COST BENEFIT ANALYSIS FOR COMBINED SPLITTING AND SPINAL CORD REMOVAL

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PREPARED BY:	K Fanning & P Green
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1.0 EXECUTIVE SUMMARY

Carcase splitting is an important part of the beef slaughter process. In Australia, it is currently undertaken by trained and experienced saw men often using splitting saw operated on hydraulic platforms. Although commercial automated systems have been developed overseas, these still require a manual operator to monitor and adjust. Furthermore there are reports that these systems can result in decreased accuracy from current manual practice. Previous prototype automated systems developed in Australia have stalled due to the lack of suitable sensor technology.

However, due to recent progress in automating other aspects of red meat processing and new ideas surrounding how carcase splitting could be automated, there is renewed interest in the potential economic benefits of automating the process. As well as the actual splitting, it is envisaged that removal of spinal cord material could be included in the automation.

AMPC contracted Greenleaf Enterprises to undertake a cost benefit analysis for automating carcase splitting and spinal cord removal. The specific project objectives were:

- Quantify the real cost to industry of soft-sided carcases (and the value opportunity from automation)
- Consider floor space and chain speed constraints, either as:
  - Opportunities to automation
  - Barriers to installation
- Understand the longer term sustainability of an automation solution relative to spinal cord removal and potential implications for market access and consumer demands
- Provide strategic insight for future investment paths in carcase splitting automation.

Data, information and insights were gathered from site visits to three abattoirs. This included current manning levels and throughput with manual splitting, yield loss due to soft siding, and other benefits, risks and barriers of automating the process. An excel model was used to determine the current costs of splitting and spinal cord removal, and benefits from automating. Consideration was given to different abattoir configuration and throughput, as well as abattoirs planning to increase throughput but splitting being a bottle neck. Discussions were also undertaken with other beef abattoirs and an automation supplier, to get their input regarding project considerations and to validate assumptions.

The current cost of yield loss (striploin), as a result of soft siding, was estimated to be $0.20/head, equating to $1.8 million/annum for the Australian beef processing industry. However, the major benefit from automating splitting and spinal cord removal was calculated to be labour savings, with $0.91 - $1.07/head of potential savings. The gross benefit for automated systems with various capability ranged from $0.55/head to $1.28/head (Table 1). The estimated ceiling cost for automated system, based on a 24 month pay back, ranged from $138,000 to $1,020,000 (Table 1). Based on feedback from automation system manufacturer, $200,000-$300,000 is the proposed ballpark figure for a splitting-only solution. The feasibility of removing spinal cord material, pre splitting, is currently being examined as part of another AMPC project (Khodabandehloo, 2017).

Table 1: Summary of gross benefit and automated system capital costs for pay back by 12-24 months, depending on system capability

System capability	Abattoir throughput		
	800 head/day	1200 head/day	2000 head/day
No yield gain; no spinal cord removal	$0.55/head* $69,000 - $138,000^	$0.56/head $137,000 - $274,000	$0.56/head $245,000 - $490,000
Yield gain; no spinal cord removal	$0.73-$0.77/head $107,000 - $214,000	$0.74-$0.77/head $195,000 - $390,000	$0.74-$0.78/head $340,000 - $680,000
No yield gain; spinal cord removal	$1.07/head $171,000 - $342,000	$0.91/head $238,000 - $476,000	$0.91/head $415,000 - $830,000
Yield gain; spinal cord removal	$1.26-$1.29/head $210,000 - $420,000	$1.09-$1.18/head $295,000 - $590,000	$1.09-$1.18/head $510,000 - $1,020,000

*Gross benefit; ^Maximum capital cost for pay back by 12-24 months.

Abattoirs that would have the greatest benefit from automated systems are those:

- planning to increase chain speed and requiring change from one splitting saw to two
- with high throughput.

Other potential benefits of automated systems include space saving and increased consistency of carcase presenting for trimming and boning.

Requirements of an automated solution would include:

- Suitable sensing technology that allows for accurate splitting
- Ability to suitably split all carcase types
- Ability to operate at chain speeds up to 135 head/hour
- High reliability.

Previous attempts at automating the process have focussed on discrete parts of the splitting process. However, it is imperative that any future research and development consider the solution in regards to full commercial implementation.

2.0 INTRODUCTION

Beef carcase splitting is a difficult slaughtering process to automate and has been attempted a number of times in the past. Although commercial automated carcase splitting systems are available in the US (Donovan&Best, 2017) and Europe (Gartside & Shaw, 2009), usually in the form of automatic circular splitting saws, regular monitoring and adjustment is required to deliver similar precision to skilful manual operators (Dikeman & Devine, 2014). Furthermore accuracy of certain systems has been reported as being lower than current manual splitting (Gartside & Shaw, 2009). Prototype systems in which band saws were mounted on industrial robots, and controlled by various sensing principles, have been trialled in Australia (Dikeman & Devine, 2014) (Gartside & Shaw, 2009). The technical limitation of these has been the lack of suitable performance or robustness of the sensing (Dikeman & Devine, 2014). Furthermore the system also requires the ability to ensure correct placement and positioning of the carcase at the beginning of the splitting process (Dikeman & Devine, 2014).

Due to recent progress in utilising sensing technologies in other aspects of red meat processing and new ideas surrounding how carcase splitting could be automated, there is renewed interest in the potential for automating the process. As well as the actual splitting, it is envisaged that removal of spinal cord material could be included in the automation.

The purpose of this project was to understand the business case for developing and implementing an automated solution. This project analysed the benefits and costs of carcase splitting and spinal cord removal automation, the likely return on investment and potential for adoption.

3.0 PROJECT OBJECTIVES

The objective of this project was to evaluate the commercial viability and quantify the value proposition of carcase splitting and spinal cord removal automation for the beef processing industry.

Specifically, the project objectives were to:

- Quantify the real cost to industry of soft-sided carcases (and the value opportunity from automation)
- Consider floor space and chain speed constraints, either as:
  - Opportunities to automation
  - Barriers to installation
- Understand the longer term sustainability of an automation solution relative to spinal cord removal and potential implications for market access and consumer demands
- Provide strategic insight for future investment paths in carcase splitting automation.

4.0 METHODOLOGY

Desktop review

A review of relevant literature was undertaken to examine the history and details of previously trialled and currently available automated splitting systems.

Consultation

Discussions with five beef processing companies (including the three abattoirs where data was collected), a major automation system manufacturer, and consultant undertaking separate feasibility assessment trials of spinal cord removal (Khodabandehloo, 2017), were undertaken throughout the project to get:

- Initial perspective on the potential benefits, barriers and risks of automated splitting and spinal cord removal, and,
- Feedback on the results of the modelling and associated assumptions to validate the findings.

Site visits and data collection

Following consultation with AMPC, site visits were undertaken at three abattoirs. The abattoirs are referred to as Abattoir A, B and C in this report. Abattoir throughput ranged from 160,000 – 250,000 head/year and further information is provided in Appendix 1 – Summary of data collected from site visits.

At each abattoir, the following procedure was used:

- Visual review of the current carcase splitting and spinal cord removal processes, within the context of the wider slaughter floor operations.
- Interviews with slaughter floor supervisors regarding the current processes, and opportunities and challenges for an automated system.
- Measurement of yield loss of primal that had been soft sided on carcases leaving the slaughter floor.
- Visual review of the boning room operations.
- Interviews with boning room supervisors in regards to yield loss and any other challenges that result from soft siding.
- Measurement of yield loss of primal that had been soft sided on carcases entering boning room.

Modelling

An excel model was developed and used to calculate costs of current manual splitting and spinal cord removal, together with benefits and costs of automated carcase splitting and spinal cord removal. A summary of the major details and considerations, that have been modelled, are outlined in Appendix 2 – Figures and assumptions used for modelling. This information was formulated based on specific data collected from the three abattoirs (Appendix 1 – Summary of data collected from site visits) as well as consideration for the wider industry.

5.0 RESULTS

Current cost of soft siding

The cost of soft siding is estimated to be $0.20/head (Table 12).

Comparison of manual and automated splitting

Table 2 provides a breakdown of the current costs of manual splitting operations (left column) with comparison to projected costs for an automated system (right column). The benefit for automation ranges between $1.07/head and $1.11/head (the range reflects the upper and lower differences in yield loss from manual operations measured during the trials). The largest benefit for automation will come from labour saving at $1.05/head, compared to yield saving (as a result of increased accuracy) of between $0.18-$0.22/head.

Table 2: Summary of costs and benefits of current manual splitting and spinal cord removal process, and proposed automated system (based on abattoir operating at 800 head/day)

			Manual		Automated splitting - 800 Hd/day	
Cost summary		% of annual	$/hd From	$/hd To	$/hd From	$/hd To
1.1 Accuracy	Soft siding	100%	$0.18	$0.22	$0.00	$0.00
2. Throughput costs			$0.00	$0.00	$0.00	$0.00
3. OH&S costs			$0.02	$0.02	$0.00	$0.00
4. Labour costs	**Cost due to saved staff**		$0.00	$0.00	-$1.05	-$1.05
	Cost due to relocated staff		$0.00	$0.00	$0.00	$0.00
Equipment costs	**Maintenance**		$0.00	$0.00	$0.01	$0.01
	Operation		$0.10	$0.10	$0.27	$0.27
	Risk of failure		$0.00	$0.00	$0.00	$0.00
$ Costs per head			**$0.30**	**$0.34**	**-$0.77**	**-$0.77**
$ Benefit per head			**$0.00**	**$0.00**	**$1.07**	**$1.11**
$ Benefit overall plant			**$0**	**$0**	**$206,168**	**$213,316**
$ Annual Costs overall plant			**$57,992**	**$65,141**	**-$148,176**	**-$148,176**

Table 3 shows the comparison of benefits and costs for the different throughput rates (capital cost based on Table 4).

Table 3: Summary of benefits and costs of abattoirs at three throughput rates

Benefit summary	Automated splitting - 800 Hd/day $/hd		Automated splitting - 1200 Hd/Day $/hd		Automated splitting - 2000 Hd/day $/hd	
	From	To	From	To	From	To
$ Accuracy Benefit per head	$0.18	$0.22	$0.18	$0.22	$0.18	$0.22
$ Labour Benefit per head	$1.07	$1.07	$0.91	$0.91	$0.91	$0.91
$ Overall Benefit per head	**$1.26**	**$1.29**	**$1.10**	**$1.13**	**$1.09**	**$1.13**
Capital cost	$0.11		$0.10		$0.11	
Maintenance	$0.01		$0.01		$0.00	
Operation	$0.17		$0.07		$0.04	
Risk of mechanical failure	$0.00		$0.00		$0.00	
Total cost per head	$0.29		$0.18		$0.15	
Total cost per head (EX CAP)	$0.18		$0.08		$0.05	

Table 4 shows that the maximum capital cost of an automated system (including setup and installation), to have a 12 month pay back, would be $210,000, $295,000 or $510,000 (for the three throughputs), respectively.

Table 4: Summary of costs and benefits of proposed automated system, for different throughput, for pay back by 12 months

	Automated splitting - 800 Hd/day		Automated splitting - 1200 Hd/Day		Automated splitting - 2000 Hd/day	
Hd / annum	191,938		287,971		480,000	
	From	To	From	To	From	To
Capital cost (pmt option, upfront)	$210,000		$295,000		$510,000	
Gross return Per head	$1.26	$1.29	$1.09	$1.13	$1.09	$1.13
Total costs Per head	$0.29		$0.18		$0.15	
Net Benefit Per head	$0.96	$1.00	$0.91	$0.95	$0.94	$0.98
Annual Net Benefit for the plant	$ 185,168	$ 192,316	$ 261,552	$ 272,277	$ 450,596	$ 468,473
Annual Net Benefit for the ex cap	$ 206,168	$ 213,316	$ 291,052	$ 301,777	$ 501,662	$ 519,539
Pay back (years)	1.02	0.98	1.01	0.98	1.02	0.98
Net Present Value of investment	$1,485,069	$1,535,278	$1,909,242	$1,984,573	$3,172,296	$3,297,860

Automated system capability

Table 5 details the range of gross benefit and maximum capital cost for pay back by 12 months for automated systems with various capability (in regards to cutting accuracy and ability to remove spinal cord material).

Table 5: Gross benefit and capital cost for 12 month pay back for different automated system capabilities

System capability	Abattoir throughput		
	800 head/day	1200 head/day	2000 head/day
No yield gain; no spinal cord removal	$0.55/head* $69,000^	$0.56/head $137,000	$0.56/head $245,000
Yield gain; no spinal cord removal	$0.73-$0.77/head $107,000	$0.74-$0.77/head $195,000	$0.74-$0.78/head $340,000
No yield gain; spinal cord removal	$1.07/head $171,000	$0.91/head $238,000	$0.91/head $415,000
Yield gain; spinal cord removal	$1.26-$1.29/head $210,000	$1.09-$1.18/head $295,000	$1.09-$1.18/head $510,000

*Gross benefit; ^Maximum capital cost for pay back by 12 months.

Table 6 provides a summary of the costs and benefits for a system that has yield gain but no spinal cord removal.

Table 6: Summary of costs and benefits for automated splitting without automated spinal cord removal

	Automated splitting - 800 Hd/day		Automated splitting - 1200 Hd/Day		Automated splitting - 2000 Hd/day	
Hd / annum	191,938		287,971		480,000	
	From	To	From	To	From	To
Capital cost (pmt option, upfront)	$107,000		$195,000		$340,000	
Gross return Per head	$0.73	$0.77	$0.74	$0.77	$0.74	$0.78
Total costs Per head	$0.24		$0.15		$0.12	
Net Benefit Per head	$0.49	$0.52	$0.59	$0.63	$0.62	$0.66
Annual Net Benefit for the plant	$ 93,490	$ 100,639	$ 169,575	$ 180,300	$ 298,296	$ 316,174
Annual Net Benefit for the ex cap	$ 104,190	$ 111,339	$ 189,075	$ 199,800	$ 331,798	$ 349,676
Pay back (years)	1.03	0.96	1.03	0.98	1.02	0.97
Net Present Value of investment	$875,780	$925,989	$1,296,953	$1,372,284	$2,153,206	$2,278,769

Transitioning to higher chain speed

For an abattoir planning to increase chain speed to a point where two splitting saws are required, a suitable automated solution would allow for saving of extra labour, whilst providing the necessary throughput rate for splitting. The cost summary (excluding capital) for this scenario is presented in Table 7. The automated solution has a reduced cost (benefit) of $0.72-$0.76/head, compared to 1 manual saw situation.

Table 7: Cost summary for manual versus automated splitting for abattoir planning to increase throughput

		1 saw - 110Hd/hr		2 saw - 125 Hd/Hr		Automated - 125 Hd/hr	
Cost summary		$/hd From	$/hd To	$/hd From	$/hd To	$/hd From	$/hd To
1.1 Accuracy	Soft siding	$0.18	$0.22	$0.18	$0.22	$0.00	$0.00
2. Throughput costs		$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
3. OH&S costs		$0.02	$0.02	$0.03	$0.03	$0.00	$0.00
4. Labour costs	**Cost due to saved staff**	$0.00	$0.00	$0.00	$0.00	-$0.95	-$0.95
	Cost due to relocated staff	$0.00	$0.00	$0.29	$0.29	$0.29	$0.29
Equipment costs	**Maintenance**	$0.00	$0.00	$0.00	$0.00	$0.01	$0.01
	Operation	$0.06	$0.06	$0.12	$0.12	$0.19	$0.19
	Risk of failure	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
$ Costs per head		$0.26	$0.30	$0.62	$0.65	-$0.46	-$0.46
$ Benefit per head		$0.00	$0.00	-$0.36	-$0.36	$0.72	$0.76

Table 8 details the costs and benefits of the automated solution relative to going to 2 manual saws. The net benefit of $0.98-$1.12/head pays for itself by 12 months at a capital outlay of $315,000.

Table 8: Summary of costs and benefits for automated solution for abattoir planning to increase throughput (relative to 2 manual saws)

	Automated - 125 Hd/hr	
Hd / annum	269,957	
	From	To
Capital cost (pmt option, upfront)	$315,000	
Gross return Per head	$1.33	$1.19
Total costs Per head	$0.21	
Net Benefit Per head	$1.12	$0.98
Annual Net Benefit for the plant	$ 303,478	$ 264,237
Annual Net Benefit for the ex cap	$ 334,978	$ 295,737
Pay back (years)	0.94	1.07
Net Present Value of investment	$2,211,529	$1,935,912

Other scenarios

Table 9 details the extra benefit for abattoirs that process grain fed animals exclusively or have higher yield loss. The average extra net benefit for these two scenarios is $0.09/head ($1.02-$0.93; based on higher price of grain fed striploin) or $0.27/head ($1.20-$0.93; based on higher striploin recovery). The accompanying maximum capital cost that pays back in 12 months would be increased to $325,000 (grain fed) or $380,000 (higher yield loss).

Table 9: Summary of costs and benefits for grain fed and higher yield loss scenario

	Automated splitting - 1200 Hd/Day		Automated - grain fed		Automated - higher yield loss	
Hd / annum	287,971		287,971		287,971	
	From	To	From	To	From	To
Capital cost (pmt option, upfront)	$295,000		$325,000		$380,000	
Gross return Per head	$1.09	$1.13	$1.18	$1.24	$1.36	$1.46
Total costs Per head	$0.18		$0.19		$0.21	
Net Benefit Per head	$0.91	$0.95	$0.99	$1.05	$1.15	$1.25
Annual Net Benefit for the plant	$ 261,552	$ 272,277	$ 285,294	$ 301,474	$ 331,930	$ 358,744
Annual Net Benefit for the ex cap	$ 291,052	$ 301,777	$ 317,794	$ 333,974	$ 369,930	$ 396,744
Pay back (years)	1.01	0.98	1.02	0.97	1.03	0.96
Net Present Value of investment	$1,909,242	$1,984,573	$2,067,069	$2,180,709	$2,378,250	$2,566,577

6.0 DISCUSSION

Costs of current practice

The major cost component of the current splitting process is labour. Soft siding is a minor cost with an estimated yield loss of $1.82 million/annum. Potential contamination of product with bone dust or spinal cord material is effectively prevented by quality assurance practices.

Opportunities for automated systems

The potential for automated systems is to deliver $0.91-$1.07/head of labour savings and yield benefit of $0.18-$0.22/head.

Abattoirs that would have the greatest benefit from automated systems are characterised by:

- Those planning to increase chain speed and requiring change from one splitting saw to two
- High throughput.

If an automated solution had a smaller footprint than the current splitting process, there would be a particular benefit to abattoirs that are wanting to increase chain speed but have space constraints that do not allow them to move 2 saws. Furthermore, the majority of abattoirs have space constraints on their slaughter floor, and any space made available by an automated system would have benefits by opening up this space for other uses and/or allowing for improving slaughter floor layout.

Increased consistency of carcase splitting would also reduce the variability between carcases presenting for trimming and boning, and may facilitate automated boning of the saddle area (rib eye and loin).

Ceiling cost for automated systems

Automated system manufacturer suggested that pay back of 12 months is standard for systems for which yield is a major benefit, but 24 months (and up to 36 months) is standard for systems for which labour saving is the major benefit. Discussions with abattoirs also suggested that 12-24 months was the required payback period. Based on this pay back and system capability, the ceiling cost for automated system ranges from $69,000 to $1,020,000 (Table 10). It is anticipated that capital costs above this would be prohibitive to uptake by abattoirs.

Table 10: Estimated capital cost of automated system for pay back by 12 to 24 months, depending on system capability and abattoir throughput

System capability	Abattoir throughput		
	800 head/day	1200 head/day	2000 head/day
No yield gain; no spinal cord removal	$69,000* - $138,000^	$137,000 - $274,000	$245,000 - $490,000
Yield gain; no spinal cord removal	$107,000 - $214,000	$195,000 - $390,000	$340,000 - $680,000
No yield gain; spinal cord removal	$171,000 - $342,000	$238,000 - $476,000	$415,000 - $830,000
Yield gain; spinal cord removal	$210,000 - $420,000	$295,000 - $590,000	$510,000 - $1,020,000

*12 month pay back; ^24 month pay back.

Requirements and considerations for automation design

Requirements of an automated solution would include:

- Suitable sensing technology that allows for accurate splitting

- Ability to suitably split all carcase types (some of this variation has been documented in (Khodabandehloo, 2017))
- Ability to operate at chain speeds up to 135 head/hour
- High reliability.

The process of suitably automating splitting is viewed as technically possible. An achievable cost of ~$300,000 for a system that only split (not certain if spinal cord removal could be incorporated) was postulated, which may reduce to ~$200,000-$250,000 (3-4 years after system is developed). A capital cost in this price range would allow all three sized abattoirs considered (Table 10) to achieve pay back within 12-36 months.

Removal of spinal cord material pre splitting would be advantageous over removal post splitting, as it would reduce or eliminate risk of contamination. Feasibility of spinal cord removal pre splitting is currently being investigated with system specifications, in regards to engineering, to be reported later in 2017 (Khodabandehloo, 2017).

In regards to system footprint, it has been indicated that for a system that only splits (does not remove spinal cord) the footprint would most probably be the same or larger than current splitting. However for a system that included remove spinal cord removal, there may be an overall space saving.

A potential yield increase of 3 mm of bone material, by using thinner blades, has been identified and estimated to equate to approximately 2 kg/carcase (Khodabandehloo, 2017). However, it is important to note that this yield benefit, in many cases, would be paid back to livestock supplier. At a whole carcase price of $5.60/kg this would increase the whole carcase cost by $11.20, but the yield benefit to the abattoir would be considerably less (estimated as ~$0.60-0.70/head by (Khodabandehloo, 2017); abattoirs that do not pay for livestock based on split carcase weight, could benefit most from the [bone] yield benefit, if they sell bone in cuts but this would still only represent a small percentage increase in saleable meat yield). As a result it is thought that many abattoirs would be resistant to any increases in carcase yield, prior to weighing of the carcase, which are a result of reduced bone dust. Thus, blades that reduce the amount of bone dust that is currently removed, would presumably require an adjustment to the standard trim by Ausmeat.

Previous attempts at automating the process have focussed on discrete parts of the splitting process. However, it is imperative that any future research and development consider the solution in regards to full commercial implementation.

7.0 CONCLUSIONS

The current cost of yield loss from soft siding is estimated to be $0.20/head. The major potential benefit from automating the processes of carcase splitting and spinal cord removal is labour savings, estimated to be $0.91-$1.07/head. Depending on system capability, and abattoir throughput, the ceiling for capital cost, which pays back in 24 months, is $138,000 to $1,020,000. It is envisaged that sale price for commercial splitting-only system would be ~$200,000-$300,000 and thus affordable by abattoirs with this throughput. Key requirements of an automated system would include:

- Suitable sensing technology that allows for accurate splitting
- Ability to suitably split all carcase types
- Ability to operate at chain speeds up to 135 head/hour
- High reliability.

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9.0 APPENDICES

Appendix 1 – Summary of data collected from site visits

All three abattoirs used a similar process for carcase splitting and spinal cord removal. This included using a splitting saw (Jarvis Buster) on a hydraulic stand, spinal cord removal using a vacuum tool, and specific trimming positions who ensured all spinal cord material was removed. Table 11 summarises the key information collected regarding the current operation and process for splitting and spinal cord material removal. The yield loss refers to the measured loss of yield as a result of soft siding. This is primal that is left on the bone and becomes render/tallow. The yield loss would constitute lost striploin. Yield loss was measured on carcases from two splitting shifts at Abattoir B (120 and 142 carcases, respectively) and C (160 and 218 carcases, respectively), and from one shift at Abattoir A (134 carcases).

Table 11: Summary of key operational details of current splitting and spinal cord removal process

Parameter	Abattoir A	Abattoir B	Abattoir C
Yield loss (g/head)			
Striploin	23	5 (shift 1), 21 (shift 2)	24 (shift 1), 25 (shift 2)
Manning levels			
Splitting saw	2	1	1
Spinal cord removal	1	1	1
Trimming/QA (ensure all spinal cord material is removed)	2	2	2
Current chain speed (head/hr)	110 (55 per saw)	110	75
Maximum chain speed (head/hr)	135 (67.5 per saw)	Plan is to move to 120-125 in the near future. With this change in speed, a second saw will be installed on current stand to be used by one operator.	100

Throughput opportunity	Splitting is not the limiting factor to increasing chain speed, with legging stand being one of the bottlenecks to increasing chain speed.	With current splitting saw operator, splitting is not a bottleneck. However, for trainees a chain speed of 110 head/hr is difficult to keep up with.	At 100 head/hr splitting saw operator begins to struggle to keep up with chain.
OH&S	Minor strain and sprain injuries for splitting saw operator and spinal cord removal. Utilisation of hydraulic stands has removed historical back and shoulder injuries associated with lifting the saw.		
Operational expenses	Splitting saw – summary from the 3 abattoirs: / Replacement cost of $10,000 / Operational life of 15 years / Water usage of 220,000 litres/year / Blade cost - 2 blades/shift @ $11/blade / Blades take 2-3 min to change. Blades cut stuck in carcase once a month and take 5 min to remove. / Repairs and maintenance cost of $8,000/year.		
Product quality or shelf life	There is no loss of product shelf life as a result of smearing of spinal cord material/bone dust. This is because of the washing process associated with current splitting saw operation. There is no rejection of product due to spinal cord material due to the stringent quality assurance processes in place (designated trimmers who have a quality assurance role).		

A range of other insights included:

- Good splitting saw operators are prized and are used exclusively for splitting operation as available. If the best operators are undertaking the splitting, the impacts are manageable. However when less experienced operators are required to undertake the splitting or when training of new operators is required (due to staff turnover or illness), soft siding is increased, particularly at higher chain speeds. This is estimated to occur 5-10% of the time depending on the abattoir.
- The different bone size, hardness and back structure of different species and breeds, and age of animals (harder bones in older animals), are challenges for splitting. Brahman are regarded as the most difficult to split due to their hump. Wagyu have smaller bones and are more symmetrical.
- Current splitting saw operation is assumed to take 12-15 seconds for a proficient operator. There is a minimum requirement for the saw to be in its stand for 6s for sterilisation process.

- If paunch has been accidentally cut and there is contamination inside carcase, the carcase is tagged and the carcase is split without the water running, to stop contamination spreading.
- One abattoir has large T-bone orders and the boning room supervisor indicated that soft siding had a significant impact on filling these orders.
- No refabrication of soft siding is being done in boning room.
- There were differences between abattoirs, in the boning room perspective of the consistency of carcase splitting (across shifts and operators). One abattoir reported very consistent splitting across the different splitting saw operators, whereas another abattoir reported larger differences.
- One abattoir noted that an automated splitting system may require retaining current splitting saw infrastructure in case of breakdown.
- Automated splitting process would need to be able to accommodate a wide range of animal specifications (including breed and animal age).
- Operationally there was general positivity for automated systems for both carcase splitting and spinal cord removal. However, there were differences between abattoirs as to the strategic relevance and importance of automating these processes. For example, one abattoir suggested that there were several other processes that they would automate prior to splitting.

Appendix 2 – Figures and assumptions used for modelling

Table 12 provides a summary of the information used for the modelling. This information is based on data collected from abattoirs (Appendix 1 – Summary of data collected from site visits) and industry wide considerations.

Table 12: Summary of information used for modelling costs and benefits of automated splitting systems versus current manual splitting

Parameter	Costs and performance details		
Yield loss	17.5 g striploin/head		
Value of striploin	Grass fed – $10.92/kg (90% of animals processed) Grain fed - $17.42/kg (10% of animals processed)		
Value of render	$0.05/kg		
Animals processed per year (approx.)	9,000,000		
Cost of soft siding to industry per annum	($10.92-$0.05)*(0.0175 kg)*(90% of 9,000,000) + ($17.42-$0.05)*(0.0175 kg)*(10% of 9,000,000) = $1.82 million		
Abattoir throughput – 3 plant sizes (head/day)	**800 head**	**1200 head**	**2000 head**
Chain speed (head/hr)	89	133	133
Shift(s)	1 x 9hr	1 x 9hr	1 x 9hr, 1 x 6hr
Shifts/year	240	240	240
Head/day	800	1200	2000
Head/year	191,938	287,971	480,000
Manning levels – manual process (labour savings)			
Splitting saw (average of 1.3 for 800 head/day based on some abattoirs [30%] having 2 saw men but most only having a single saw man)	1.3 (1.3)	2 (2)	2(2)
Spinal cord removal	1 (1)	1 (1)	1 (1)
Trimming/QA (ensure all spinal cord material is removed – 2 trimmers have a partial role [~25% of task assigned to trimming soft siding and making sure all spinal cord material is removed])	2 (0.5)	2 (0.5)	2 (0.5)

Operational expenses - manual	Splitting saw: / New stand for splitting saw estimated at $100,000 / Replacement cost of $10,000 / Operational life of 10 years / Water usage of 220,000 litres/year (@$3.6/kl) / Blade cost - 2 blades/shift @ $11/blade / Repairs and maintenance cost of $8,000/year. Staff: / Salary and on-costs / Recruitment and training costs / Minor strain and sprain injuries. Risk of failure: / Once per month blade gets stuck in carcase or blunt during shift, and needs to be replaced (5 min x 12 = 60 min/year).
Capital and operational expenses - automated	/ Automated system capital – based on pay back of 12 months / Engineering works – for setup and installation in abattoir; added to system cost (included in capital cost) and based on pay back of 12 months / Service contract - $30,000/year / Maintenance materials - $17,000/year. Risk of failure / 1 hr/month = 12 hr/year.
Other scenarios	1. No spinal cord removal: / Labour saving is only splitting saw men (1-2). 2. Abattoir moving from 1 saw to 2 saws to increase throughput: / Current chain speed of 110 head/hr (244,000 head/year); 1 saw man (manual) / New chain speed of 125 head/hr (278,000 head/year); requiring 2 saw men (manual) / Automated solution operating at 125 head/hr (278,000

	head/year). Labour saving of 3.5; 2 saw men plus trimming (0.5) and spinal cord removal (1). 3. Abattoirs who process **grain fed** exclusively: / Costs of yield loss was calculated based as yield loss (0.02 kg) x grain-fed price of striploin ($17.42/kg). 4. Abattoirs with **higher yield loss** than average: / Amount of yield loss was changed to 2.9 times higher (50 g/head).

Further details regarding these figures and assumptions, are as follows:

- Industry average prices for striploin and render were used in determining cost of yield loss with a split between grass and grain fed prices of 90:10, respectively.
- Current chain speed of 89 head/hr was selected as it was in the range of 75-110 head/hr for the abattoirs surveyed and equates to 800 head/day (which resembles medium sized abattoirs).
- Chain speed of 133 head/hr was selected for larger abattoir throughput scenarios, as maximum operating chain speed of 135 head/hr is possible for certain abattoirs without modifications, and this equates to 1200 head/day and 2000 head/day (based on 1-2 shifts; which covers the upper range of abattoir throughput).
- Manning levels for manual splitting saw are assumed to be 2 at 133 head/hr. Other relevant manning levels (spinal cord removal and trimming) are assumed to be chain speed independent.
- Staff turnover has been set at 8% and the increased yield loss incurred during training of a new splitting saw operator has been set at $1/head loss (approximately 5 times greater than experienced splitting saw operator), with 20 days training to become fully competent.
- Maximum possible capital costs (for abattoir to consider system purchase) have been estimated based on 12-24 month pay back for each throughput. Equipment life has been set at 10 years with 7% discount rate. Operational expenses for automated system have been estimated from automated systems in the sheep industry.
- In the exclusively grain fed scenario, the assumption is that yield loss is the same but cost of yield loss is higher as a result of higher value of grain fed striploin.
- In the higher yield loss scenario, the assumption is that yield loss is greater (2.5 times).