final report

Project Code: P.PSH.0539

Prepared by: Greenleaf Enterprises

Date published: August 2010

PUBLISHED BY
Meat and Livestock Australia Limited
Locked Bag 991
NORTH SYDNEY NSW 2059

Value proposition for automated X-ray Primal Cutting Systems – (Generic Bandsaw)

Meat & Livestock Australia acknowledges the matching funds provided by the Australian Government to support the research and development detailed in this publication.

Abbreviations

CBA	Cost Benefit Analysis
FQ	Forequarter
HQ	Hindquarter
LD	Longissimus Dorsi muscle (or strip loin)
MLA	Meat and Live Stock Australia
RTL	Robotic Technologies Limited (A joint subsidiary company of Scott Technology and Silver Fern Farms)
SLP	Short Loin Pair
TDR	Tender Loin (Psoas major muscle)

1 Executive Summary

Robotic Technologies Limited (RTL) in conjunction with several other stakeholders including Meat and Livestock Australia (MLA) and a New Zealand lamb processing company have developed automated lamb primal cutting equipment guided with the use of X-Ray Technology. Prototype equipment has now been in operation in a commercial processing plant in New Zealand for over 12 months, and has now reached the stage of commercialisation. As part of the final commercialisation phase of the equipment a cost benefit analysis review has been conducted.

The review firstly identifies the costs associated with the current manual cutting systems of lamb carcasses, and secondly identifies the value opportunity for the automated X-ray primal cutting systems in the existing plant. Review work was conducted in both two Australian lamb processing plants using two different manual primal cutting systems, and one New Zealand processing plant where the automation equipment was operational.

Benefits identified with the use of the automated equipment as compared to the manual cuttings systems included improved retail value of carcasses through improved accuracy in cuttings lines, further product quality benefits achieved through technical advantages provided by the cutting system including a) increased yield for boneless loin b) yield gains through reduced bandsaw dust c) increased shelf life. Other benefits relating to process efficiencies included increased efficiency of existing labour due to automation, OH&S savings and actual labour savings. The overall contribution of each individual and its associated dollar value can be seen in Figure 1.

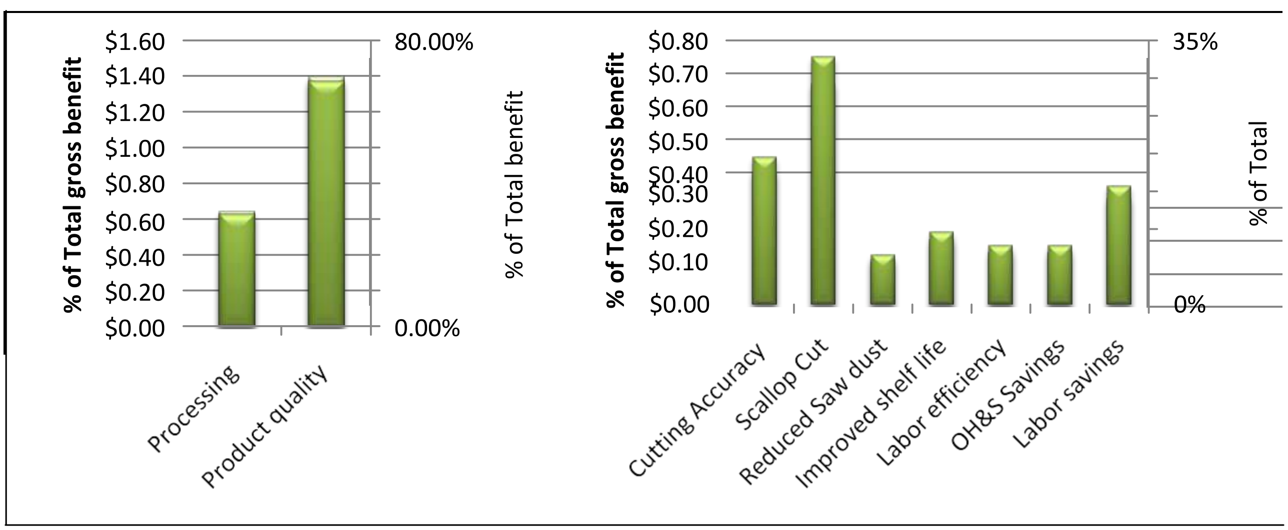

Figure 1: Summary results of RTL Automated X-Ray Primal cutting equipment

2 Introduction

Robotic Technologies Limited (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.

At this stage, the first of these modules, the "X-Ray and Primal" automated primal cutter is now ready to be commercially released and the first of the commercial machine has been installed in a New Zealand lamb processing plant.

The primary financial benefit of RTL's Primal Cutting Robot is improvement in yield. However, other benefits including reductions in full time labour and training costs, improvements in safety, product quality, and production rates all contribute to the potential return on equipment investment.

The following report estimates the value proposition for this equipment and is designed to provide an outline of the methods used for data collection, explanation of calculations, description of model drivers, and explain the development of CBA.

3 Objectives

1. To establish a generic benchmark for the value opportunity that exists for automated primal cutting systems when compared against existing manual cutting systems.
2. To develop a value benefit analysis outlining the main drivers for adoption of the equipment for Australian lamb processing plants.

4 Data collection and Calculations

The following costs and benefits shown in Table 1 were identified as being relevant financial drivers in the installation of an automated X-Ray lamb primal cutting system.

Table 1: 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 advantageous 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 establish the value opportunity for automated primal cutting at plant 1, the basic method was first to bench mark the performance of the existing manual cutting system. With this bench mark established it was possible to review the performance of the automated cutting system and identify the value opportunity of automated X-ray primal cutting for plant 1.

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.

The following section 4 of the report is designed to explain 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 Model drivers used for calculations

The objective of the trial work was to establish the $/hd value of each of costs and benefits listed in Table 1. Calculations presented for these benefits are calculated using production numbers and sales prices shown below.

4.1.1 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 2). These values remain independent to adjustable drivers shown in the cost benefit summary section of the model.

Table 2: Calculation used for determining production base line production volumes for "generic plant"

Production volumes	Current	New
hd/min	5.24	6.50
hd/hr	314	390
Saw run time (min)	420	420
Hrs/day	7	7
hd/day	2,201	2,730
days operation	265	265
hd/yr	583,212	723,450

Work day calculation	Days
weeks/yr	52
Work days per week	5
Word days per yr	260
Public holiday	10
Less public holiday	250
No weeks / yr work on Saturday	15
Total work days per year	265

4.1.2 Sales prices

Values shown in light green can be adjusted. If this model is being used for an application other than Australian Dollars, simply changing these Currency/KG numbers to the relevant prices will adjust all model results to the required currency, including results presented in 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 17.

Table 3: 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	

4.2 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 existing accuracy levels observed with the manual cutting system, and the costs incurred because of these inaccuracies.

Figure 2 illustrates the three cutting lines that the automated primal cutting equipment will perform, and the various the cuts associated with the different primals. Furthermore Table 4 communicates the expected losses with the various inaccuracies of the cutting lines.

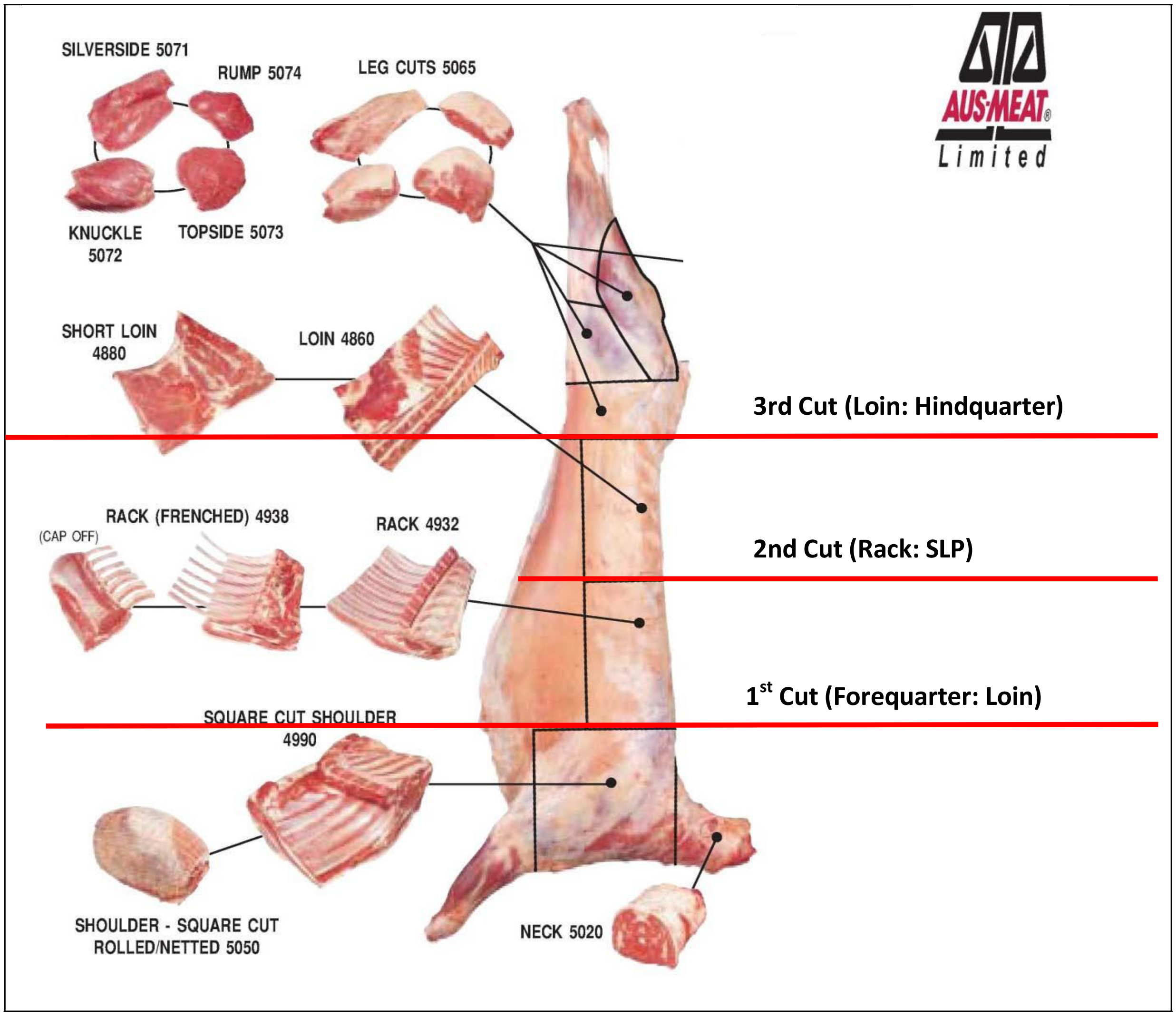

Figure 2: Cutting lines that the automated primal cutting system will perform on the lamb carcass (Source: Aus Meat 2003)

Figure 3 shows the carcase after primal cutting and the resultant four primals including Forequarter, Rack, short loin and Leg or hindquarter.

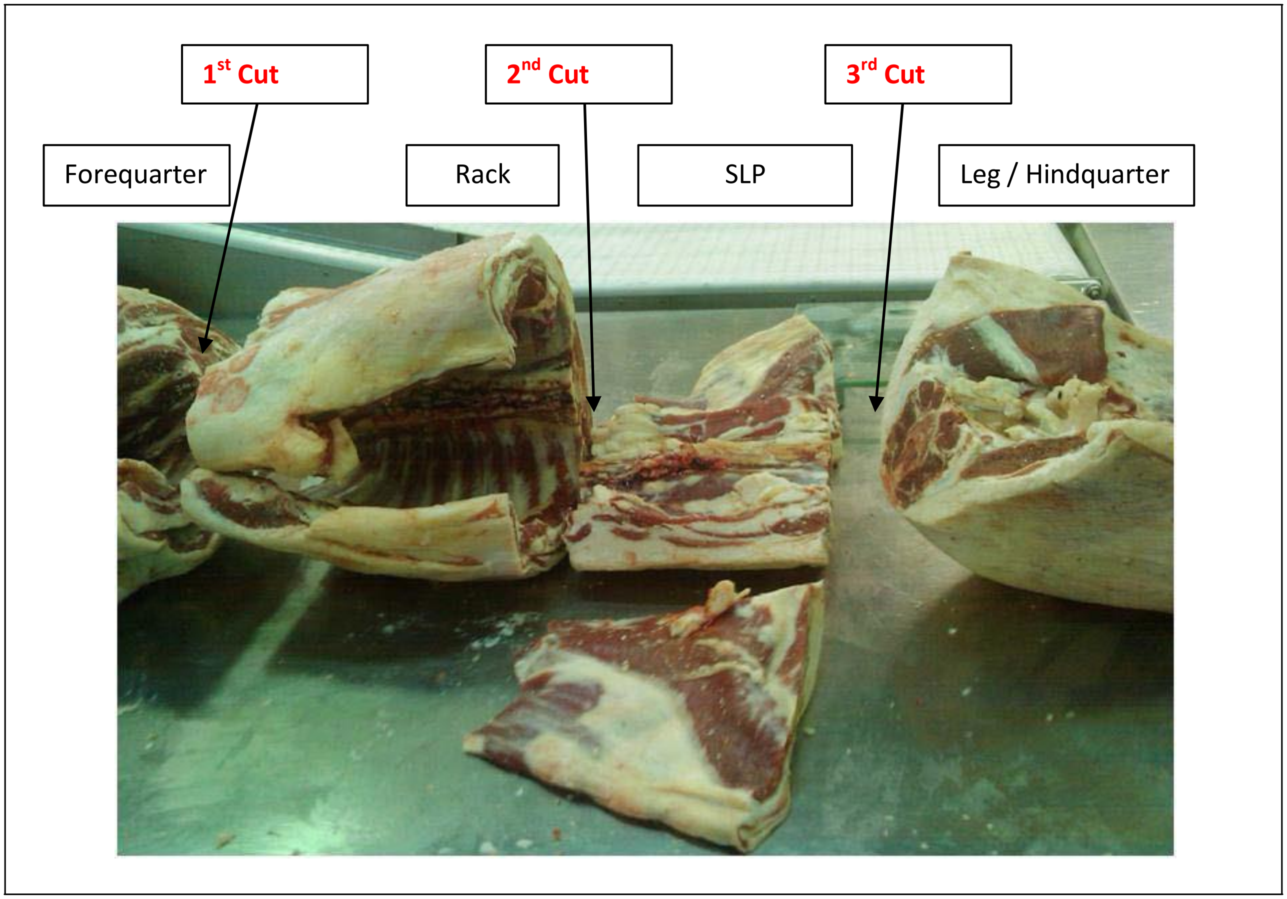

Figure 3: Three primal cuts, and the 4 respective primals

Table 4: 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	

4.2.1 1st Cut, Forequarter & loin (measurement and results)

4.2.1.1 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 (Figure 4) number of ribs, 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.

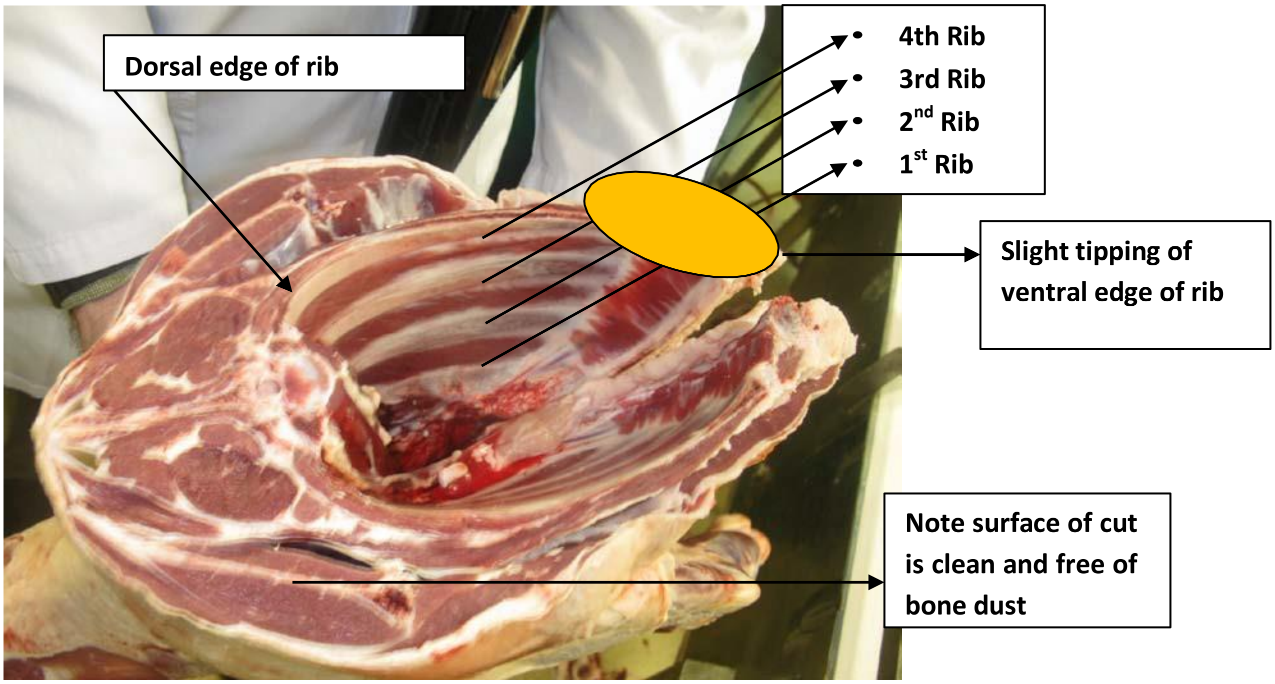

Figure 4: Measurement of cutting for forequarter rib.

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.

4.2.1.2 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 values (Figure 5, Figure 6 & Figure 7).

Figure 5: Impact of cutting one rib long, figure showing amount of loin lost

Figure 6: Correct cutting line between forequarter and loin for a four rib shoulder rack

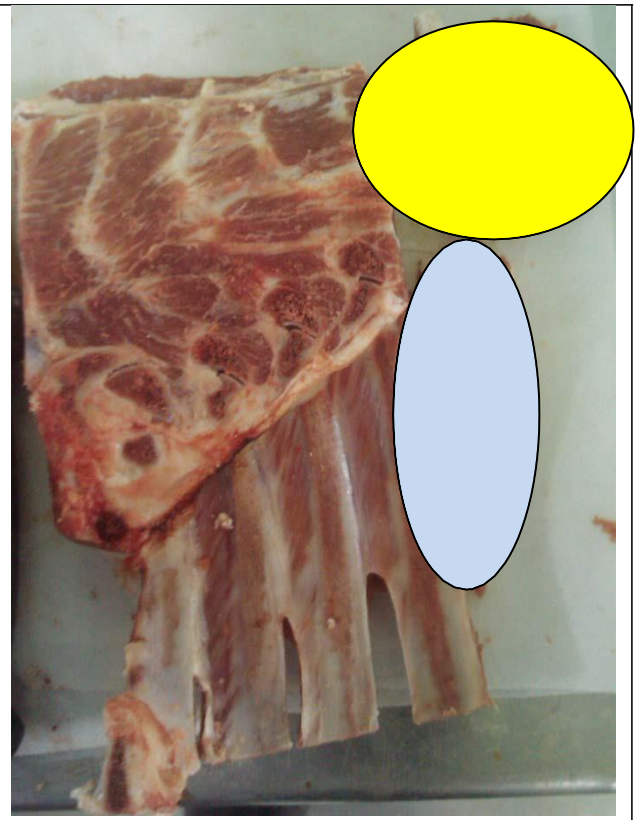

Figure 7: Cutting line long for a four rib shoulder rack. Highlighted items represent value lost (Loin lost to trim and part rib lost to render).

Table 5 shows the methods used to establish the cost of various cutting inaccuracies. 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 19 section 5.1).

Table 5: Costing of forequarter inaccuracies **

Forequarter					
(-2 ribs) 2 rib short on shoulder					
Increased value in loin		Discount rate on 3 rib rack		Loss of bone to render from SLP	
Weight of loin	0.064	Weight (kg) 2 rib	0.240	Extra loin value	$0.67
Value as shoulder	$0.55	Weight (kg) 4 rib	0.450	Weight of bone	0.038
Value as loin	$1.22	Standard rack price	$3.87	Bone as loin	$0.73
Gain	$0.67	Discount less one rib	$1.65	Bone as waste	$0.006
		Difference	-$2.22	Difference	$0.72
Loss (+ value of loin, less FQ discount, less bone loss)					$2.16

(-1 rib) 1 rib short on shoulder					
Loss of FQ Value		Increased loin value		Loss of bone to render from SLP	
Sd wt (kg) 3 rib	0.403	Weight of loin	0.032	Extra loin value	$0.33
Sd wt (kg) 4 rib	0.450	Value as shoulder	$0.28	Weight of bone	0.019
Standard rack value	$3.87	Value as loin	$0.61	Bone as loin	$0.36
Discount less one rib	$2.77	Gain	$0.33	Bone as waste	$0.003
				Difference	$0.36
Difference (lost shoulder value)	$1.10			Value gained	-$0.03
Loss (=increased loin value-(loss of FQ value + loss of r ib value)					$1.12

1 rib longer					
FQ Gain		Rack remains the same		Loss of cutlet to Short Loin	
Weight of 4 rig	0.45	No Change - difference passed on to short loin		Weight of bone	0.047
Value of 4 FQ	3.87			Value	$0.89
Weight as 5 rib	0.497				
Value of 5 FQ	$3.42				
Gain	-$0.45			Bone as waste	
				Difference	$0.89
Loss (=increased loin value-(loss of cutlet)					$1.34

2 rib longer					
FQ Gain		Loss to Rack		Loss of SLP	
Weight of 4 rig	0.45	No Change - difference passed on to short loin		Weight of BL loin	0.450
Value of 4 FQ	3.87			Value	9.900
Weight as 6 rib	0.61			Discount Value	6.120
Value of 6 FQ	$5.25				$3.78
Gain	-$1.38	Discount less one rib	$0.00		
		Difference	$0.00	Difference	$3.78
Loss (+ value of loin, less FQ discount, less bone loss					$2.40

** Please see Appendices Section 7.1.3 Table 23 for weights used for bone and muscle.

4.2.1.3 Results

Table 6 shows that there was significant increase in the accuracy when comparing manual and automated cutting systems. The only exception is that there was one observation in the automated data set which had more than two ribs greater. In terms of achieving the correct rib number the automated X-Ray primal cutting system was 5.3 % more accurate than the manual cutting system. 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.

Table 6: Accuracy observations for both manual and X-ray cutting systems

FQ RIB ACCURACEY BANDSAW							
	Manual		X-Ray		% Difference		
FQ - Mid	No Obs	%	No Obs	%	%	Cost	Daily Cost
-2	0	0.00%	1	0.00%	0.00%	$2.16	$0.00
-1	19	8.33%	17	2.00%	6.33%	$1.12	$156.54
0	185	81.14%	249	96.00%	5.32%	$0.00	$0.00
1	25	10.96%	18	2.00%	8.96%	$1.34	$264.57
2	0	0.00%	3	0.00%	1.04%	$2.40	$55.11
Number of observations		229		288		Daily	476.22
						Annual	126,198.35
						Per head	$0.22

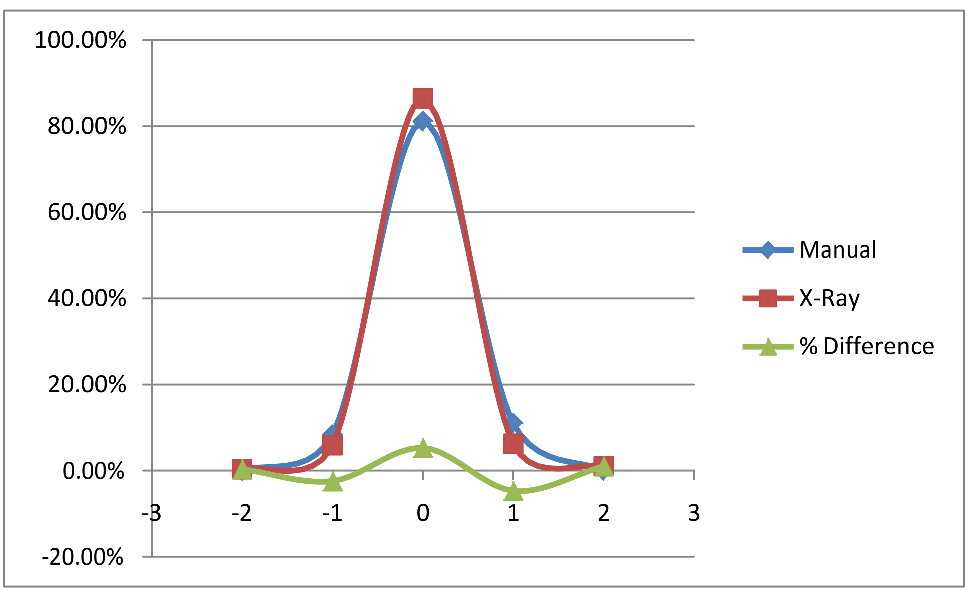

Figure 8: Comparison of the accuracy between manual and X-Ray cutting systems

4.2.1.4 Impact of cut angle

Figure 9 shows the distribution of manual cutting accuracy relative to the 4th rib. 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 crainial 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 that over 64% of the cuts are 5mm or more away from the edge of rib under manual cutting conditions.

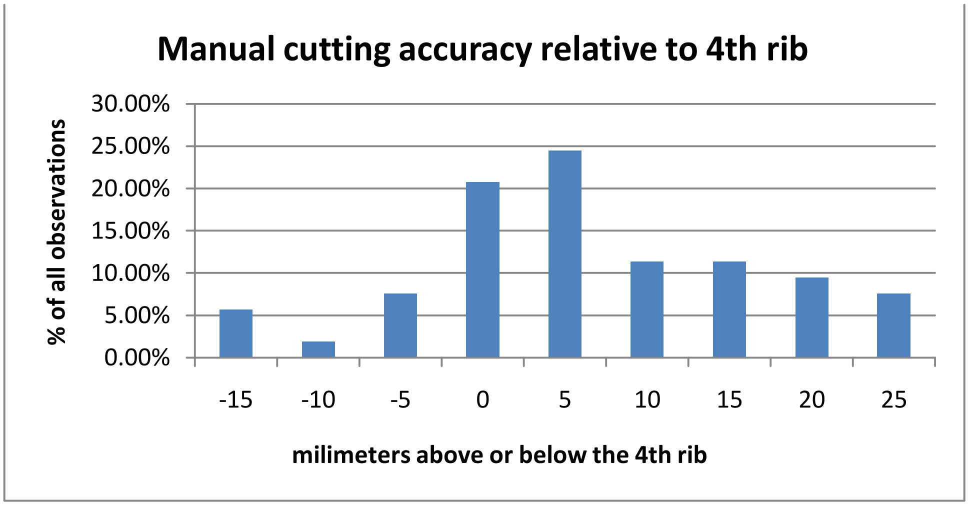

Figure 9: Manual cutting lines relative to the 4 th rib on a 4 rib shoulder cut.

When a shoulder is cut long (beyond the caudal edge of the 4th rib), losses occurs due to higher value rack loin muscle achieving only shoulder value. As shown in Figure 6 & Figure 7 lost loin was removed from the shoulder and weighed. Figure 10 illustrates the relationship between the levels of cut accuracy and 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.

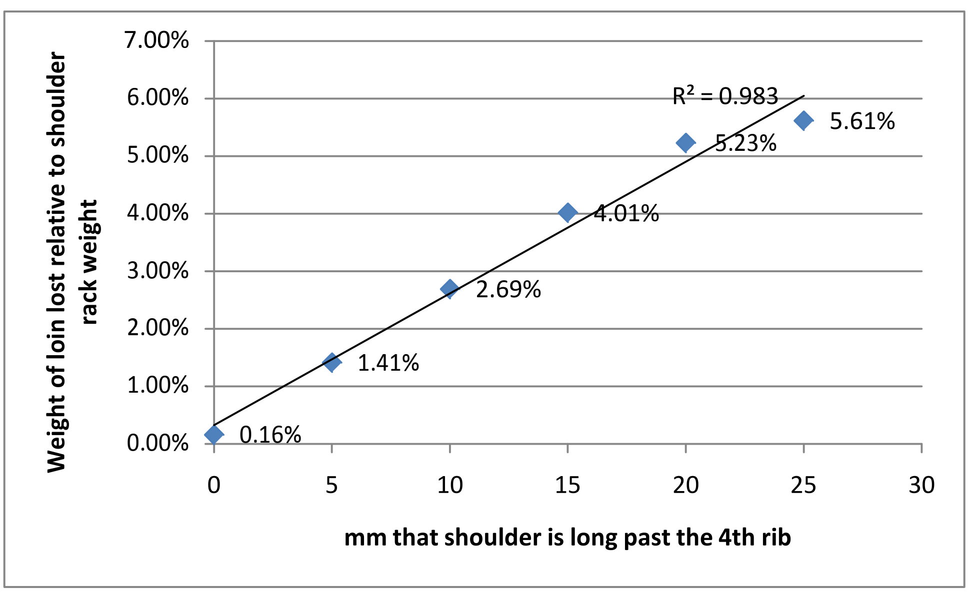

Figure 10: Scatter plot showing relationship between mm of inaccuracy and the loss of shoulder rack relative to its weight

Based on the level of accuracy observed in Figure 9, the current cutting system was resulting in a loss of $0.16/hd, or $83 000 per annum for the plant.

4.2.2 Second Cut (Rack & Short Loin Pair)

The cut between the rack and short loin pair is a cut that is not currently done with the automated primal cutting equipment that was observed during the review process. However similar technologies used on other cuts would be included in the proposed equipment that the analysis work was conducted for. For this reason the data presented for this cut represents the value opportunity that is currently available for improvement in the existing manual cutting systems. These results would then need to be confirmed against observations from the equipment for this cut once it was commissioned and in commercial use.

4.2.2.1 Measurement

Measurement of manual 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 crainial and caudal edges of the rack were also observed.

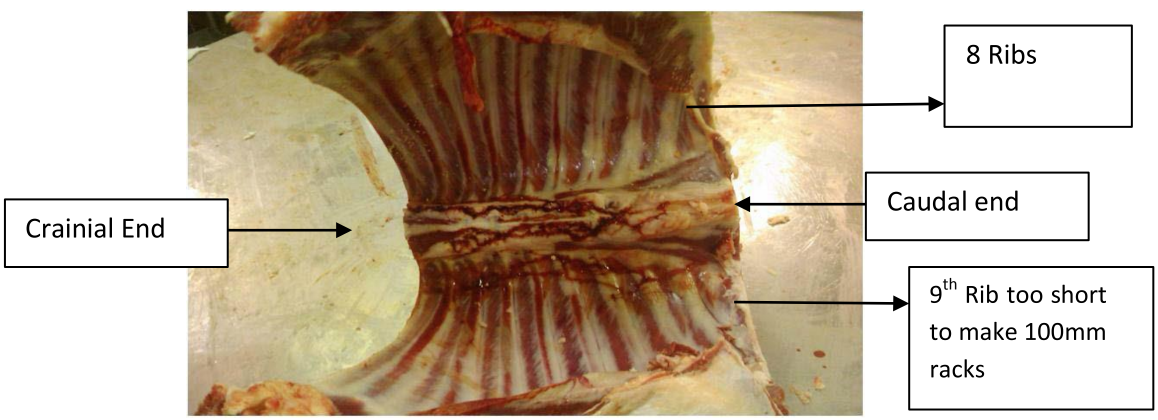

Figure 11: 8 rib rack cut with manual bandsaw.

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. Any more ribs than this (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 12).

Figure 12: Bones removed from SLP as only two ribs may remain in bone in short loin.

4.2.2.2 Costing

Again the costings shown in Table 7 will not apply to every situation. Provision is made in the model to customise costings to an individual plant.

Table 7: Costings used to calculate inaccuracies in the manual cutting of the primal cut between the Rack and SLP

RACK			
(-2 Ribs) 2 ribs short on rack			
Loss of Rack value		Increase value of SLP	
Weight of 6 rib rack (kg)	0.395	Loss of bone to waste	
Standard Value	$7.51	Weight of bone	0.038
Discount Value	$6.01	Value as Rack	$0.73
Discount Cost	$1.50	Value as Render	$0.01
		Lost value of bone	$0.72
		Increased value of loin	
		Increased Weight of loin	0.064
		Value as Rack	$1.22
		Value as Boneless back strap	$1.41
		Increased Loin Value	**$0.19**
		Total lost value of two ribs moving from the Rack to SLP	$0.53
Total lost value of two ribs moving from the Rack to SLP			$2.03

(-1 Ribs) 1 ribs short on rack		
Loss of Rack value	Increase value of SLP	
Loss of 1 Cutlet No Discount applied, for 1 rib short, difference in cutlet value passed to short loin	Loss of bone to waste	
	Weight of bone	0.019
	Value as Rack	$0.36
	Value as Render	$0.00
	Reduced value of bone	**$0.36**
	Increased value of loin	
	Increased Weight of loin	0.032
	Value as Rack	$0.61
	Value as Boneless back strap	$0.71
	Increased Loin Value	**$0.10**
Total lost value of two ribs moving from the Rack to SLP		$0.26

(+1 Ribs) 1 ribs Long on rack			
Increased value to Rack		Loss of Value to SLP	
Increased weight of Rack	0.047	Loss of Loin from Blackstrap	
Value as trim	$0.13	weight of Loin	0.032
		Value as Rack	$0.71
		Value as Render	$0.00
		Reduced value short loin	**$0.71**
		Increased value of loin	
Value Gain			$0.58

** Please see Appendices Section 7.1.3 Table 23 for weights used for bone and muscle.

4.2.2.3 Results

Table 8: Shows the value opportunity that was observed for increasing the accuracy of the cut between the rack and the short loin pair. As mentioned previously the automated cutting system that was observed did not currently have this cut operational, however this cut will be available on future automated primal cutting systems. Of the 220 observations and based on a daily production of 2200hd a value opportunity of $0.13 / hd is identified if an accuracy of 100% is achieved.

Table 8: Current cost of cutting inaccuracies between rack and short loin pair

	Manual		NO X-Ray data available		% Difference	
FQ - Mid	No Obs	%	No Obs	%	%	Cost
-2	0	0.63%		0.00%	0.63%	$2.03
-1	19	18.13%		0.00%	18.13%	$0.26
0	185	68.75%		100.00%	-31.25%	$0.00
1	25	12.50%		0.00%	12.50%	$0.58
2	0	0.00%		0.00%	0.00%	$0.00
Number of observations		229		0		Daily
						Annual
						Per head

4.2.3 Third cut (Loin – Hindquarter cut)

4.2.3.1 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.

Accuracy of the leg cut was largely assed 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 lumbrosacral 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 13). Figure 14 shows where the tip of the ilium bone cartilage is just visible on the cut surface of the leg.

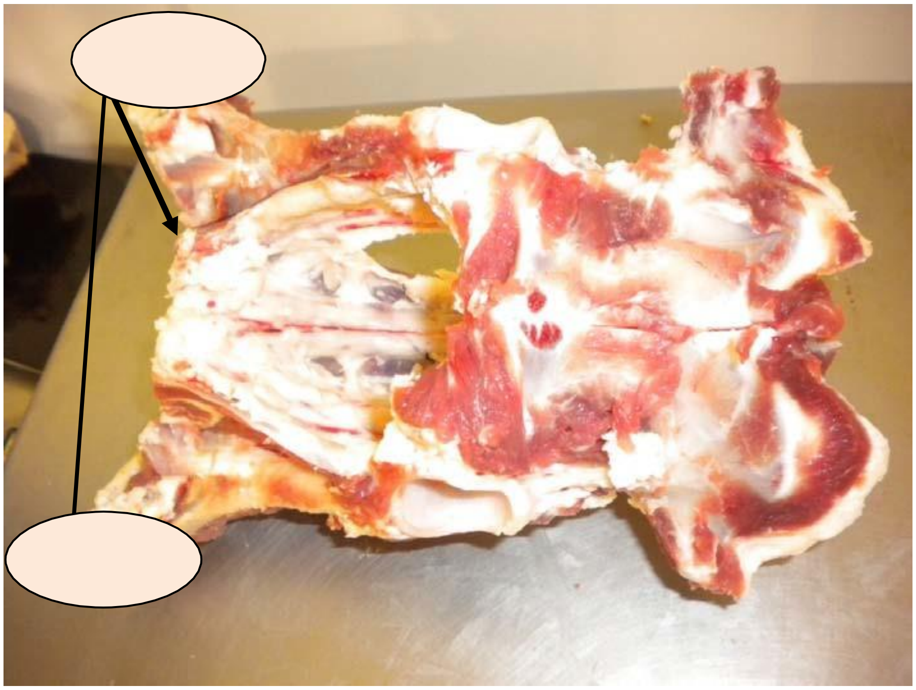

Figure 13: Correct cutting line between hindquarter and loin.

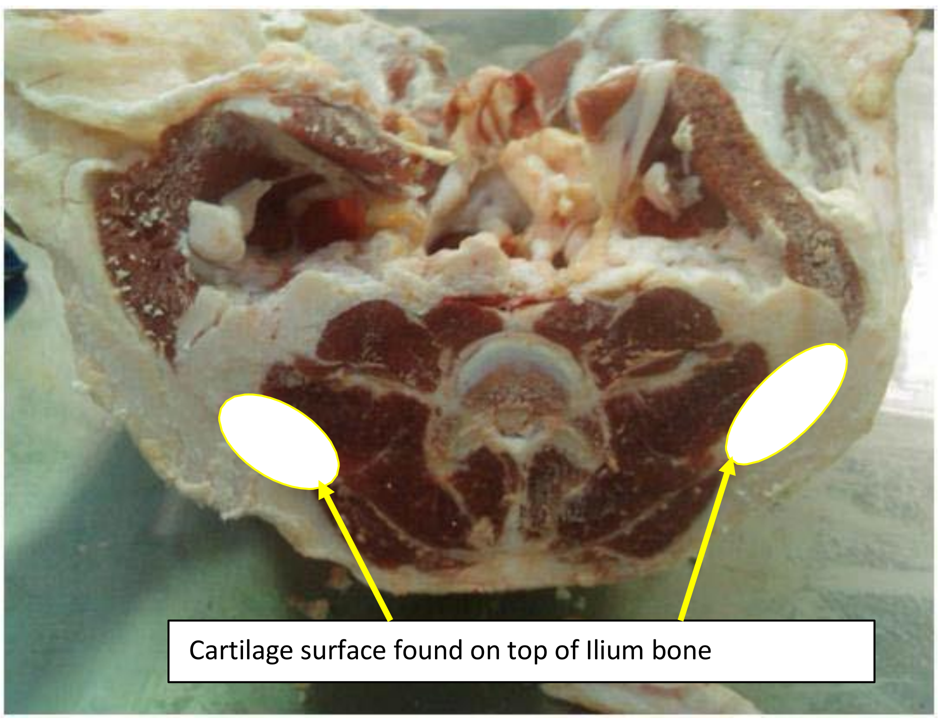

Figure 14: 100% accurate cutting line: Un-boned hindquarter with bone still remaining

Figure 15 illustrates a boneless back strap from the caudal edge.   The section highlighted in the image shows some cartilage from the atich 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, there would however be an increased labour cost to trim the boneless loin.

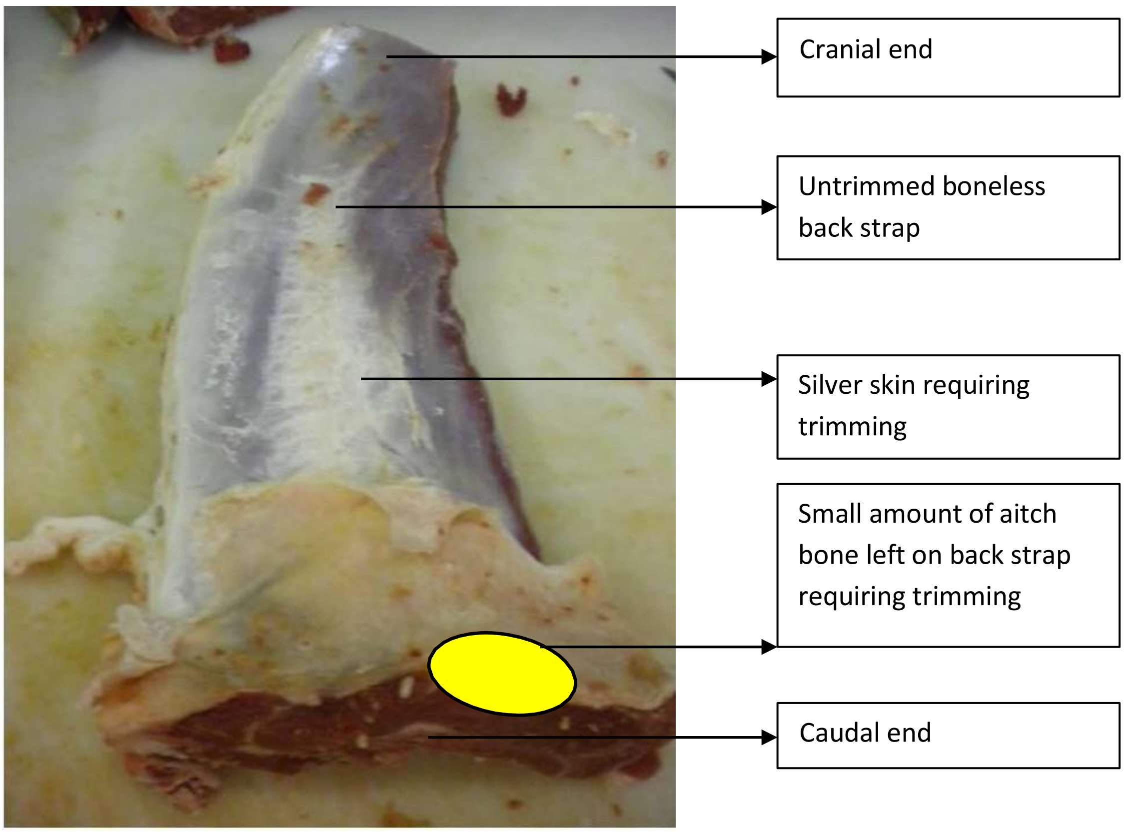

Figure 15: Boneless back strap showing small amount of aitch bone cartilage left on the surface of the muscle.

The following images (Figure 16, Figure 17 & Figure 18) 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 16: Aitch bone showing cut where leg is long, and loin would be short, knife edge marks correct cutting line

Figure 17: Same aitch bone with trim removed

Figure 18: Loin muscle recovered from the aitch bone after fat was trimmed.

4.2.3.2 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.

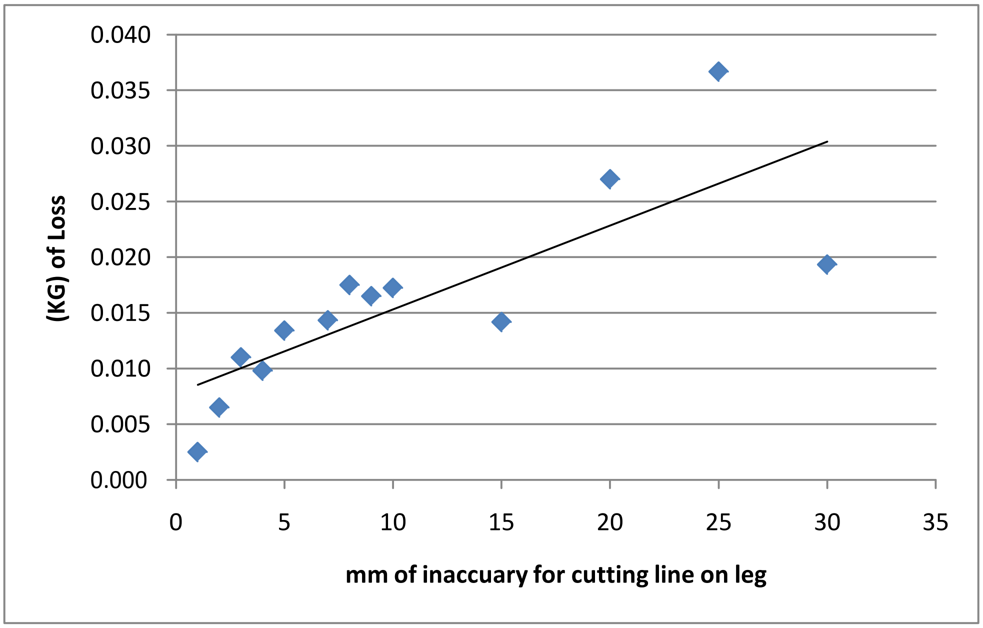

Figure 19: Average weight of loin recovered from aitch bone based on mm of cutting line inaccuracy

4.2.3.3 Results

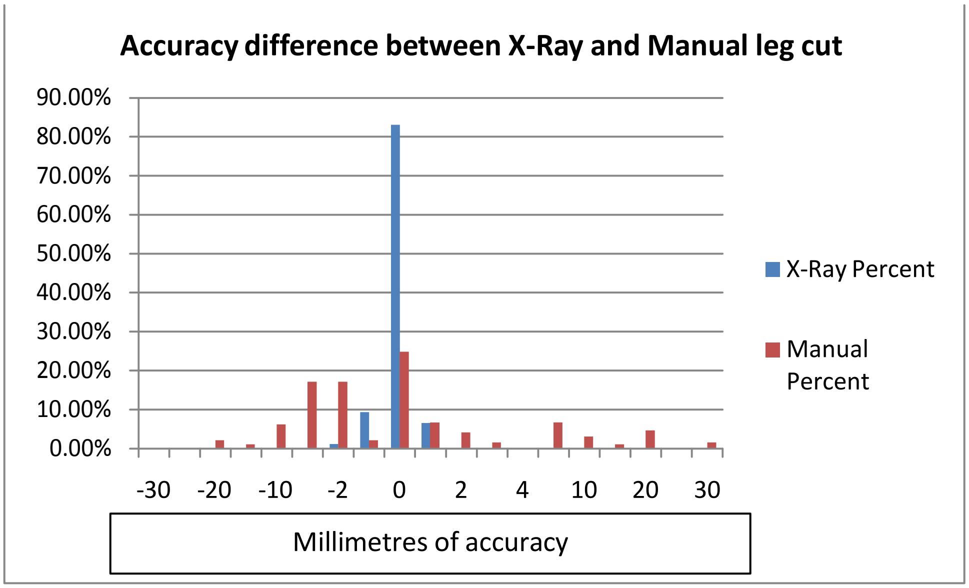

Figure 20: Survey results showing level of cutting accuracy for Loin – Leg cut under manual band saw operating conditions

Table 9 is used to illustrate the cost of inaccuracies shown in Figure 20, 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 percent occurrence where the leg was long with X-Ray cutting systems was then subtracted from the manual percent 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.

Table 9: Costing inaccuracy of cutting leg primal long

Value opportunity of increased accuracy of leg cut using X-Ray cutting system									
mm Accuracy	Manual Percent	X-Ray Percent	% Difference	Kg /side	Kg /hd	Value as render	True Value	Saving	Daily Cost based on % occurrence
-30	0.00%	0.00%	0.00%	0.000	0.000	$0.000	$0.000	$0.000	$0.00
-25	0.00%	0.00%	0.00%	0.000	0.000	$0.000	$0.000	$0.000	$0.00
-20	2.07%	0.00%	2.07%	0.000	0.000	$0.000	$0.000	$0.000	$0.00
-15	1.04%	0.00%	1.04%	0.000	0.000	$0.000	$0.000	$0.000	$0.00
-10	6.22%	0.00%	6.22%	0.000	0.000	$0.000	$0.000	$0.000	$0.00
-5	17.10%	0.00%	17.10%	0.000	0.000	$0.000	$0.000	$0.000	$0.00
-2	17.10%	1.09%	16.01%	0.000	0.000	$0.000	$0.000	$0.000	$0.00
-1	2.07%	9.29%	-7.22%	0.000	0.000	$0.000	$0.000	$0.000	$0.00
0	24.87%	83.06%	-58.19%	0.000	0.000	$0.000	$0.000	$0.000	$0.00
1	6.74%	6.56%	0.18%	0.003	0.005	$0.001	$0.110	$0.109	$0.43
2	4.15%	0.00%	4.15%	0.007	0.013	$0.002	$0.286	$0.284	$25.90
3	1.55%	0.00%	1.55%	0.011	0.022	$0.004	$0.484	$0.480	$16.44
4	0.00%	0.00%	0.00%	0.010	0.000	$0.000	$0.000	$0.000	$0.00
5	6.74%	0.00%	6.74%	0.013	0.027	$0.004	$0.590	$0.586	$86.81
10	3.11%	0.00%	3.11%	0.017	0.034	$0.006	$0.759	$0.753	$51.52
15	1.04%	0.00%	1.04%	0.014	0.028	$0.005	$0.623	$0.619	$14.11
20	4.66%	0.00%	4.66%	0.027	0.054	$0.009	$1.188	$1.179	$121.04
25	0.00%	0.00%	0.00%	0.037	0.073	$0.012	$1.613	$1.602	$0.00
30	1.55%	0.00%	1.55%	0.019	0.039	$0.006	$0.851	$0.844	$28.89
				Total Daily Cost					$345.13
				Annual Cost					$91,460.14
				Cost per head					$0.16
				Saving / hd based on % chump on leg					$0.16

4.3 Scallop cut

Figure 21 illustrates the two locations where loin can be recovered from the aitch bone with the use of the 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.

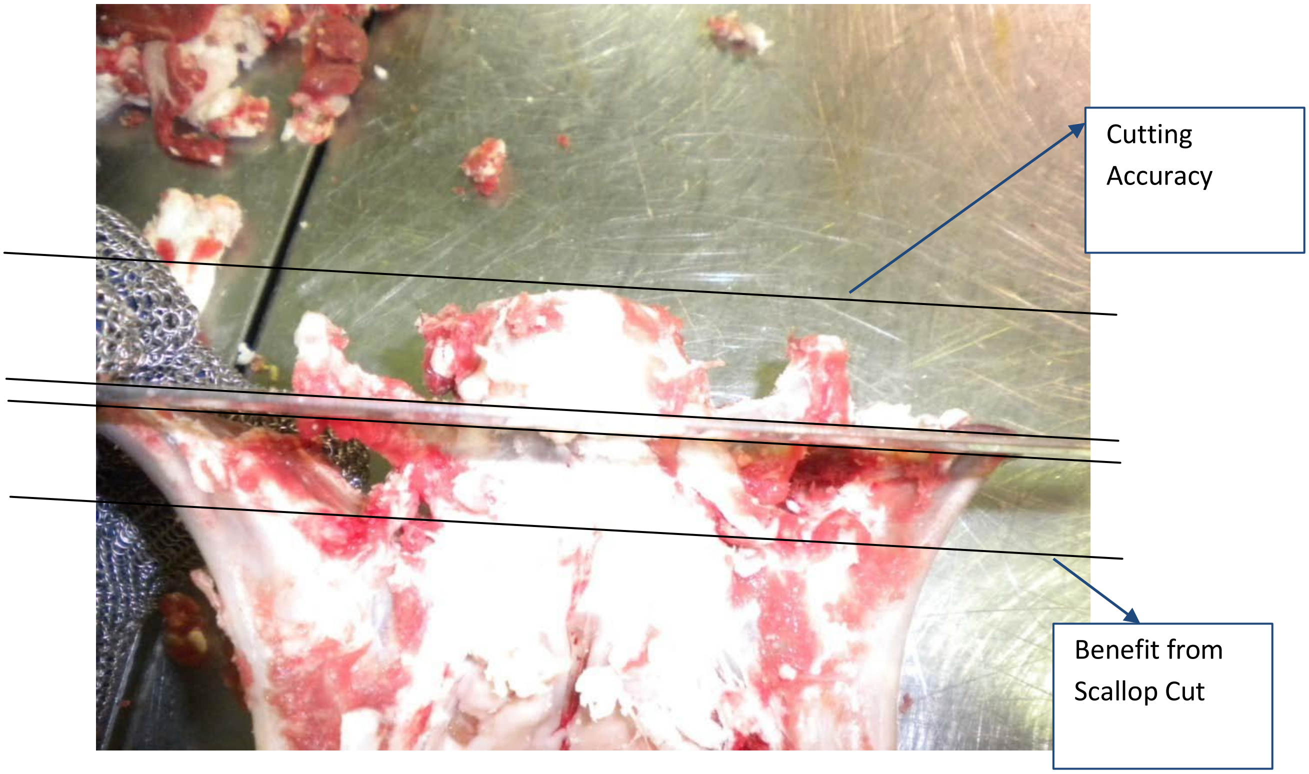

Figure 21: Aitch bone showing value opportunity for increased accuracy in cutting lines, and also value opportunity technical advantageous achievable with the scallop cut.

Figure 22: Shape of scallop cut, note greater loin recovery from aitch bone.

Figure 23: 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 23 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 aitchbones cut using the standard cutting method. Recovery averaged 74 grams per aitch bone. Aitch bones were then 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 19). For the current analysis a saving of 20grams per side is assumed.

Table 10: 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 Back Strap		$0.79
Daily		1,730.36
	Annual	458,544.60

** See Heading "Market Specification in Table 19 for an explanation on why total value per head is calculated on $0.79 per head and not $0.87/ hd.

4.4 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 / carcass across two different manual processing plants (Table 11). 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 three 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 11 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		$295.85
Value per annum		$78,400.44
	2 cuts	$0.09

Value per hd	3 cuts	$0.13

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

Figure 24: Lamb hindquarter cut with the leap3 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 12) due to improved visual appearance of the product and increased shelf life.

Table 12: 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)*

4.6 Increased efficiencies on existing labour

The main assumption behind increased efficiencies for existing labour is more consistent throughput of product through the boning room. Currently the bandsaw operator is responsible for setting the speed at which the lamb carcasses enter the processing belt. While each rotation currently processed the specified number of carcasses in a given time period, large variations in the processing speed can occur during the rotation. This can lead to labours either operating at less than optimum speeds, or build up of product where operators are not able to keep up.

One of the main advantages of the automated primal cutting equipment identified by the boning room supervisor where the equipment was running commercially 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. The main driver for the reduced labour cost per kg shown in Table 14 is the assumption in the model drivers that consistency in product flow will result in an increased labour efficiency of 4%.

Table 13: Manning of processing room

Manning Costs of processing room					Loading		20.00%
Task	Number labour units	hr Rate	Cost per hr	Cost per day	Loading	Cost /hr	Cost / day
Supervisor	1	$34.00	$34.00	$238.00	$40.80	$40.80	$285.60
QA	1	$30.00	$30.00	$210.00	$36.00	$36.00	$252.00
Cold room	2	$22.00	$44.00	$308.00	$26.40	$52.80	$369.60
Inspection	2	$22.00	$44.00	$308.00	$26.40	$52.80	$369.60
Band Saw	3	$28.00	$84.00	$588.00	$33.60	$100.80	$705.60
Bonner	2	$27.00	$54.00	$378.00	$32.40	$64.80	$453.60
Knife hand	20	$23.36	$467.20	$3,270.40	$28.03	$560.64	$3,924.48
Trimmers	7	$23.36	$163.52	$1,144.64	$28.03	$196.22	$1,373.57
Packer	8	$23.12	$184.96	$1,294.72	$27.74	$221.95	$1,553.66
Gen Labor	6	$23.12	$138.72	$971.04	$27.74	$166.46	$1,165.25
Maintenance	1	$19.85	$19.85	$138.95	$23.82	$23.82	$166.74
Total	52.0		$1,264.25	$8,849.75		$1517.10	$10,619.70

Table 14: Increase in existing labour due to consistent product flow through the boning room.

Increased processing / person		
Average Daily head processed		2,201
Average kg		24.0
Average Kg boned per day		52,819
Boning room cost / day		$8,849.75
Labor cost \ per kg to bone		$0.17
Labor cost \ per hd to bone		$4.02
New kg boned per day (due to greater efficiency of existing labor		54,932
New Labor cost \ per kg to bone		$0.16
New Labor cost \ per hd to bone		$3.87
Saving per head		$0.15
Annaul Saving		$90,199.38

In the cost benefit results, consideration is given to the impact of being able to increase the processing capacity of the plant due to increased cutting speed of the equipment. It is important to make the distinction the current benefit outlined here is in relation to the efficiency of existing labour costs, and is not accounting for increased capacity of the processing plant.

4.7 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 15).

Table 15: OH&S Benefits of automated X-Ray Lamb primal cutting

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		$3,000.00
Annual Cost		$10,000.00
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		$3,000.00
Annual Cost		$15,000.00
Annual Saving per head		$0.03
TOTAL OH&S Benefit		$0.04

4.8 Labour Savings

The data displayed in Table 16 shows a saving of 3 labour units for band saw operators, and no savings for bone scrapers. Again this data would need to be customized for each different analysis context. Two point six bandsaw labour units results in a saving of $0.28 per head, or 16% of the total benefit provided by the automated primal cutting equipment.

Table 16: Labour savings achieved with automated X-Ray Primal cutting equipment

Labor Savings with X-Ray Primal cutter		
Number band saw labor units saved		2.6
Hourly Rate		$33.60
Hourly savings		$87.36
Daily		$611.52
Annual		$162,052.80
Band saw saving per head		$0.28
Saving in bone scrapers		2.0
Hourly rate		$23.8
Hourly Cost		$47.6
Daily Cost		$333.5
Annual cost of Bone Scraper		$88,372.20
Bone scraping savings per hd		$0.15
Total Annual saving		$250,425.00
Saving per head		$0.43

4.9 Equipment Costs

Table 17 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 17: Estimated capital, and operational costs of automated X-Ray primal cutting equipment

RTL Automated X-Ray Primal Cut Costs				
List Item	**Total Cost**	**Annual cost**	**Current hd**	**New Processing rate**
Equipment purchase Price	$1,800,000	$180,000	$0.31	
Installation costs	$180,000			
Sub Total - Capital Costs	**$1,980,000**	**$198,000**	**$0.34**	**$0.27**
Maintenance Costs		$40,000	$0.07	$0.07
Service Contract		$30,000	$0.05	$0.04
Risk of down time		$15,171	$0.03	$0.02
Sub Total - Non Captial costs			$0.15	$0.13

4.9.1 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 with the existing plant. At a generic level an indicative 10% of the total cost of the equipment has been allowed for onsite modifications and installations costs. The capital cost per head processed will reduce as the total annual number of head processed increases.

4.9.2 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 refers to an agreement that would exist between the plant and the manufacturing company and would cover 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.

4.9.3 Risk of down time

Table 18 shows the calculation used to estimate the cost of down time. 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 13) 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 18: Estimated cost of down time

Risk of down time	
Weekly down time (hr's)	0.25
Hourly labor cost for boning room	$1,264.25
Weekly Cost	$316.06
Annual Cost	$15,171.00
Cost per head	$0.03

5 Cost Benefit Results

Based on the calculations shown in Section 4, the following section firstly explains variable drivers that can be used to adjust the model, and provides the summary results of the cost benefit analysis using the drivers shown in Table 19.

5.1 Drivers used in CBA analysis

The purpose of Table 19 is firstly to explain drivers that can be used to adjust the model parameters to best represent a given situation; secondly the numbers shown in this table represent the settings used for the analysis results shown under headings 5.2 and 5.3.

Table 19: Model Drivers and description

DRIVER TITLE	Actual drivers used in excel model		DESCRIPTION OF MODEL DRIVER	
Processing rates				
	Current	New	Current	New
Cutting speed hd / min	5.24	6.50	Select the correct number of head per minute that processing room currently runs at	Selected expected increased in processing rate with installation of automated primal cutter
Saw speed hd / hr	314	390	Calculation: do not change (= hd/min x 60)	
Room speed hd/hr	314	NA	Calculation: do not change (with processing rooms currently running with more than one band saw)	NA (analysis only applies to the installation of one automated primal cutting system)
Shifts / day	1	1		
Saw Blade run time (min)	420	420	Select the number of minutes that processing room will be running for	Select new min of run time If processing time is going to be extended once the new primal cutting equipment is installed
Hrs / Shift 1	7.00	7.00	Calculation; do not change (Based on band saw run time, any time over 480 minutes will be applied to the second shift)	
Hrs / Shift 2	0.00	0.00	Calculation; do not change (any band saw run time over 480 minutes is applied to the second shift).	
No hd processed / day	2201	2730		
Annual days	265	265	Enter the number of days per year the plant is operational	
Annual # of hd processed	583,212	723,450	Calculation, do not change. Number of head being processed annually based on processing parameters above	

DRIVER TITLE	Actual drivers used in excel model	DESCRIPTION OF MODEL DRIVER
Life Span of equipment		
Life expectancy (yrs)	**10**	Select the number of years that the equipment is expected to be in operation for. This value is used to calculate annual cost of capital (straight line depreciation) and the number of years used in the calculation of NPV
Existing Cutting system		
Existing Cutting system	**Band Saw**	Existing cutting system determines the base line for calculating the value that automated primal cutting equipment can provide the lamb processing plant. (circular saw, has less bone dust, higher accuracy, and safer compared to band saw) IMPORTANT!! Ensure "Baseline data" is set to GLE data to observe difference in cutting systems
Number of existing band saw stations	**1**	Used for calculating the existing number of head being processed and labour savings.
Number of cuts required	**3**	Select the number of cuts that the primal cutting system will be required to perform
Carcass Specification		
Average Carcasses weight (kg)	**24.00**	Select the average annual weight of carcasses processed in the plant. (main purpose for this driver is to estimated the number of kg processed in the room)
Reduced cutting costs		
Number of band saw operators saved	**2.6**	Select the estimated number of band saw operators that will be saved (also check band saw operator hourly rate on benefit calculations page) Labour saving
Number of bone scrapers saved	**2.00**	Select the estimated number of bone scrapers that will be saved (also check bone scraper hourly rate on benefit calculations page)
Reduced labour cost per kg to increased labour efficiency	**4.00%**	Eliminating fluctuations in the processing speed reduces pressure on critical limiting factors, and eliminates the number of stop-start during processing room operation, hence increase the efficiency of existing labour
Market Specification		
Base Line data	**GLE Data**	Select GLE data to use Greenleaf trial results, or select "other " to manually adjust **cutting accuracies** and the **calculation of costings** according to different market specifications or plant specific drivers (use "different costing" for customization)

DRIVER TITLE	Actual drivers used in excel model	DESCRIPTION OF MODEL DRIVER
% of Annual hd processed as boneless back strap	**90%**	Select the % of total annual production that is processed as Boneless Back strap. Benefits achieved through the scallop cut are only applied to annual % of processing that is sold as boneless back strap
Expected kg yield gain for scallop cut /SIDE based on markets acceptance	**0.020**	Select the yield benefit from the scallop cut that will achieve boneless back strap price (If unsure of how markets will respond to angled edge of boneless back strap reduce the amount of yield achieved relative to the amount of trimming that occurs to the loin)
Increase in Loin yield per head	**0.034**	Calculation: do not change (above loin benefit x2 = gain / hd)
Production quality benefit drivers		
Current % of product discounted at retail level	**4%**	Select current estimated level of discounting of product that occurs at the retail level
Reduced discount - increased shelf life	**10%**	Select the amount by which current retail discounting will reduce. Reduced discounts are assumed through increased sales (visual appearance), and increased shelf life (reduced bacterial loading).
New portion of production discounted	**3.6%**	Select the average discount rate applied to discounted product (major retailers will often start discounting at 20%)
Average amount prices are discounted by	**20 %**	Select the average discount rate applied to discounted product (major retailers will often start discounting at 20%)
Finance		
Discount rate for NPV calculation	**7%**	NPV calculations for equipment investments should include the cost of the capital in the first year of the investment. Select YES to include cost of capital in the first year.
Include equipment cost in year 1 of NPV?	**YES**	NPV calculations for equipment investments should include the cost of the capital in the first year of the investment. Select YES to include cost of capital in the first year.
Cost of equipment	**$1,800,000**	Enter price quoted from manufacture
Infrastructure costs for robot install	**$180,000**	Enter the capital required for site specific changes to install the automated primal cutting equipment (Generic assumes 10% of equipment cost).
TOTAL INITIAL INVESTMENT	**1,980,000**	Calculation: do not change

5.2 Summary of Costs and Benefits

The combined results for the different benefits and costs associated with the installation of the X-Ray cutting primal system in a "generic" processing plant are shown in Table 20. Based on the drivers selected for the current analysis the gross benefit of the equipment is estimated at $2.26/hd, and a cost of $0.49/hd. This result shows an estimated average net benefit of $1.78 for every head processed through the equipment (including the cost of capital).

Table 20: Summary results of individual costs and benefits associated with automated X-Ray primal cutting of lamb carcasses

COST - BENEFIT ANALYSIS OF X-RAY PRIMAL CUTTING EQUIPMENT					
		Current production		Increase in rate	
Numbers of head processed per annum		hd/yr	583,212		723,450
Accuracy of cut	1.1: 1st cut FQ : loin	$0.11	$63,015	0.11	$78,168
	1.2: 2nd cut Rack : SLP	$0.13	$77,481	0.13	$96,112
	1.3: 3rd cut Loin : HQ	$0.16	$91,460	0.16	$113,452
Cutting Technique	1.4: Scallop cut	$0.79	$458,545	0.79	$568,805
	1.5Saw dust yield loss	$0.13	$78,400	0.13	$97,252
	1.6 Shelf life	$0.20	$113,890	0.20	$141,275
2.1 Increase in labor efficiency		$0.16	$93,314	0.16	$115,752
2.2 OH&S savings		$0.16	$93,314	0.16	$115,752
2.3 Labor savings		$0.43	$250,425	0.43	$310,642
$ Benefit per head		**$2.26**	**$1,319,844**	**2.26**	**$1,637,211**
Capital cost		$0.34	$198,000	0.27	$198,000
Maintenance		$0.07	$40,000	0.07	$49,618
Service Agreement		$0.05	$30,000	0.04	$30,000
Risk of product damage		$0.00	$0	0.00	$0
Risk of down time		$0.03	$15,171	0.02	$15,171
Total cost per head		$0.49	$283,171	0.40	$292,789
Total net $ benefit per head		$1.78	1,036,673	1.86	$1,344,422

5.3 Financial viability of equipment

Application of this equipment to any given plant will have something of a different impact, however based on the drivers shown in Table 19 the following analysis provides a net annual return to the plant of approximately $1,200,000 excluding the cost of capital. Considering an initial total cost of investment of $1,980,000, this delivers a payback period of 1.6 years or 19 months 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 $8,947,328.

Finally, one of the benefits not yet outlined of the equipment is the anticipated increase in speed at which the processing plant will be able to operate. Current manual primal cutting speed is approximately 5.24 hd / minute, however the automated equipment that is in current commercial operation is running at a speed of 10 hd/ minute, for two cuts (1st cut and the 3rd cut outlined in Figure 2 and Figure 3). Using the existing configuration of the equipment to perform 3 cuts, it is expected that the cutting system will have a minimum operational speed 7.5 hd/ minute. Obviously the processing plant needs to have the existing capacity to increase overall production (trimming – packaging – chill/ freeze – load out). However by 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 can be achieved. This results in an increased net benefit with the equipment, and in the anticipated payback period for the investment.

Table 21: Summary financial results for the installation of RTL Automated X-Ray primal cutting system.

SUMMARY PERFORMANCE MEASURES				
Hd/yr	583,212		Hd/yr	723,450
%increase in production with new equipment installed			24.05%	
Capital cost (payment option, upfront	$1,980,000		$1,980,000	
Gross return Per head	$2.26		$2.26	
Total costs Per head	$0.49		$0.40	
Net Benefit Per head	$1.78		$1.86	
Annual Net Benefit (including Cap ex)	$1,036,673		$1,344,422	
Annual Net Benefit (excluding cap ex)	$1,234,673		$1,542,422	
Pay back (years - months)	1.60	19	1.28	15
Net Present Value of investment	$8,947,328		$11,638,735	

5.4 Net Present Value over different time periods

As an overall summary Table 22 shows the Net Present values of the investment at the various time periods that the equipment could operate for. The difference between current processing capacity and anticipated increase of 24% in processing capacity is also shown. Note useful working life of the equipment is estimated at 10 years, and continued use of this equipment past this time period would likely result in costs not contained in the analysis.

Table 22: Net Present value of investment in automated lamb primal cutting equipment for different time periods (based on an initial investment of $1,980,000, and a discount rate of 7%)

	Current Processing rate	New Processing rate
NPV (5 yrs)	$3,211,936.77	$4,473,767.63
NPV (6 yrs)	$4,034,651.68	$5,501,548.57
NPV (7 yrs)	$4,803,544.12	$6,462,091.50
NPV (8 yrs)	$5,522,135.19	$7,359,795.18
NPV (9 yrs)	$6,193,715.63	$8,198,770.57
NPV (10 yrs)	$6,821,360.90	$8,982,859.73
NPV (11 yrs)	$7,407,945.26	$9,715,653.33
NPV (12 yrs)	$7,956,154.94	$10,400,507.17
NPV (13 yrs)	$8,468,500.44	$11,040,557.48
NPV (14 yrs)	$8,947,328.01	$11,638,735.34
NPV (15 yrs)	$9,394,830.42	$12,197,780.08
NPV (16 yrs)	$9,813,056.96	$12,720,251.79
NPV (17 yrs)	$10,203,922.89	$13,208,543.11
NPV (18 yrs)	$10,569,218.15	$13,664,890.14
NPV (19 yrs)	$10,910,615.59	$14,091,382.68
NPV (20 yrs)	$11,229,678.62	$14,489,973.85

6 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>

7 Appendices

7.1.1 List of Tables

7.1.2 List of Figures

7.1.3 Loin Yield weights

Table 23: Weights used for costing analysis

#	Total	fat	meat	Fat + Meat	Bone	% nonbone
1	0.061	0.016	0.027	0.042	0.023	0.646
2	0.060	0.010	0.028	0.037	0.022	0.627
3	0.073	0.016	0.036	0.052	0.020	0.722
4	0.069	0.012	0.037	0.048	0.017	0.738
5	0.083	0.026	0.037	0.063	0.020	0.759
6	0.079	0.022	0.040	0.060	0.020	0.750
7	0.080	0.021	0.040	0.062	0.018	0.775
8	0.044	0.006	0.024	0.030	0.015	0.667
9	0.045	0.007	0.020	0.027	0.017	0.614
sum	0.594	0.136	0.289	0.421	0.172	
Avg	**0.066**	**0.015**	**0.032**	**0.047**	**0.019**	**69.98%**
StDev	0.015	0.007	0.007	0.014	0.003	6.16%
min	0.044	0.006	0.02	0.027	0.015	61.36%
max	0.083	0.026	0.04	0.063	0.023	77.50%
Diff	0.039	0.02	0.02	0.036	0.008	16.14%