final report

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Prepared by: P. Green, K. Bryan
Greenleaf Enterprises

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

Automated ovine shoulder breakup

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Abstract

A machine to break up the shoulder primal of ovine carcasses by performing neck, brisket and shank, and splitting for square cut shoulder has been developed. A commercial solution is now available avoiding the need to use band-saws. The project has considered the variability in the shoulder primal piece from carcasses in a wide weight range and accommodates for the variability. Trials using a prototype machine at a nominated plant have demonstrated capability that compares with and is more economically attractive than using band-saws. Calculations show payback of better than 24 months based on preliminary in-plant testing.

This report marks the conclusion of the research, whilst pointing to development possibilities that would enhance performance as the machine becomes more widely used in the commercial environment.

Executive Summary

ATTEC Australia in conjunction with MLA and AMPC has developed an automated ovine shoulder cutting solution. This report is an ex-post review of the commercial outcomes from trialling the prototype system in an Australian lamb abattoir.

This system conducts three automated cuts splitting the shoulder barrel into the shanks, brisket, neck and two square-cut shoulders. The installation has been operating on a trial basis and the ex-post analysis demonstrated a net benefit of between $0.15 and $0.87 per carcase. Table 1 summarises the investment and likely payback for a plant operating this system at 5 carcases per minute across one shift which is the maximum production rate for the system. The data set collected from the system and manual operation is small due to the system being operational on a trial basis only. The wide range in manual performance accuracy is reflected in payback ranging between 0.5 and 3.5 years. The value estimated is due to:

1. Improvements in yield on shoulder cuts.
2. Reduction in bandsaw dust due to use of circular saws
3. A slight reduction in OH & S costs and labour down skilling

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

SUMMARY PERFORMANCE MEASURES		
	ATTEC Ex-Post	
Hd / annum	576,000	
Production increase with equipment	0.00%	
	From	To
Capital cost (pmt option, upfront)	$275,000	
Gross return Per head	$0.27	$0.98
Total costs Per head	$0.11	
Net Benefit Per head	$0.15	$0.87
Annual Net Benefit for the plant	$ 88,664	$ 501,873
Annual Net Benefit for the ex cap	$ 79,512	$ 492,721
Pay back (years)	3.46	0.56
Net Present Value of investment	$540,884	$3,443,092

Estimated improvements in both production efficiency and increased saleable product value are summarised in the left of Figure 1. All product value benefits are from increased saleable meat yield due to increased cutting accuracy. The breakdown of benefits is summarised in the figure on the right and primarily focused on increased saleable yield, reducing the number of bandsaws and decreasing likelihood of OH&S incidents.

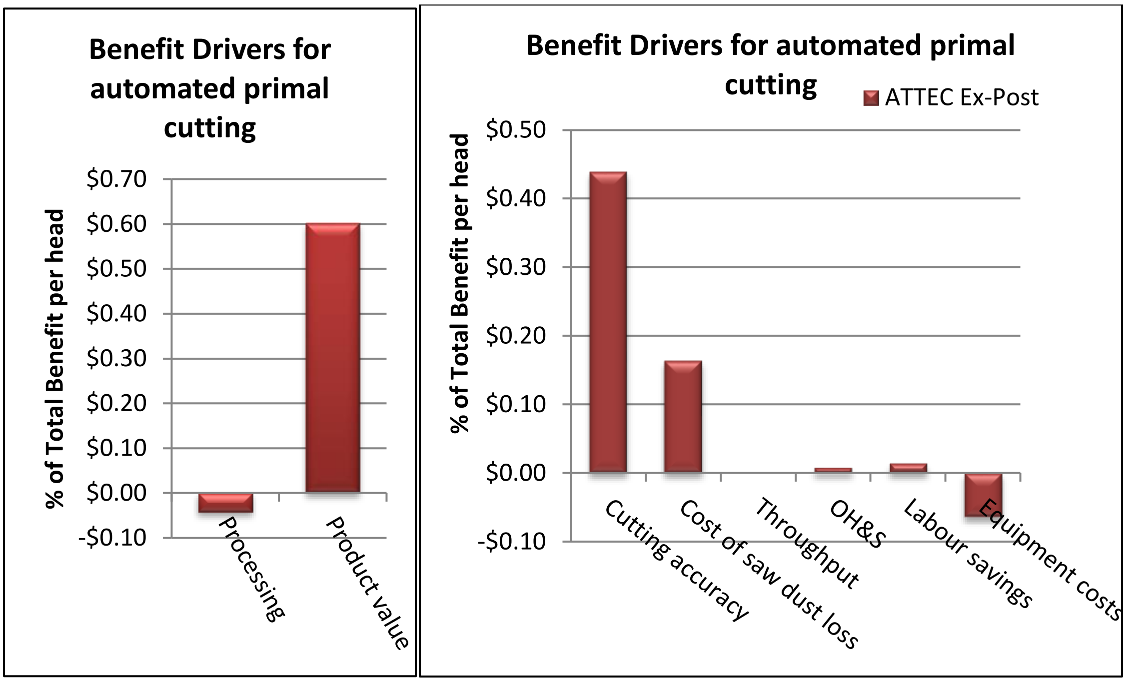


Figure 1: Broad grouping and detailed breakdown of benefits delivered by ATTEC's automated ovine cutting solution.

Contents

1 Introduction

The task of cutting the shoulder primal on a bandsaw requires manipulation of the primal to conduct a number of cutting actions by hand at speed. This R&D task is a continuation of the already part contracted AMPC-MLA project which is in its rig design and construction phase for off-line trials in April 2012.

The final aim to be met by this project is to produce an automated solution using the knowledge gained and integration of cutting tools and handling solution already proven in the experimental trials conducted.

The machine will be capable of integration with existing lines and automated solutions and already at GM Scott the position in the recently upgraded line has been allocated for this machine.

The work was done in two steps.

Step one involved upgrade the machine for trial production runs in Australia. Key to this development will be the implementation of the machine for safe and easy cut use, keeping the process of loading and then cutting by the machine simple, whilst making the machine adapt to the variability in shoulder primal pieces (already specified by the current project).

Step two researched the important aspects of reliability, blade life and life cycle assessment as well as cost benefit analysis, which are often left as a side issue, but considered highly relevant parts of the research if such machines are to add value in the day to day business of processors. The implementation was done in conjunction with ATTEC Denmark A/S.

As part of the above project, Greenleaf have carried out a high level ‘ex post’ CBA assessment of the costs and benefits of this unit and is the focus of this report.

2 Objectives

The objectives of this report were to address the following points:

- Economic benefits and costs, focused on yield, processing efficiency, labour saving and OH&S.
- General (qualitative) observations about the system, including technical, quality or other issues.
- Any factors that may assist with value engineering or further improvement of the system so as to address adoption barriers and assist ATTEC in the commercialization of the technology.

All the objectives were achieved successfully.

3 Equipment description

The machine conveyors the shoulder through an enclosed cutting process which progressively breaks it down through a series of four cuts. Figure 2 shows the modules in final implementation with the overview of the design shown in Figure 3.

The machine is operated as follows:

- Load shoulder, neck trailing and down,
- Index carrier by pressing the operator button,
- The shoulder enters the machine and as it travels through the machine, the shank and brisket are cut,
- The carrier stops at the neck blade position and the shoulder is measures by laser to determine the line of cut for the neck, then the neck is held by a gripper mechanism as is the shoulder and the neck is cut.
- The operator would load another shoulder at the loading point and when pressing the operator button, the pieces already in the machine is split in two square cut shoulder pieces as the carrier indexes forward.
- The piece loaded, would go through the same process of cutting and so on and so forth.
- The pieces fall on exit conveyors on both side of the carrier.

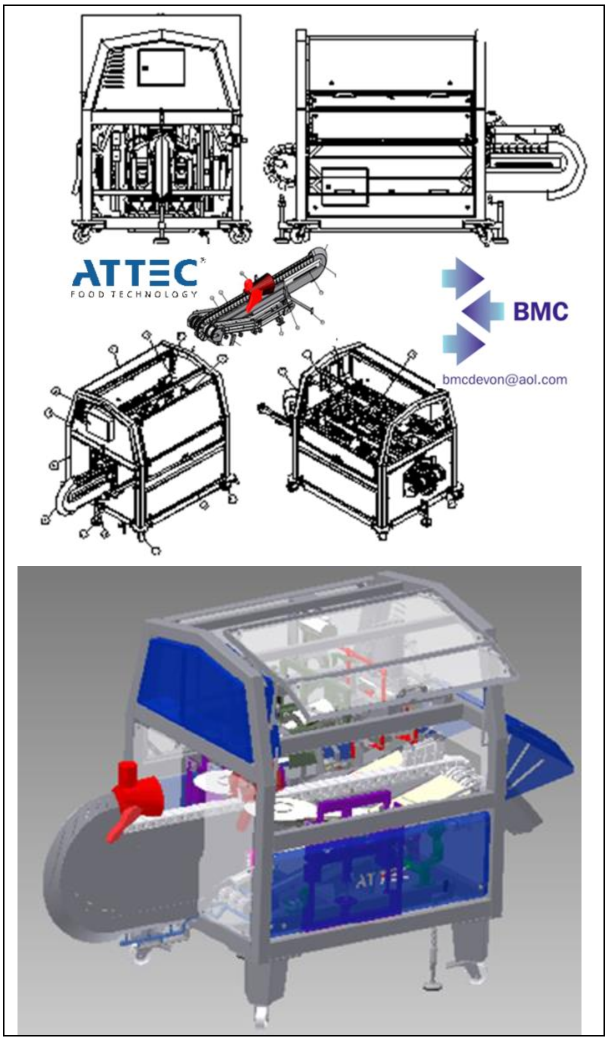


Figure 2: ATTEC system design

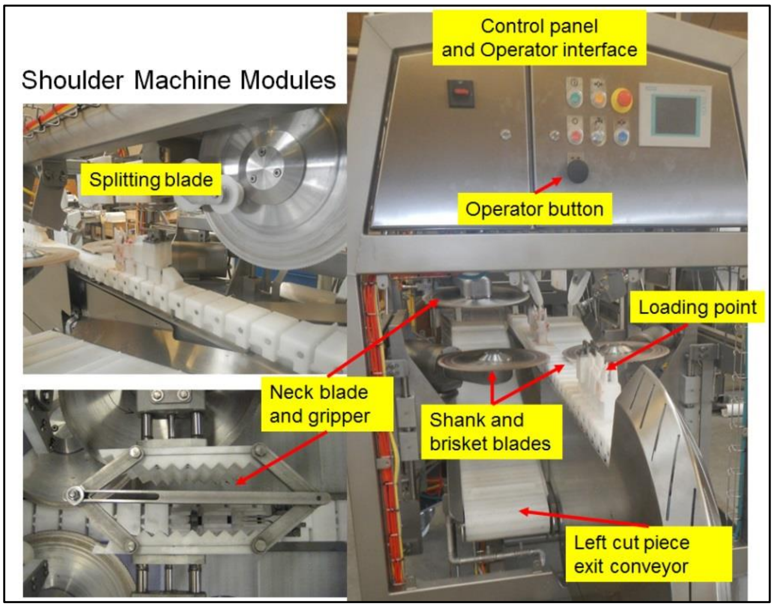


Figure 3: Attec shoulder system installation

4 Data collection & Methodology

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

1. Brisket and shank removal ($0.06 to $0.46)
2. Neck Removal ($0.02 to $0.21)
3. 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 correlations are shown in Figure 4 resulting from the methodology applied in Figure 5 to Figure 7. The second part involves the measurement of cut accuracy within the plant to quantify the variation in the cut value being gained or lost.

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

- Labour Savings
- Yield benefits
- OH & S savings

4.1 Yield Benefits

The yield benefits associated with the automation of the shoulder cuts is due mainly to the removal of the brisket and neck. This results from minimising variation in cut accuracy saving cut value each side of the cutting lines.

4.1.1 Shank & Brisket Removal

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.

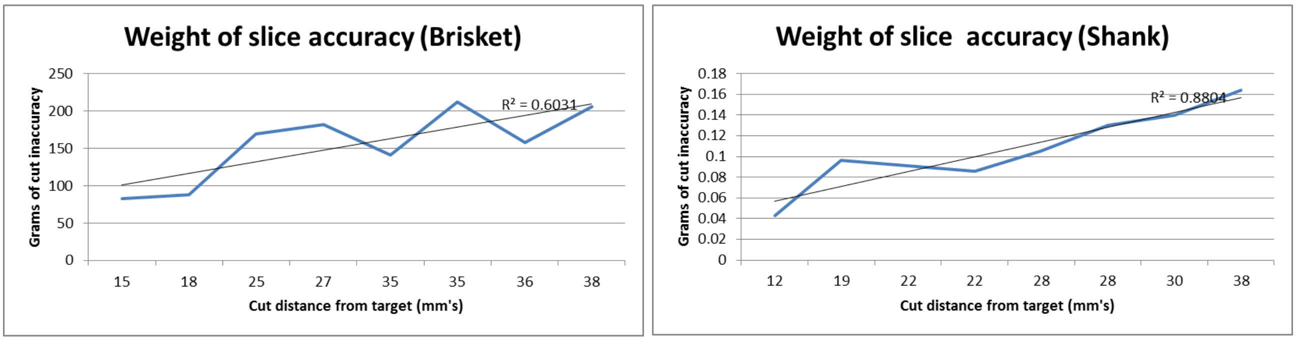


Figure 4: Cut accuracy standards for brisket and shank

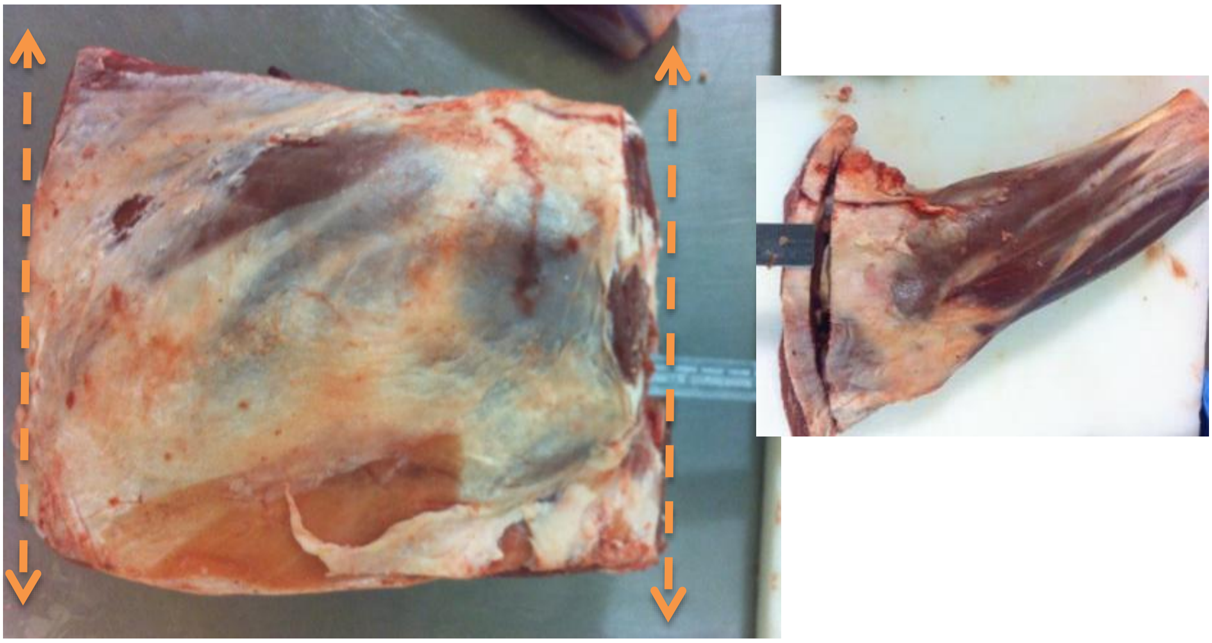


Figure 5: Removal of shank from forequarter parallel to the back

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 plants depending on the value of shanks and shoulders. It is estimated that the value of automating this cut is between $0.06 to $0.46 per head. The benefit of automating this cut is to minimise cutting into the shoulder but allow adjustment to cut further into the brisket on larger carcases. The automated solution allows the operator to modify the specifications to increase the value of the cut. Based on information supplied by ATTEC they indicate the system will be able to operate with a net increase in shoulder yield of +5mm from target specification.

4.1.2 Separating neck from square cut shoulder

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

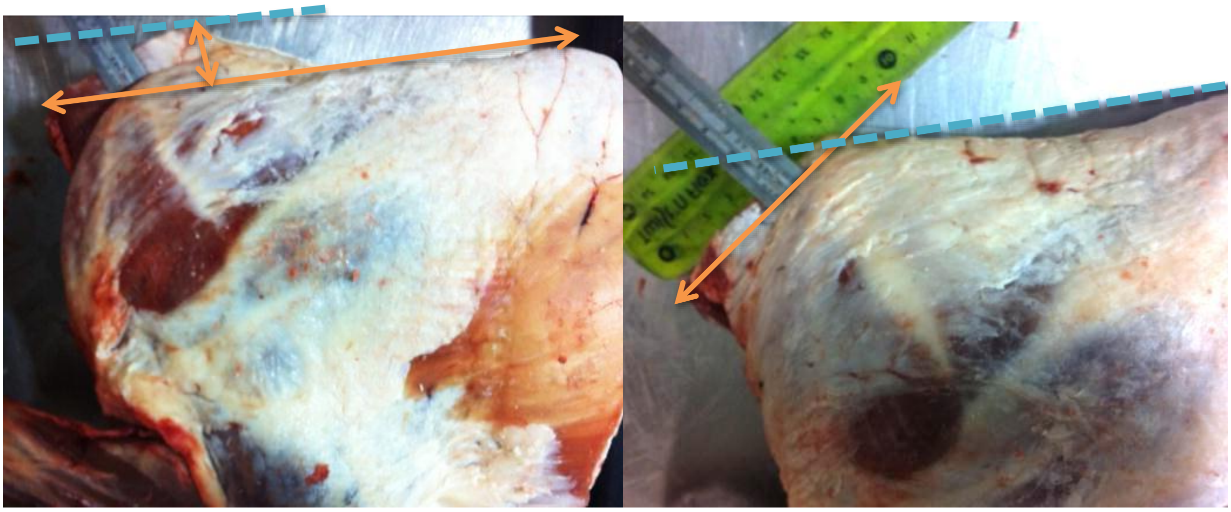


Figure 8: Removal of neck from forequarter perpendicular to neck for unstrung carcases

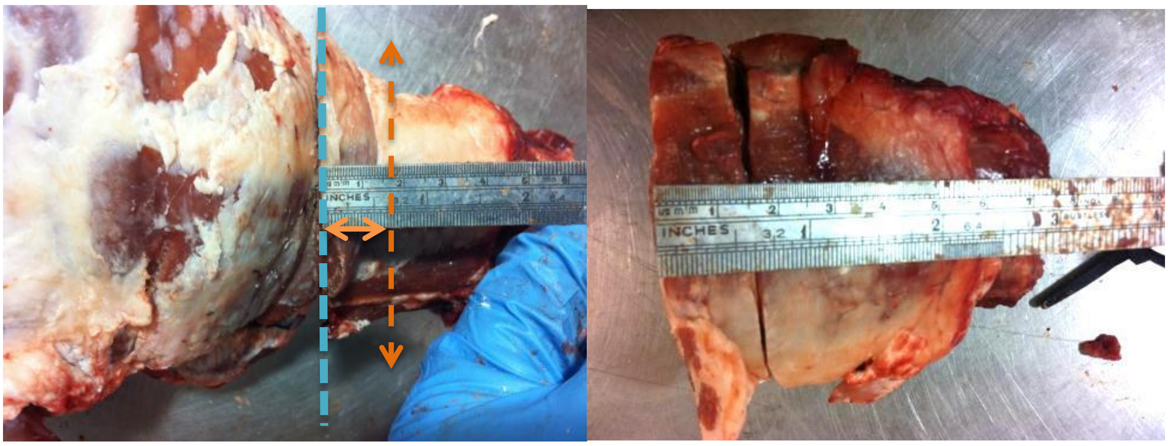


Figure 9: Neck cut accuracy

4.1.3 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 automated ovine shoulder cutter can prefer the cut within ±5mm from the centre line of the vertebra as both the shoulders are sold at the same value.

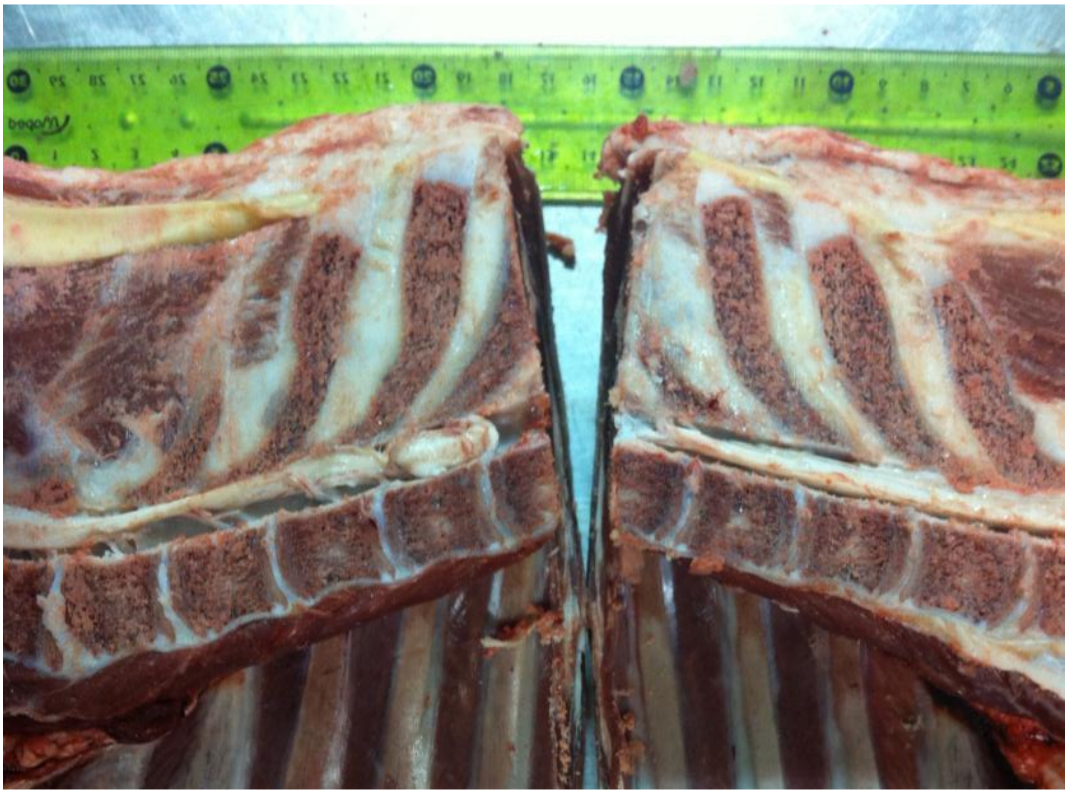
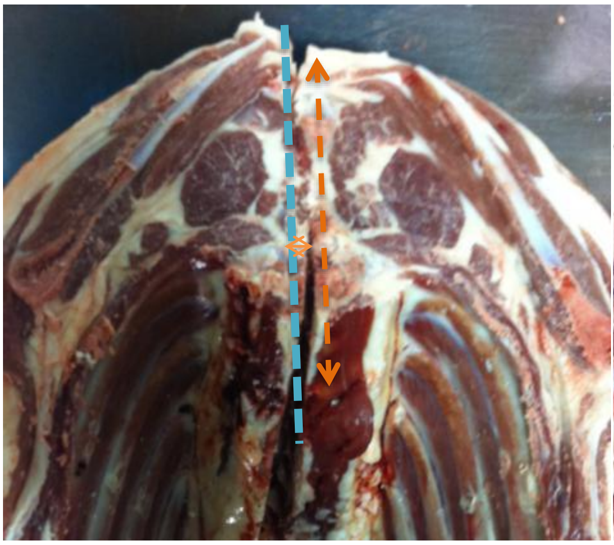


Figure 10: Perfect cutting line leaves equal amounts of spinous process on each primal and spinal column split in half



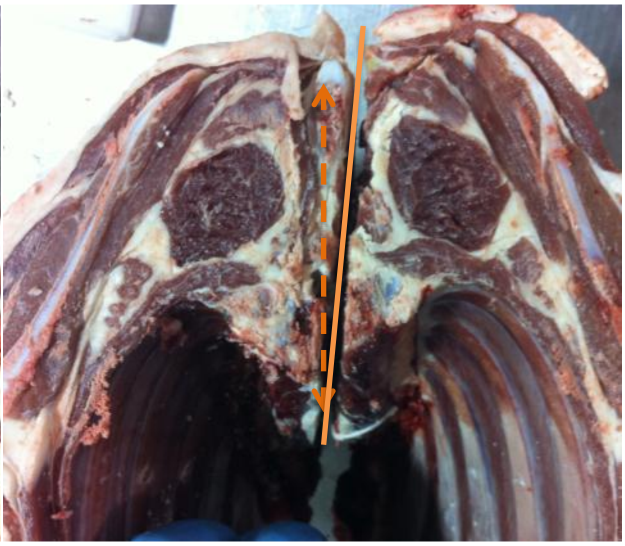


Figure 11: Parallel to cutting line but to left of centre line

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.

5 Cost Benefit Results

The increased value came from yield benefits, OH & S savings and labour savings. The summary results in Table 2 demonstrate the performance of the ex-post review when compared to the manual performance.

Table 2: Summary of benefits for the ATTEC ex-post review

SUMMARY PERFORMANCE MEASURES		
	ATTEC Ex-Post	
Hd / annum	576,000	
Production increase with equipment	0.00%	
	From	To
Capital cost (pmt option, upfront)	$275,000	
Gross return Per head	$0.27	$0.98
Total costs Per head	$0.11	
Net Benefit Per head	$0.15	$0.87
Annual Net Benefit for the plant	$ 88,664	$ 501,873
Annual Net Benefit for the ex cap	$ 79,512	$ 492,721
Pay back (years)	3.46	0.56
Net Present Value of investment	$540,884	$3,443,092

The ex-post net benefit expected for this system was from $0.15/hd to $0.87/hd. The data set collected from the system and manual operation is small due to the system being operational on a trial basis only. The wide range in manual performance accuracy is reflected in payback ranging between 0.5 and 3.5 years and will depend on the accuracy of the manual process at each plant.

There is no production increase expected with the equipment shown in Table 2 as the cutting process is set at a fixed speed regardless of how fast the cuts can be loaded.

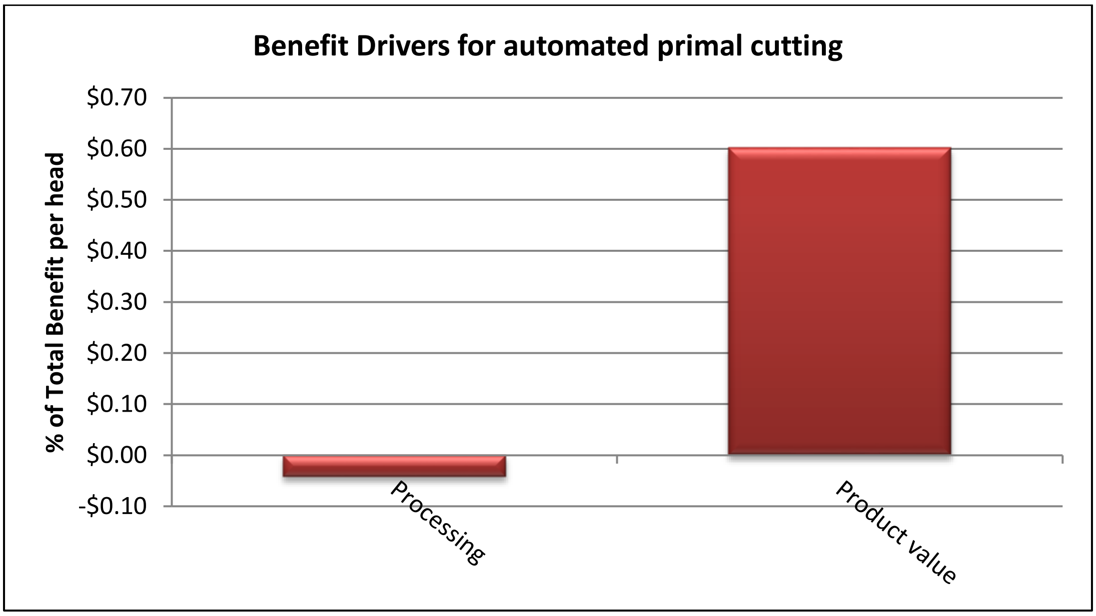


Figure 14: Broad grouping of benefits delivered by the automated solution

The main benefits of the automated cutting technology are the increase in yield and a reduction in labour pay rate from a band saw operator to a general labourer. Occupational health and safety costs will reduce by removing bandsaws. There are expected to be small yield gains through reduced bandsaw dust and shelf life. The contribution of each individual benefit is summarised in Figure 15 and Table 3.

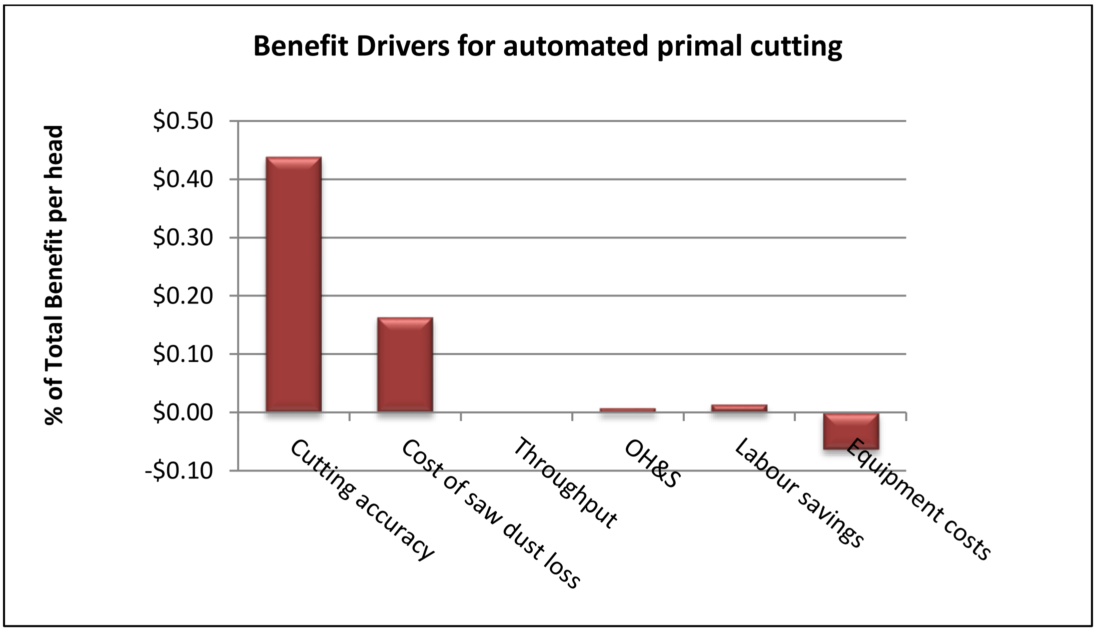


Figure 15: Summary of benefits expected to be delivered from the automated ovine shoulder cutting solution.

Table 3: Breakdown of benefits and costs by area

Benefit Drivers for automated primal cutting		
	ATTEC Ex-Post	
	$/ hd	$/ annum
Processing	-$0.04	-$24,039
Product value	$0.60	$346,807
	$0.56	$322,768
Cutting accuracy	$0.44	$252,489
Cost of saw dust loss	$0.16	$94,318
Throughput	$0.00	$0
OH&S	$0.01	$4,500
Labour savings	$0.01	$8,113
Equipment costs	-$0.06	-$36,652
	$0.56	$322,768

A summary of the range in costs and benefits for each scenario are included in Table 4 below.

Table 4: Ex-post costs and benefits breakdown

COST - BENEFIT ANALYSIS OF ROBOTIC PRIMAL CUTTING EQUIPMENT		
	ATTEC Ex-Post	
Benefit summary	$/hd	
	From	To
$ Accuracy Benefit per head	$0.08	$0.80
$ Technique Benefit per head	$0.16	$0.16
$ Labour Benefit per head	$0.02	$0.02
$ Automation Costs	($0.06)	($0.06)
$ Overall Benefit per head	**$0.20**	**$0.92**

** 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	$0.05
Maintenance	$0.00
Operation	$0.01
Risk of mechanical failure	$0.05
Total cost per head	$0.11
Total cost per head (EX CAP)	$0.06

Table 5 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. 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. The negative loss for the Attec accuracies on section 1.1 of the table indicate an increase in value will be achieved by adjusting the machine to cut on the longer side of target cutting spec but within the customer range of tolerance.

Table 5: Summary results of individual costs associated with the ATTEC V boning solution

COST DUE TO INACCURACIES AND MANUAL INTERVENTION		Manual		ATTEC Ex-Post	
Cost summary		$/hd From	$/hd To	$/hd From	$/hd To
1.1 Accuracy	Splitting shoulders	$0.00	$0.00	$0.00	$0.00
	Shank & Brisket Removal	$0.06	$0.66	$0.00	$0.20
	Neck Removal	$0.00	$0.23	-$0.02	$0.02
1.2 Cutting Technique	Cost of saw dust loss	$0.16	$0.16	$0.00	$0.00
3. OH&S cost		$0.05	$0.05	$0.04	$0.04
4. Labour cost		$0.00	$0.00	-$0.01	-$0.01
Equipment costs	**Maintenance**	$0.00	$0.00	$0.00	$0.00
	Operation	$0.00	$0.00	$0.01	$0.01
	Risk of failure	$0.00	$0.00	$0.05	$0.05
$ Costs per head		**$0.27**	**$1.10**	**$0.06**	**$0.32**
$ Benefit per head		**$0.00**	**$0.00**	**$0.21**	**$0.79**
$ Benefit overall plant		**$0**	**$0**	**$121,302**	**$452,384**
$ Annual Costs overall plant		**$155,801**	**$635,256**	**$34,499**	**$182,872**

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.

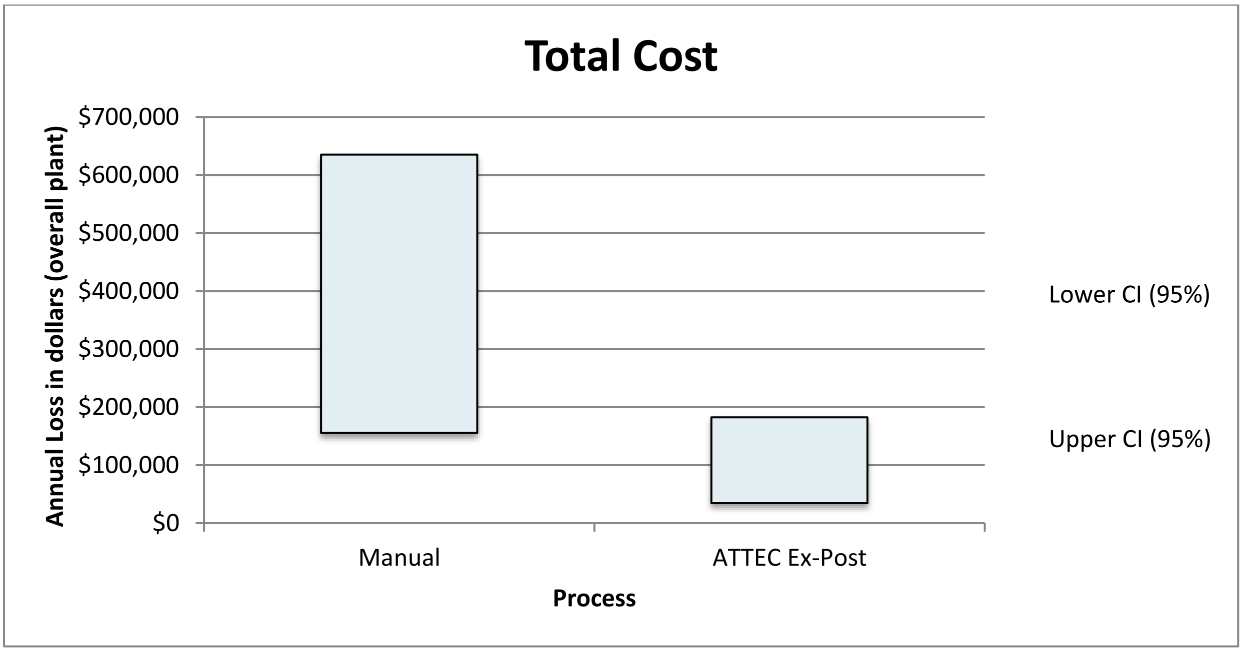


Figure 16: Graphical representation of losses captured in Table 5

5.1 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 5 the following analysis provides an annual benefit of between $88,000 and $502,000. Considering an initial total cost of investment of $275,000 this delivers a payback period of between 0.56 and 3.46

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 $0.54 and $3.4 million over 10 years.

5.2 Yield Benefits

The yield benefits are a result of the measurements collected during the site visit and on manual measurements collected at another lamb processing plant.

5.3 Labour Savings

This plant has an estimated labour savings of $0.01 per head when using the automated ovine cutting solution as a general labourer could be used to operate this system rather than a highly skilled bandsaw operator.

5.4 Increased Productivity

There has been no improvement in the efficiency of the boning room factored into the cost benefit analysis as additional factors as the automated ovine shoulder cutting system requires manual loading at a maximum rate similar to a bandsaw operator.

5.5 OH & S Risks

The OH & S issues associated with the manual 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 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 framework in Table 6 shows OH&S Benefits. The estimated OH & S savings that can be achieved through the installation of the automated system is up to $0.005 per head. These costing do not included the trauma which can be caused through amputations as this is very difficult to cost.

Table 6: OH&S Benefits of the automated ovine shoulder cutting system

OH&S	Band Saw cutting	Sprain and Strain from lifting		Manual	ATTEC Ex-Post
Job Role Affected	Band Saw operator	3			
Claims in last 10 years	4.0	50.0			
Risk / FTE / Year	6.7%	83.3%			
Annual Premium	$30,000	$3,000			
Job Annual Hours				11,520	9,600
Limb Losses per year				0.400	0.333
Sprains and Strains per year				5.000	4.167
Annual Cost				$27,000	$22,500
Annual Cost / Head				$0.047	$0.039
Annual saving per head				$0.000	$0.008

5.6 Operational Costs

Table 7 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. It has been assumed that the electricity costs between bandsaws and the ATTEC system will be similar.

Table 7: Estimated capital and operating costs of automated ovine shoulder cutting system

Capital Cost	Manual		ATTEC Ex-Post	
	Cost	Life span	Cost	Life span
Capital Cost of the equipment			$250,000	10
Essential and insurance spares			$10,000	10
Other Capital install (conveyors etc.)			$15,000	10
Total			**$275,000**	
Service maintenance	Manual		ATTEC Ex-Post	
	Units	Cost	Units	Cost
Estimated - COSTS				
Electricity	0.00 KW	$0.22 /KWH	0.00 KW	$0.22 /KWH
Maintenance labour (Daily)		0 /Yr		0 /Yr
Maintenance labour (Preventative)		0 /Yr		8088 /Yr
Maintenance labour (Breakdown)		0 /Yr		0 /Yr
Maintenance labour (Training)		0 /Yr		0 /Yr
Operational		**$0**		**$8,088**
Maintenance		**$0**		**$0**
Annual Sub Total (excluding major overhaul costs)		**$0**		**$8,088**
Total Annual Estimated Expenses	Hours	Cost	Hours	Cost
Expected downtime hours per year	0	$0	12	$28,564

5.6.1 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 on double shifts.

5.6.2 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.

5.6.3 Risk of Downtime

The risk of down time shown in Table 7 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.

5.7 Development considerations

The development of the shoulder splitting system has been developed to complete a high number of cuts on the shoulder. However if the system could be further developed to the incorporate the following the savings and uptake could be increased:

- Knuckle Tipping
- Self loading mechanisiums
- Increasing the rate of operation to 10 shoulders per miunte would reduce the foot print required in larger processing plants

These imporvemenst would increase the benefit to the plant through increased labour saving and increasing the rate of operation

6 Appendices

6.1 List of Tables

6.2 List of Figures