final report

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Ex-ante scoping options for automated ovine shoulder breakup

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Abstract

As part of project A.CIS.0034 that was to conduct an ex-ante study of the LEAP IV Middle primal machine a preliminary investigation was requested to scope out options for an automated machine to break up the shoulder primal of ovine carcasses. The concept included cutting of neck, brisket and shank, and splitting of the square cut shoulder. The scoping exercise considered the variability in the shoulder primal from a range of carcase weights. Standards were established to quantify the value of cutting accuracy for each cut and very preliminary cutting accuracy for manual operations were collected. A model was developed to help scope and trial a combination of cutting accuracies, capital costs and throughput rates to identify the performance range required to develop a viable machine with reasonable payback.

This report marks the conclusion of the research and enables what-if-analysis to inform development possibilities that would enhance shoulder breakdown performance.

Contents

1 Background

As part of project A.CIS.0034 that was to conduct an ex-ante study of the LEAP IV Middle primal machine a preliminary investigation was requested to scope out options for an automated machine to break up the shoulder primal of ovine carcasses. The concept included cutting of neck, brisket and shank, and splitting of the square cut shoulder. The scoping exercise considered the variability in the shoulder primal from a range of carcase weights. Standards were established to quantify the value of cutting accuracy for each cut and very preliminary cutting accuracy for manual operations were collected. A model was developed to help scope and trial a combination of cutting accuracies, capital costs and throughput rates to identify the performance range required to develop a viable machine with reasonable payback.

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2 LEAP V Cost Benefit Analysis

The forequarter processing robot receives the primal from the primal cutting station and breaks up the forequarter using the following cuts:

1. Knuckle tipping ($0.07 to $0.12/hd)
2. Brisket bone removal (-$0.45 to -$0.14)
3. Shank Removal (-$0.04 to $0.20)
4. Neck Removal ($0.18 to $0.39)
5. Splitting Shoulders ($0.00 to $0.00)

The data collection for the cost benefit analysis (CBA) was conducted across a very limited data set. The costing methodology involves a two part process including the setup of standard yields to quantify the cost of inaccuracy for each cut. The second part involves the measurement of cut accuracy within the plant to gain the variation in the cut.

The main benefits have been provided as a result of the following:

- Labour Savings
- Yield benefits
- OH & S savings

2.1 Yield Benefits

The yield benefits associated with the automation of the shoulder cuts is mainly contributed to the removal of the brisket and neck. This is due to the variation in the value of cuts between each side of the cutting lines.

2.1.1 Knuckle tipping

Knuckle tipping is a single cut removing the leg bone from the shank above the knuckle joint as shown in Figure 1. The accuracy of this cut is relatively high with only minimal all variation within 10mm of the ideal location of the cut. The value which can be added to the cut could be maximised if the location of the blue line in Figure 1 could be increased within the customer specifications. The current estimations are that the robotic system will add between $0.00 and $0.05/hd.

Figure 1: Removal of knuckle from fore shank

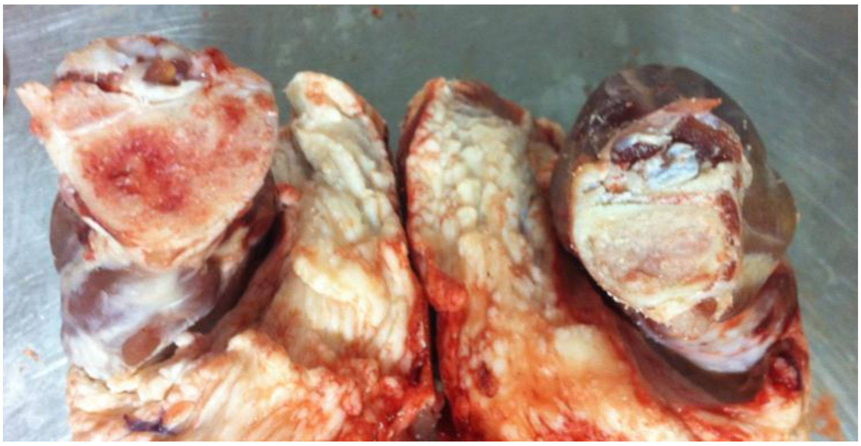

Figure 2: Left knuckle removed at the joint. Right knuckle cut higher up into shank.

2.1.2 Removing Brisket – Strung carcases

Removal of brisket from the forequarter on strung carcases is more difficult than on unstrung carcases. The shoulder robot has to make a straight cut across the full forequarter perpendicular to the midline of the vertebrae. The saw cut through the brisket must leave the elbow joint intact and on some carcases drops down very low on the brisket. The cut removing the brisket is usually parallel to the back. Where the elbow joint is too low the robot angles the cut to remove enough brisket to meet customer specifications as in Figure 3. A maximum of 45mm of brisket is removed, measured from the brisket tip as shown in Figure 4.

Figure 3: Removing brisket without tipping elbow joint sometimes requires angled cut to ensure enough brisket removal

Figure 4: Removal of brisket no more than 45mm from the brisket tip

The value added to the processing chain from the automation of the brisk removal cut has will add between -$0.11 and $0.11/hd. The variation in this cut has moved from -10mm to 10mm either side of the blue line shown in Figure 3.

2.1.3 Removing Shank – Un-strung carcases

Removal of shank is parallel to the back and just through the junction between the shank and the brisket as in Figure 5 below. Shank and brisket should be removed in the same cut with both parts being barely joined as in Figure 6. A range of cutting lines and the resultant weight of each were captured during the trials as in Figure 7. This data will be used in Milestone 3 to quantify the value trade-off and the impact of different cutting accuracies.

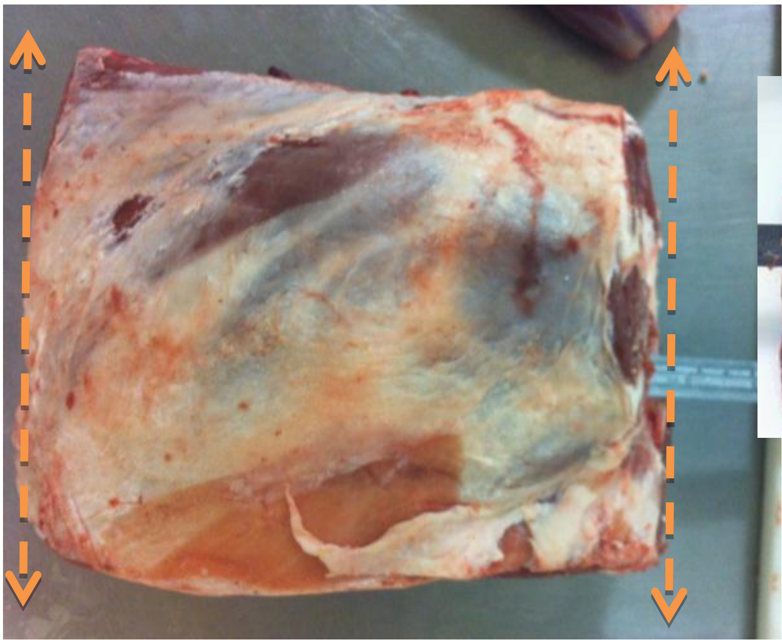

Figure 5: Removal of shank from forequarter parallel to the back

Figure 6: Brisket and shank removed at the point where both attach to the forequarter

Figure 7: Weighing different thickness of shank to establish costing standards for cutting line accuracy to remove shank

The value of this cut will vary between plant to plant depending on the value of shanks and shoulders. It is estimated that the value of automating this cut is between $0.00 and $0.02 per head when the price of shanks is $4.50/kg and shoulders were worth $6.00/kg. The benefit of automating this cut would be to modify the cutting line depending on the value of each cut. The automated solution will allow the specifications to be modified to increase the value of the cut.

2.1.4 Separating neck from square cut shoulder

Separation of the neck from the forequarter should be parallel to the backbone for unstrung carcases and perpendicular to the neck vertebrae for strung carcases. Figure 8 and Figure 9 demonstrate the measures and methods used to weigh and calculate value of cut accuracy.

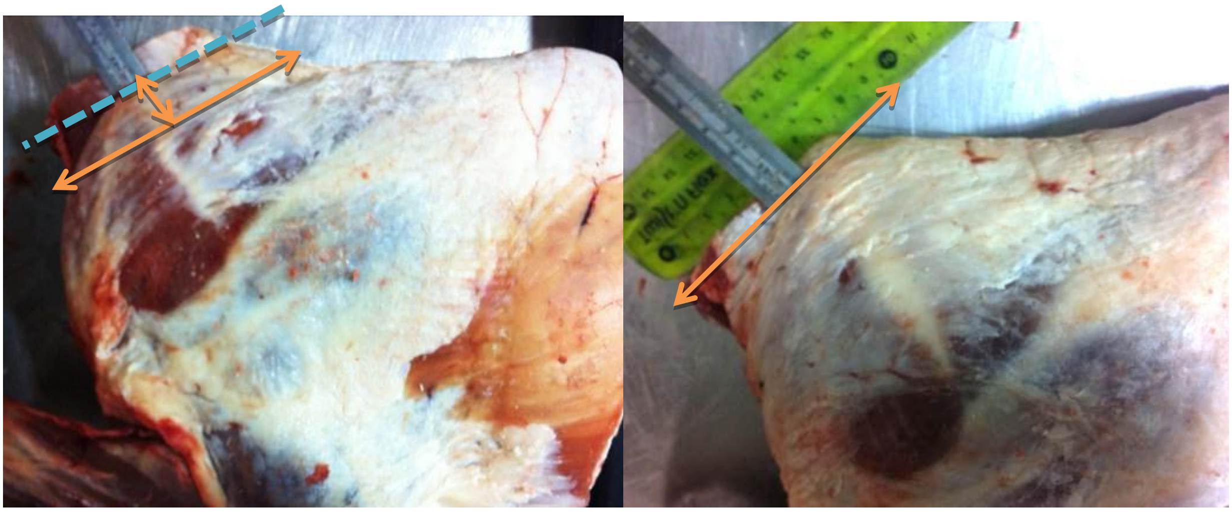

Figure 8: Removal of neck from forequarter perpendicular to neck for unstrung carcases

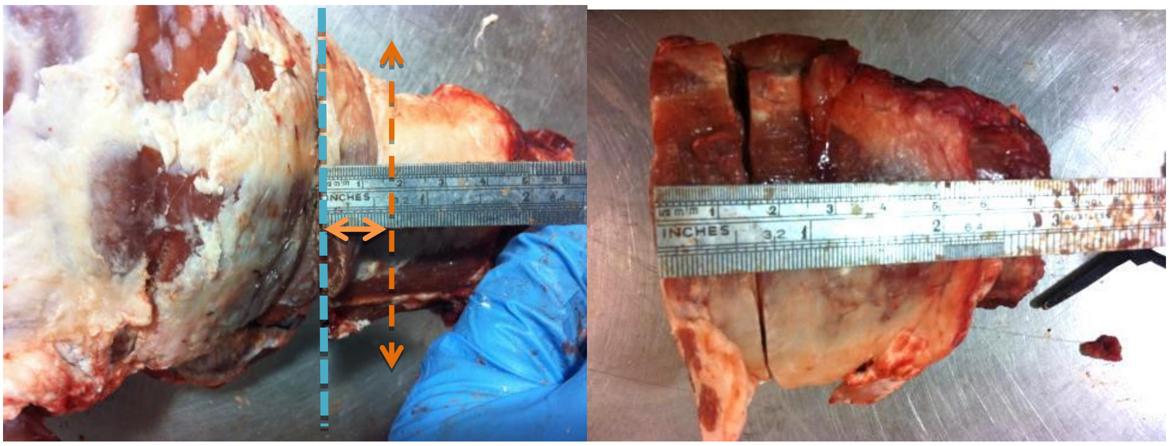

Figure 9: Neck cut accuracy

2.1.5 Shoulder Split

The final cut splitting the left and right sides of the forequarter passes through the spinal column and should separate the vertebrae leaving equal amounts of bone on each primal as in Figure 10. Measurement of cutting accuracy was taken by piecing together left and rights sides of matching shoulders as in Figure 11 and Figure 12. Distance from target was measured at both ends of the cut surface to capture the degree to which cuts angled from parallel.

There will be no value added to this cut as long as the LEAP V robot can prefer the cut within ±5mm from the centre line of the vertebra as both the shoulders are sold at the same value.

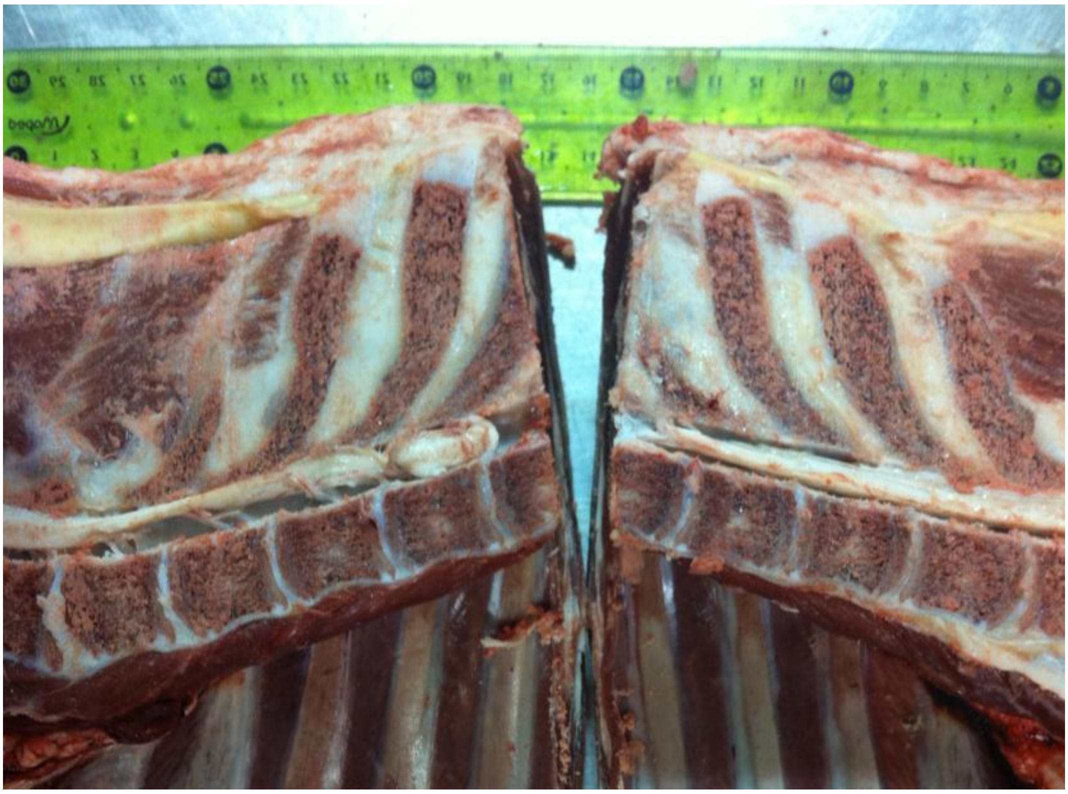

Figure 10: Perfect cutting line leaves equal amounts of spinous process on each primal and spinal column split in half

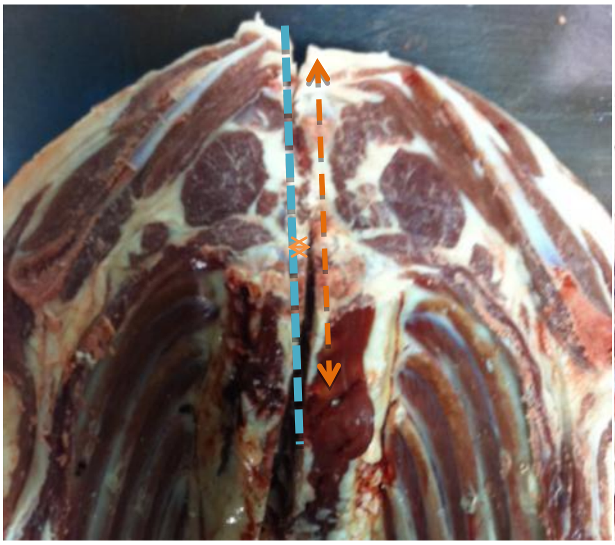

Figure 11: Parallel to cutting line but to left of centre line

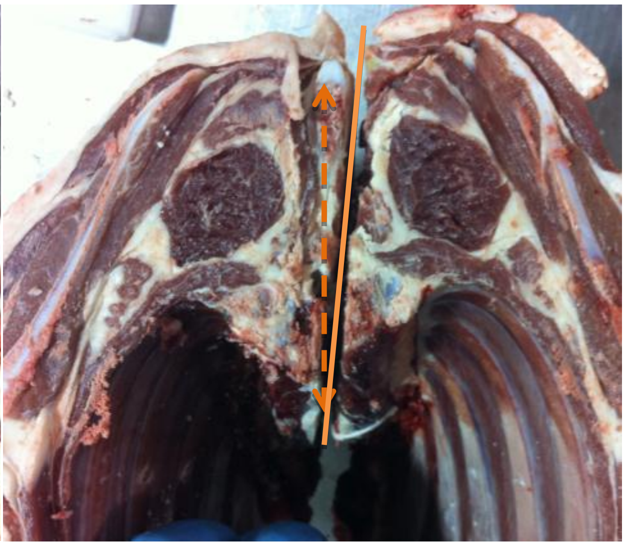

Figure 12: Split through centre of spinal column but off centre at top of spinous processes

In most cases minor miss-splitting of the forequarters does not impact on value. Where the cutting line is off-centre more than 15mm primals do not meet specification and the shoulder needs to be boned out.

Figure 13: Severe soft-siding of forequarter in the right of the photo. Weight of shoulder and bone lost to the opposite primal

2.2 Cost Benefit Results

The increased value came from yield benefits, OH & S savings and labour savings. The summary results in Table 1 demonstrate the performance of the two ex-ante scenarios compared to current manual performance.

The ex-ante net benefit expected for this system was from $0.07/hd to 0.62/hd. This delivers an estimated return on investment of between 0.13 and 2.12 years depending on the accuracy of the automated system.

Table 1: Summary of benefits for the ex-ante assessment

SUMMARY PERFORMANCE MEASURES		
	Ex-Ante	
Hd / annum	2,035,584	
Production increase with equipment	2.06%	
	From	To
Capital cost (pmt option, upfront)	$150,000	
Gross return Per head	$0.09	$0.64
Total costs Per head	$0.02	
Net Benefit Per head	$0.06	$0.61
Annual Net Benefit for the plant	$ 125,123	$ 1,249,243
Annual Net Benefit for the ex cap	$ 106,745	$ 1,230,864
Pay back (years)	1.41	0.12
Net Present Value of investment	$834,169	$8,729,515

The production increase shown in Table 1 is a result of the decrease in labour requirements of the boning room. There may be increases in throughput possible but these have not been factored into the CBA as the system is still in development. The variation used to display these results as the price paid for primals and the variation in number of carcases per year.

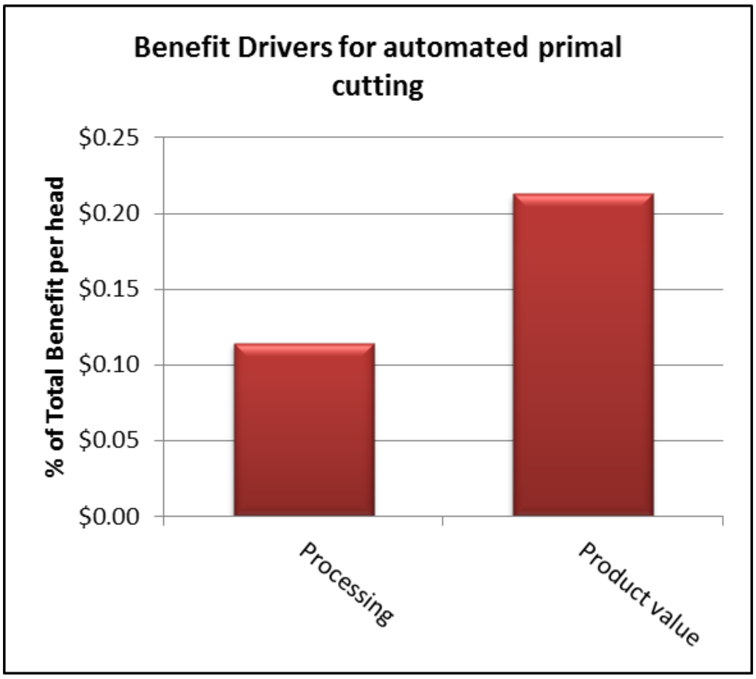

Figure 14: Broad grouping of benefits delivered by the LEAP V solution.

The main benefits of the automated cutting technology are the increase in yield and a reduction in labour units required. Occupational health and safety costs will reduce by removing bandsaws. There may be small yield gains through reduced bandsaw dust and shelf life. The contribution of each individual benefit is summarised in Figure 15 and Table 2.

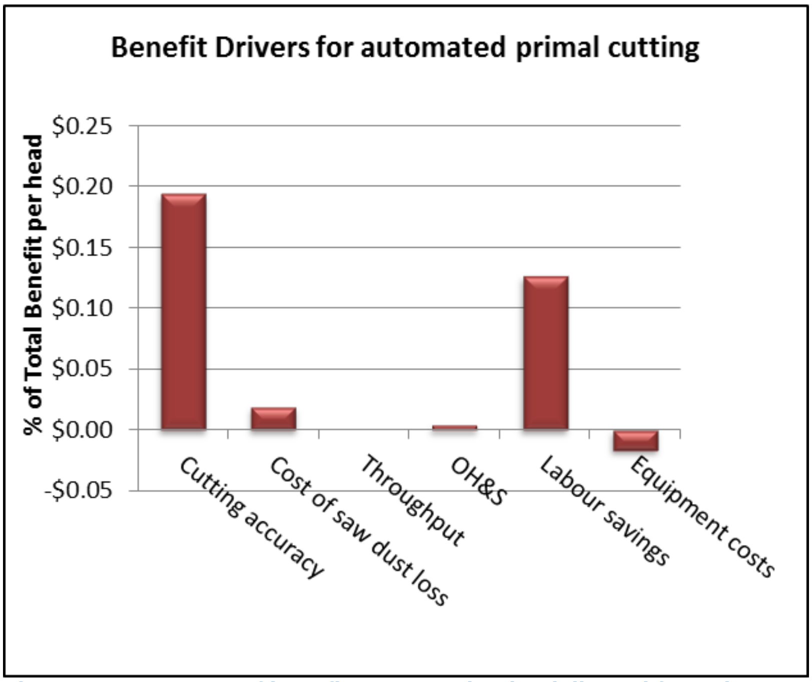

Figure 15: Summary of benefits expected to be delivered from the LEAP V solution.

Table 2: Breakdown of benefits and costs by area

Benefit Drivers for automated primal cutting	Ex-Ante	
	$/ hd	$/ annum
Processing	$0.13	$268,976
Product value	$0.21	$433,207
	$0.34	**$702,183**
Cutting accuracy	$0.19	$394,664
Cost of saw dust loss	$0.02	$38,543
Throughput	$0.00	$0
OH&S	$0.02	$44,000
Labour savings	$0.13	$258,355
Equipment costs	-$0.02	-$33,379
	$0.34	**$702,183**

A summary of the range in costs and benefits for each scenario are included in Table 3 below.

Table 3: Ex-ante costs and benefits breakdown for the ex-ante analysis

COST - BENEFIT ANALYSIS OF ROBOTIC PRIMAL CUTTING EQUIPMENT	Ex-Ante	
Benefit summary	$/hd	
	From	To
$ Accuracy Benefit per head	($0.08)	$0.47
$ Technique Benefit per head	$0.02	$0.02
$ Labour Benefit per head	$0.15	$0.15
$ Automation Costs	($0.02)	($0.02)
$ Overall Benefit per head	**$0.07**	**$0.62**
** Cost is reported as the inaccuracy from target specification OR as the difference between Manual vs. Auto costs*		
COST ASSOCIATED WITH THE EQUIPMENT		
	$/hd	
Capital cost	$0.01	
Maintenance	$0.00	
Operation	$0.00	
Risk of mechanical failure	$0.01	
Total cost per head	$0.02	
Total cost per head (EX CAP)	$0.02	

Table 4 shows the range in value associated with each cost of processing including breakdown of value opportunity for each cutting line. The cost is calculated as any loss from the maximum benefit possible. Throughput cost is the cost of labour for the boning process. Presenting the figures this way in the detailed section of the model demonstrates the total costs involved and highlights areas where future savings could be generated.

Table 4: Summary results of individual costs associated with the LEAP V boning solution

COST DUE TO INACCURACIES AND MANUAL INTERVENTION						
			Manual		Ex-Ante	
Cost summary		% of annual production	$/hd From	$/hd To	$/hd From	$/hd To
1.1 Accuracy	Knuckle Tipping	100%	$0.07	$0.12	$0.00	$0.00
	Brisket removal (Strung carcases)	70%	-$0.11	$0.11	$0.21	$0.21
	Shank Removal (Unstrung carcases)	30%	-$0.03	$0.07	-$0.01	$0.01
	Neck Removal	100%	$0.00	$0.23	-$0.18	-$0.15
	Splitting shoulders	100%	$0.00	$0.00	$0.00	$0.00
1.2 Cutting Technique	Cost of saw dust loss		$0.02	$0.02	$0.00	$0.00
3. OH&S cost			$0.06	$0.06	$0.04	$0.04
4. Labour cost			$0.00	$0.00	-$0.13	-$0.13
Equipment costs	**Maintenance**		$0.00	$0.00	$0.00	$0.00
	Operation		$0.00	$0.00	$0.00	$0.00
	Risk of failure		$0.00	$0.00	$0.01	$0.01
$ Costs per head			**$0.01**	**$0.62**	**-$0.07**	**-$0.01**
$ Benefit per head			**$0.00**	**$0.00**	**$0.09**	**$0.64**
$ Benefit overall plant			**$0**	**$0**	**$27,096**	**$231,511**
$ Annual Costs overall plant			**-$12,908**	**$191,507**	**-$40,004**	**-$40,004**

Figure 16 shows the difference in cost between the systems. Thickness of the box in the graph represents the upper and lower variation in value based on performance variation captured in the data.

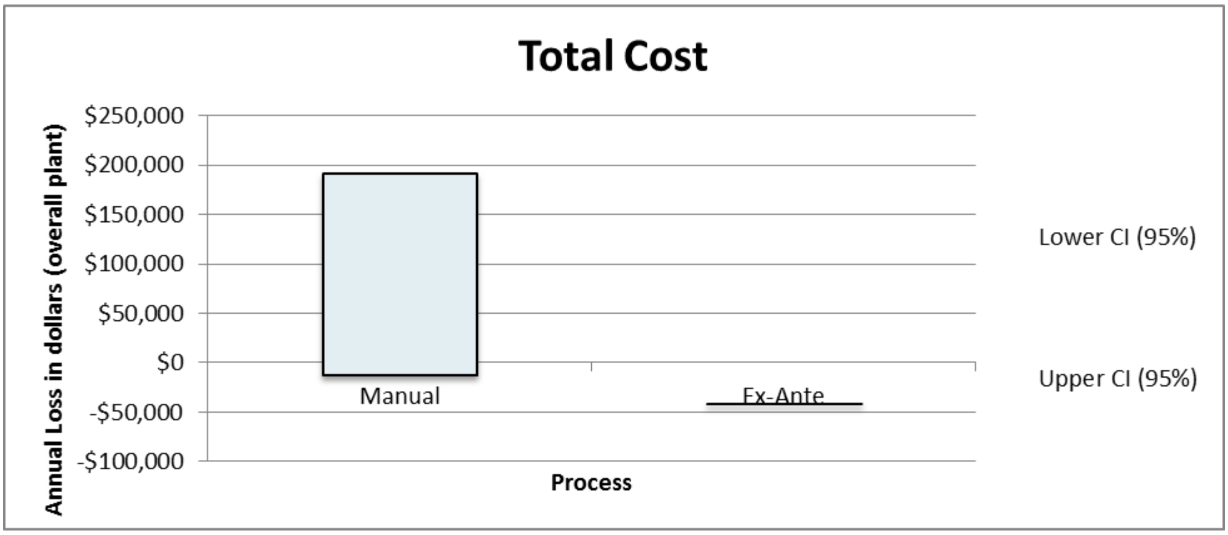

Figure 16: Graphical representation of losses captured in Table 4

2.3 Financial Viability of Equipment

Value of this equipment will vary between plants depending on market specifications and processing speeds. However based on the drivers show in Table 4 the following analysis provides a net annual return of between $27,000 and $231,000 per annum. Considering an initial total cost of investment of $150,000 this delivers a payback period of between 0.13 and 2.12 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 $580,000 to $8.48 million.

2.4 Yield Benefits

The yield benefits displayed in the following section are a result of the measurements collected during the site visit.

2.5 Labour Savings

This plant has an estimated labour savings of $0.13 per head when using the LEAP V solution. The number of staff saved at other plants will depend on the layout of the abattoir's boning room.

2.6 Increased Productivity

There has been no improvement in the efficiency of the boning room factored into the cost benefit analysis as additional factors will affect the ability of the LEAP V system to increases the process flow.

2.7 OH & S Risks

The OH & S issues associated with the current processes include the full range of repetitive strain injuries, minor cuts and amputations.

A major benefit in the application of automation in a high risk task is eliminating the risk of serious human injury.

The following economic analysis considers the cost of limb loss at an estimated 80% chance over a ten year period with an associated total premium cost of $300,000 (NSW WorkCover, Unknown).

Based on the assumptions above, the following frame work in Table 5 shows the OH&S benefits. The estimated OH & S savings that can be achieved through the installation of the automated system is up to $0.02 per head. These costing do not included the trauma which can be caused through amputations as this is very difficult to cost.

Table 5: OH&S Benefits of the LEAP V solution

OH&S					
	Band Saw cutting	Sprain and Strain from lifting			
Job Role Affected	Band Saw operator	3			
Claims in last 10 years	4.0	40.0		Manual	Ex-Ante
Risk / FTE / Year	6.7%	66.7%			
Annual Premium	$300,000	$3,000			
Job Annual Hours				21,888	14,592
Limb Losses per year				0.400	0.267
Sprains and Strains per year				4.000	2.667
Annual Cost				$132,000	$88,000
Annual Cost / Head				$0.065	$0.043
Annual saving per head				$0.000	$0.022

The current boning room chain employs 6 bandsaw operators and one scribing knife throughout the chain with 4 bandsaws being used on the forequarter. Through the removal of these saws it will decrease the risk level of the room.

2.8 Operational Costs

Table 6 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 6: Estimated capital and operating costs of automated LEAP V primal cutting equipment

Capital Cost	Manual		Ex-Ante	
	Cost	Life span	Cost	Life span
Capital Cost of the equipment			$150,000	10
Essential and insurance spares				10
Other Capital install				10
Total			**$150,000**	
Service maintenance	Manual		Ex-Ante	
	Units	Cost	Units	Cost
Estimated - COSTS				
Electricity	6.00 KW	$0.22 /KWH	6.00 KW	$0.22 /KWH
Maintenance labour (Daily)		0.00 /Yr		0.00 /Yr
Maintenance labour (Preventative)		0.00 /Yr		0.00 /Yr
Maintenance labour (Breakdown)		0.00 /Yr		0.00 /Yr
Maintenance labour (Training)		0.00 /Yr		0.00 /Yr
Operational		**$4,815**		**$4,815**
Maintenance		**$0**		**$0**
Annual Sub Total (excluding major overhaul costs)		**$4,815**		**$4,815**
Major maintenance	Manual		Ex-Ante	
	Total	Life span	Total	Life span
Sub Total: Operating Expense				
Combined Total: (cap ex + operating)				
Total Annual Estimated Expenses	Hours	Cost	Hours	Cost
Expected downtime hours per year	**0**	0.00 /Yr	**12**	28563.52 /Yr

2.8.1 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 allowances have 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.

2.8.2 Maintenance and Service Costs

Maintenance and service costs are also supplied by the equipment manufacturer. Maintenance costs are additional running costs that the plants will incur with the installation of the equipment and include components such as parts and labour. The service contract covers ongoing service and maintenance.

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.

2.8.3 Risk of Downtime

The risk of down time shown in Table 6 is the estimated cost of down time for an average installation across the wider industry and has been calculated as follows. 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.

2.9 Development considerations

The development of this robotic system has a number of considerations which need to be overcome prior to commercialisation of the system. Currently speed at which the robotic system can operate will reduce the uptake of system and limit the plants which can install the LEAP V system due to the following reasons:

- There will be 4 robots required to keep up with the LEAP III & LEAP IV systems
- The foot print required will limit the number of plants which can install the system
- The cost and upkeep will reduce the benefit to industry

2.10 Recommendations

There would need to be a more detailed review into the LEAP V robot prior to the commercialisation of the system. The variation in the benefits from $0.06 to $0.61/hd would require additional analysis and data collection in an Australia abattoir to ensure the accuracy of the results. Due to the variation in types of lamb's process between Australia and New Zealand, it would require an EX-Ante study to be completed in Australia prior to moving forward on this investment.