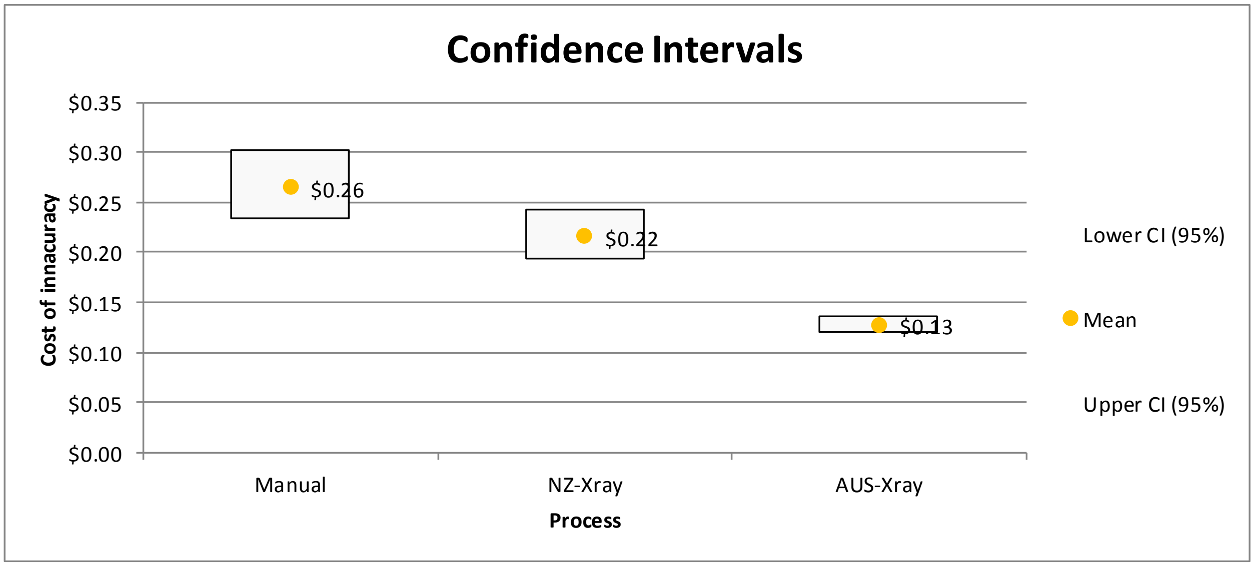



Graph 21: Improvement from manual process

Analysis of variance tests were conducted between each of the three combinations for manual, NZ and AUS LEAP III systems. The result was that all three sets of results differed significantly from each other. As can be seen from the confidence limits around the average number of ribs in Graph 22, the means for both x-ray machines are quite similar – 0.17 and 0.18 ribs left on the bone after cutting as opposed to the manual process which left an average of 0.26 ribs on the bone after cutting. However the variance for the NZ machine is quite wide compared to the AUS machine which is why the ANOVA tests conclude that the results for the 2 LEAP III machines are not considered to be similar.



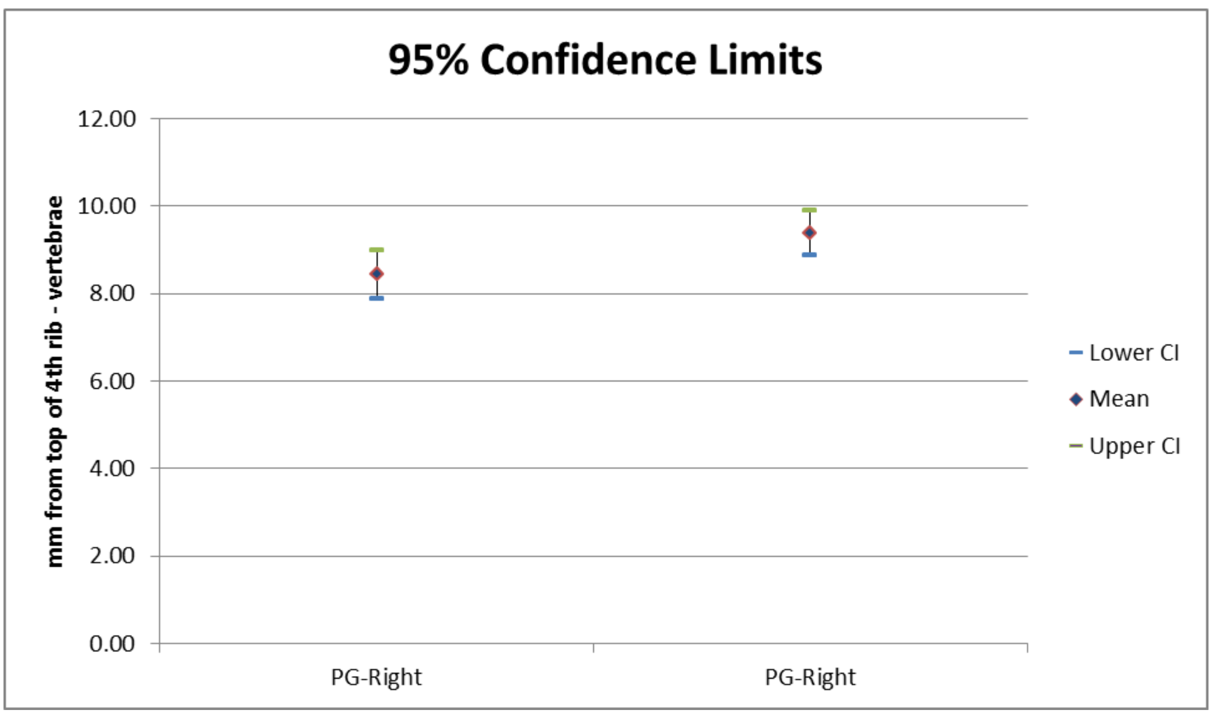

Graph 22: 95% confidence limits around # of ribs




Graph 23: 95% confidence limits around cost of inaccuracy for # of ribs

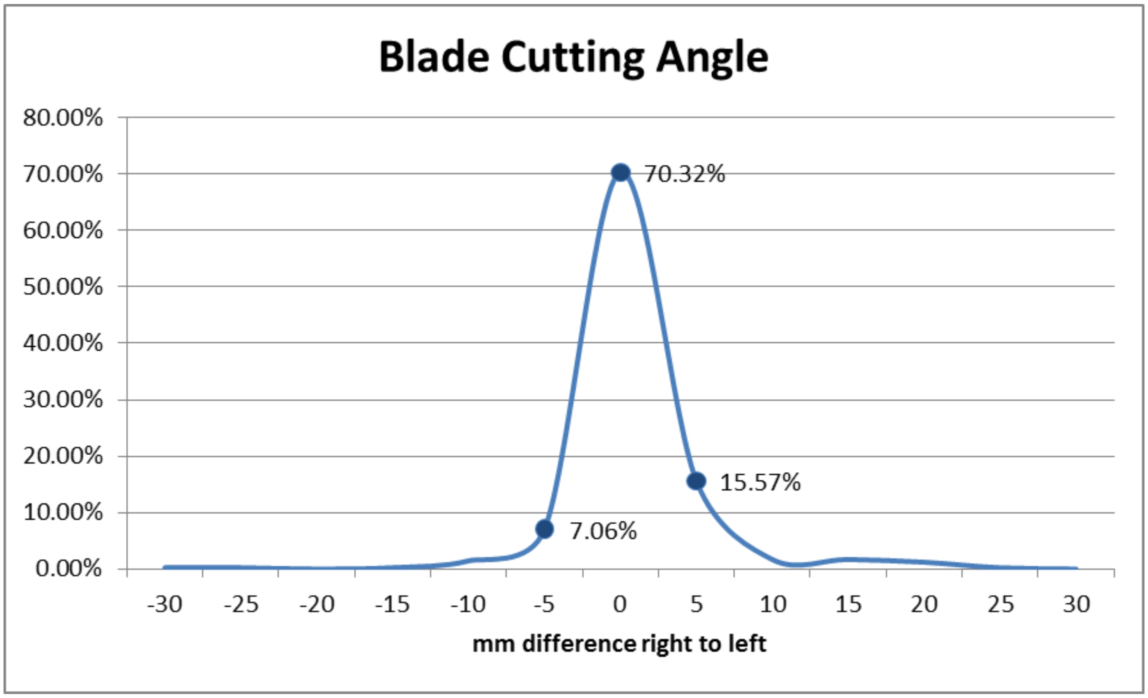
### 10.1.1 Meat left above rib – vertebrae

The results in Graph 24 show the amount of meat left on the bone after cutting….




Graph 24: Confidence limits

The results in Graph 25 show the distribution of blade cutting angle. While 70% of the measurements showed a zero angle, the two key observations were that 15.57% of cuts recorded a blade angle between 5mm and 10mm right to left and a further 7.06% of cuts recorded a blade angle between 5mm and 10mm left to right.



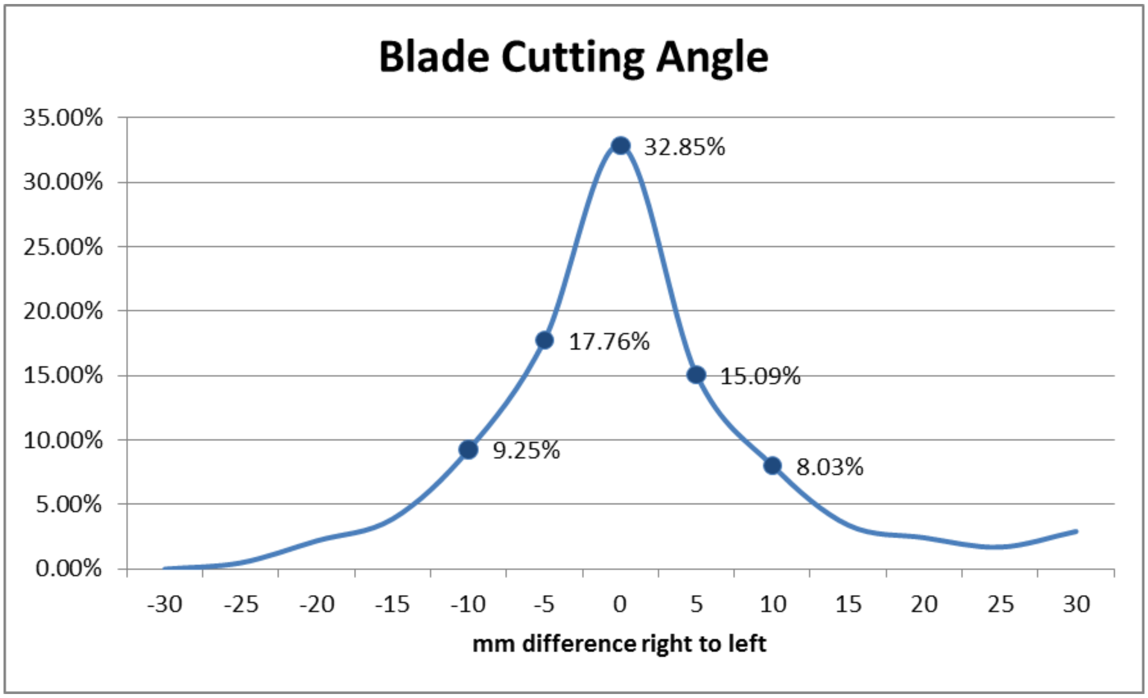

Graph 25: Blade cutting angle – right to left - vertebrae

### 10.1.2 Meat left above rib – belly

The results in Graph 24 show the amount of meat left on the bone after cutting.

Graph 26: Confidence limits

The results in Graph 27 show the distribution of blade cutting angle. In this case, only 32.85% of cuts were straight with another 36.25% of cuts having an angle of between 5 and 15 mm left to right or right to left.




Graph 27: Blade cutting angle – right to left - belly

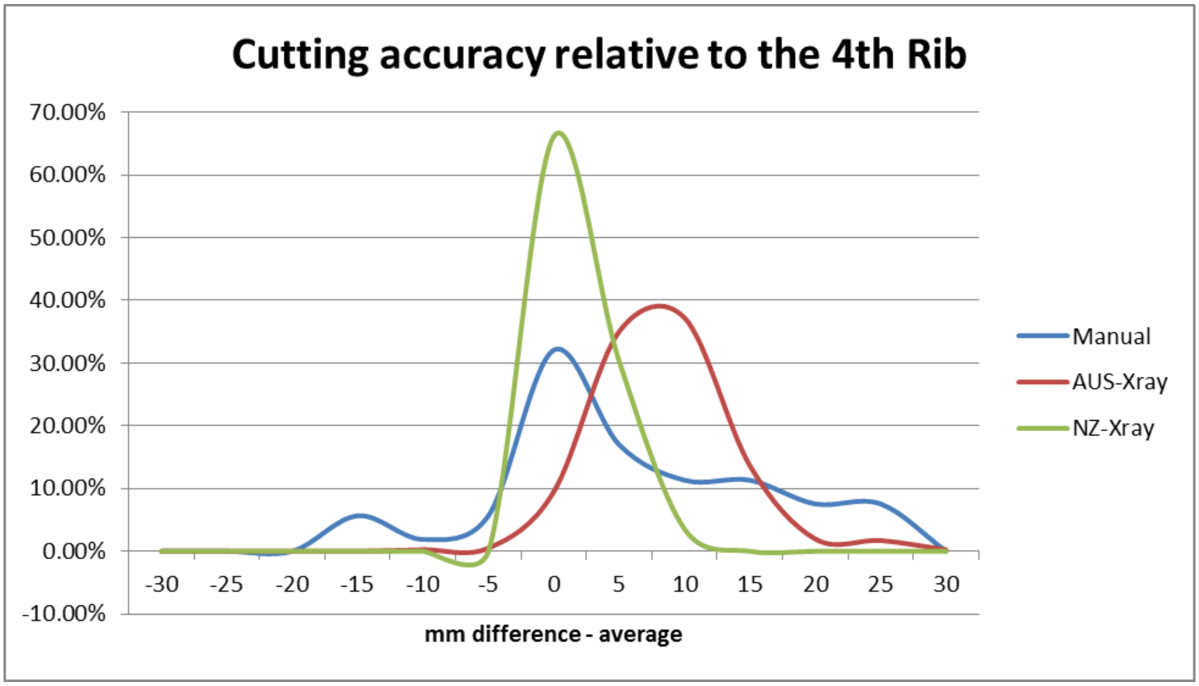
### 10.1.3 Meat left above rib – summary

The 2nd round measured the height from the top of the 4th rib to the top of the meat at both the vertebrae and the belly, left and right side. The first analysis took a single measurement for this value. In order the keep consistent, we took an average of the 4 measurements to compare with the first set of measurements.

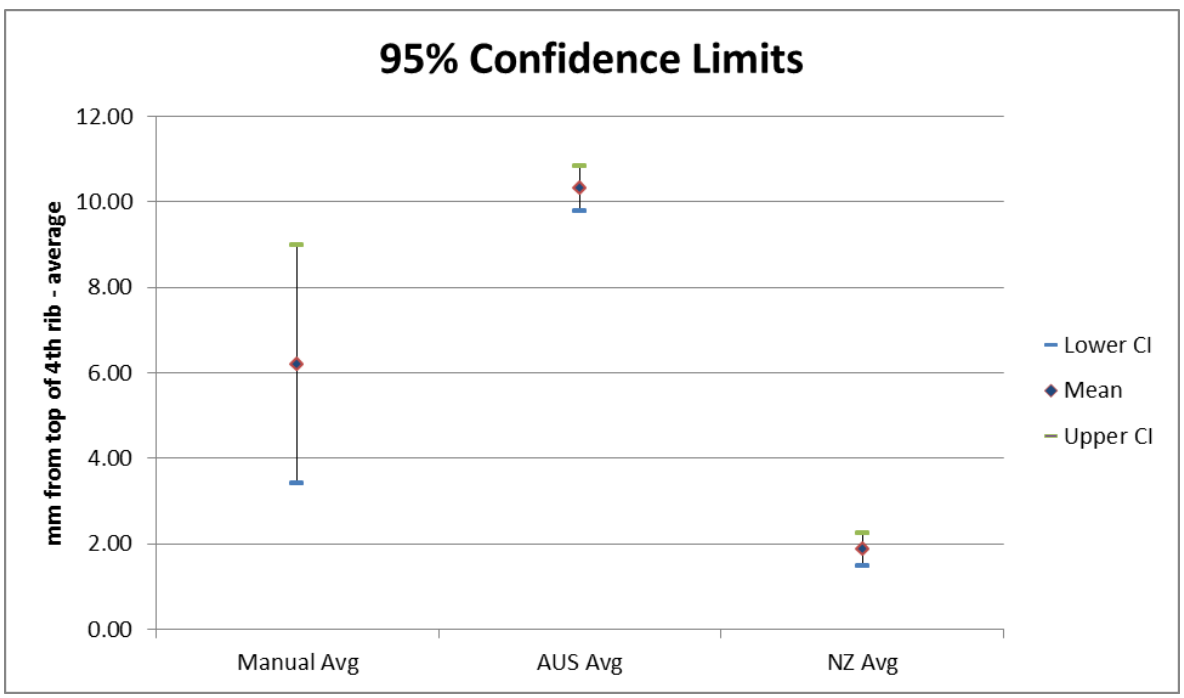
Some initial results can be seen below – 2nd graph shows the AUS LEAP III machine skewed to leaving 5 to 15 mm on the rib which is not only more than the NZ LEAP III but also more than the manual process.

Graph 29 shows that this equates to a 95% confidence interval of 9.8mm to 10.8mm left on the rib with the AUS LEAP III as opposed to 3.4mm to 8.98mm left on the bone with the manual process. This equates to $0.18 to $0.19 per head with the LEAP III process as opposed to $0.09 to $0.16 per head with the manual process. This equates to an average $0.06 cents difference plus or minus $0.03. NOTE: This is calculated using the figures:

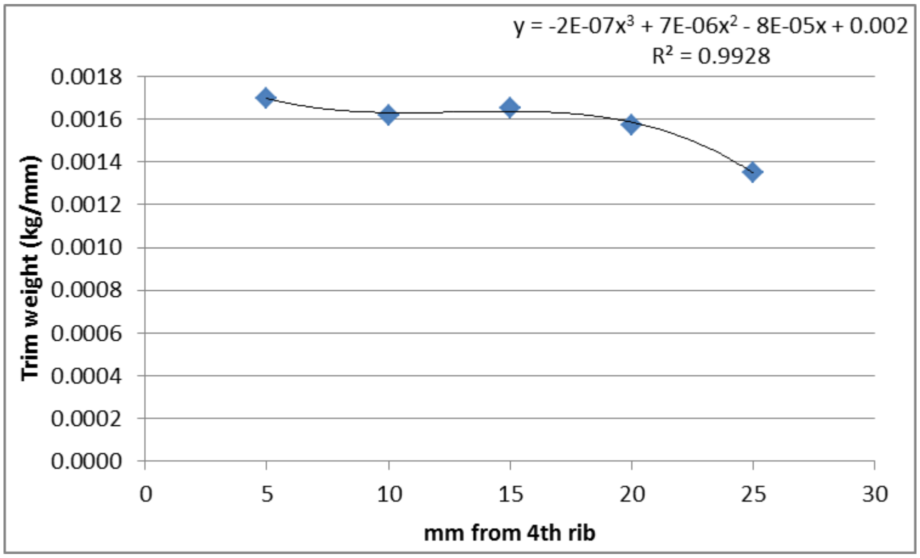
- Avg Rack weight per 1mm is calculated by the formula $y = 2x(-2E\text{-}07x^3 + 7E\text{-}06x^2 - 8E\text{-}05x + 0.002)$ (based on spread sheet data - \\StaffData\Greenleaf\PROJECTS\MLA912 L3S\Trial Data\MLA912 ALC shouler.xlsx$sheet2). Formula has a R2 value of 0.9928. This can be seen in Graph 30
- Cost difference from an 8 Rib rack @$14.00 to a shoulder Rack @$8.60 is $5.40.




Graph 28: Cutting accuracy relative to the 4th rib



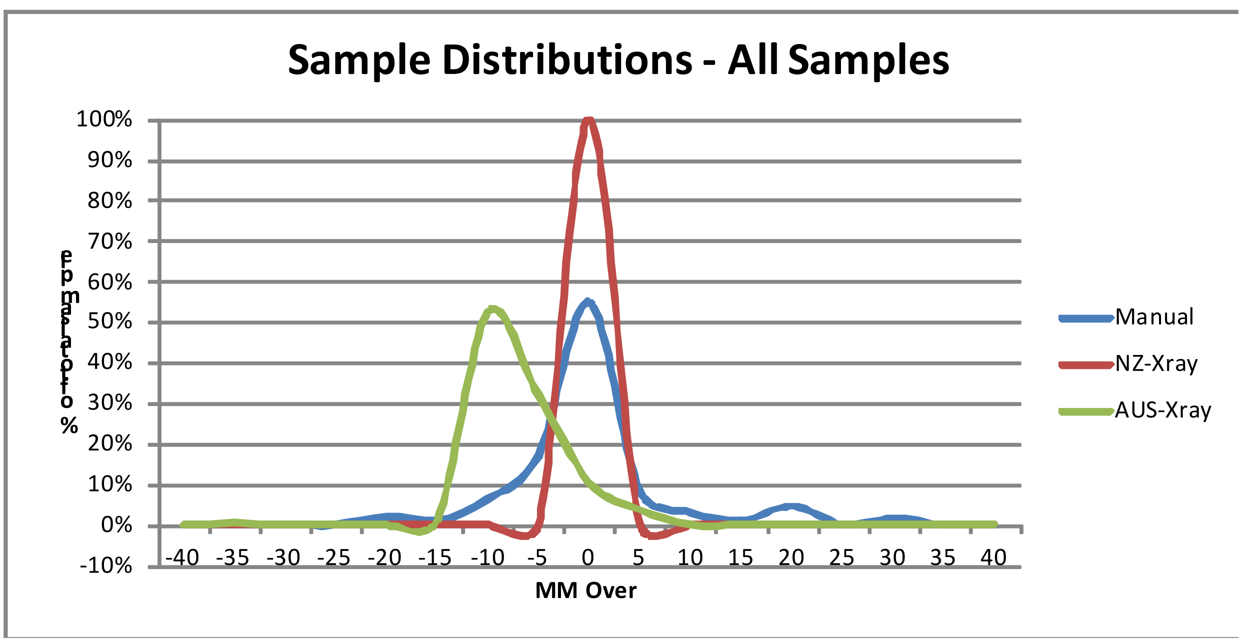
**Graph 29: Confidence intervals**



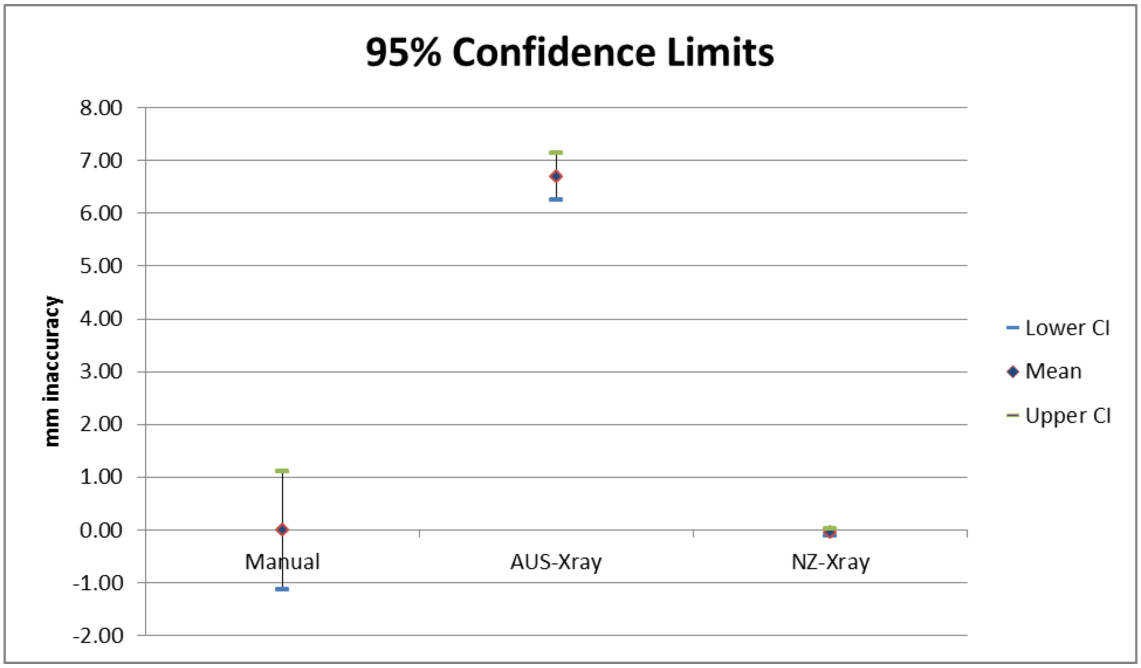

**Graph 30: Trim weight per mm from 4th rib formula – single side**

## 10.2 Loin - Hindquarter

Graph 31 shows the distributions of inaccuracy in the cut for the Hindquarter. Both the Manual and NZ inaccuracies centre on zero with the NZ LEAP III presenting all inaccuracy measurements within -2 and 2 mm. The AUS LEAP III however is skewed around 5 to 10mm of inaccuracy which is a significant difference. Graph 32 gives a more numerical view of this with the AUS LEAP III averaging at 6.7 plus or minus 0.45mm.



Graph 31: Inaccuracy of cut comparison



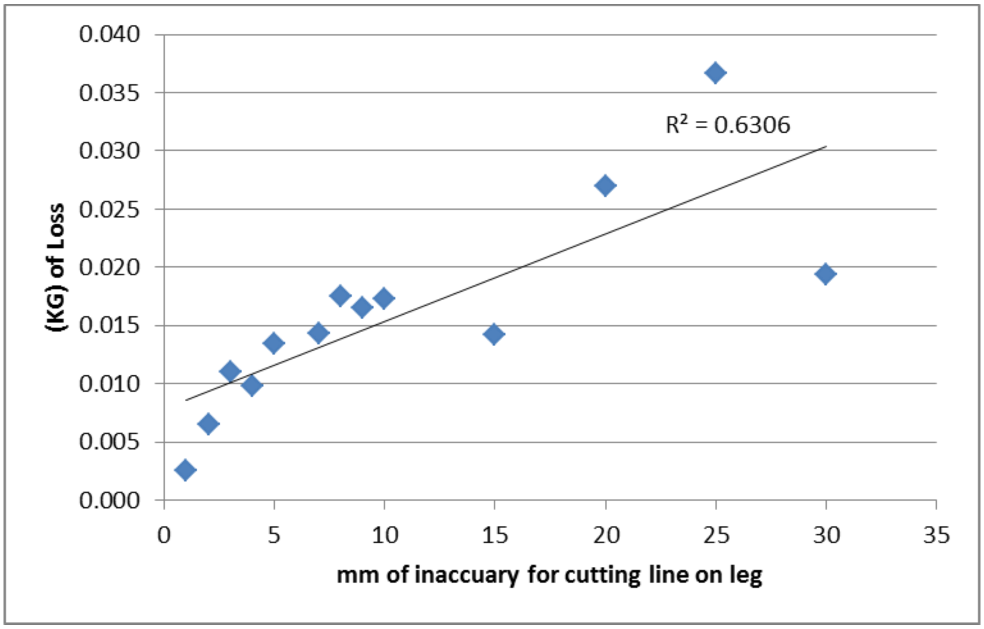

Graph 32: mm Inaccuracy confidence limits

To put a cost to these figures, we used data gathered during the first set of trials. Graph 33 shows the model arrived at in the first set of trials. Since we are only interested here at inaccuracy levels of 10mm or below, we have reconstructed the model using only this data where we can see, the data follows a more logarithmic path. Graph 34 shows this model which has an $R^2$ value of 0.9612.

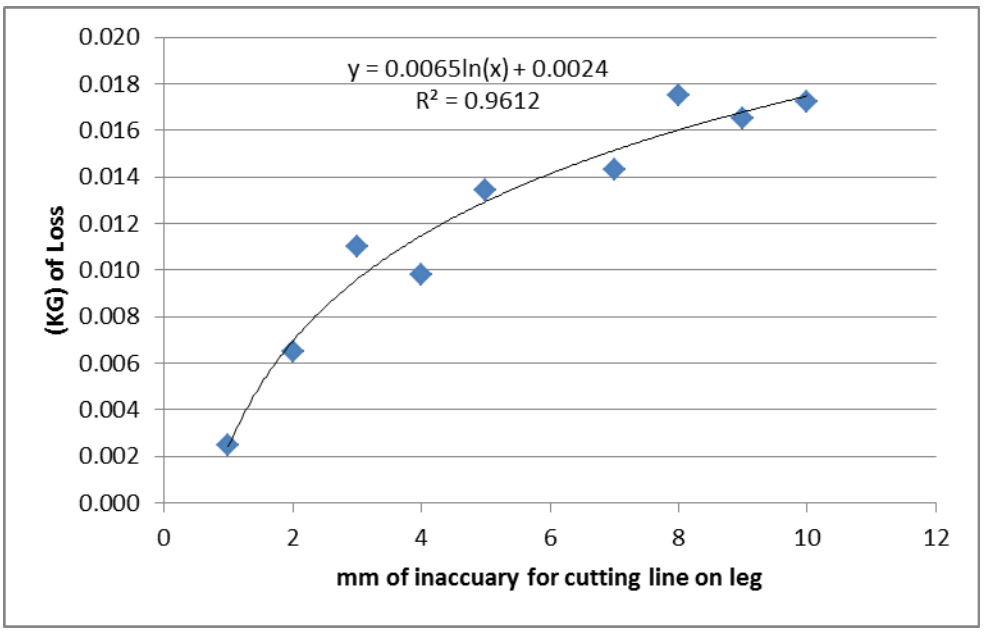
This formula gives rise to the following:

- The manual process loss is $0.12 to $0.20 per head
- The NZ LEAP III process loss is $0.01 per head
- The AUS LEAP III process loss is $0.56 to $0.61 per head

We have used the average cost increase (manual to AUS LEAP III) of $0.43 per head and in our calculations and a cost decrease of $0.15 per head manual to NZ LEAP III.




Graph 33: Linear model of cost associated with loss




Graph 34: Logarithmic model of cost associated with loss