Cost Benefit Analysis – Automated Scribing System Non-Confidential

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Executive Summary

The Intelligent Robotics (IR) automated scribing system operating at KGF Kilcoy plant was reviewed over several days comparing the manual scribing accuracy to the automated scribing system for three carcase types; long-fed, mid-fed and short- grain fed cattle. The accuracy of the cuts were compared for the cube roll to the chuck, the cube roll to the striploin, brisket scribe and chuck-short rib scribe using tools developed by Greenleaf to calculate the value impact per carcase and for KGF. The cut value prices used were provided by industry avaerage pricing. The accuracy of the IR Automated scribing system, has improved the cutting accuracy over manual operators for all cutting lines. As can be seen in Table 1 it provides a payback of between 1.15 and 1.21 years, which is based on the estimated Ex-works capital cost for the IR scribing system provided by IR. The benefits are based on the actual system accuracy of the cutting lines shown in Table 2.

Table 1: Summary of performance measures

SUMMARY PERFORMANCE MEASURES		
	Ex-Post Review	
Hd / annum	482,500	
	From	To
Capital cost (pmt option, upfront)	$3,050,000	
Gross return Per head	$5.40	$5.66
Total costs Per head	$0.47	
Net Benefit Per head	$4.92	$5.19
Annual Net Benefit for the plant	$ 2,376,275	$ 2,502,157
Annual Net Benefit for the ex cap	$ 2,528,775	$ 2,654,657
Pay back (years)	1.21	1.15
Net Present Value of investment	$20,719,149	$21,868,273
Equipment Life	20 Years	
Discount Rate	9%	

Table 2: Overall plant benefit

TOTAL BENEFIT			
		Ex-Post Review	
Benefit summary		$/hd From	$/hd To
1.1 Accuracy	Cube-strip separation	$1.47	$1.39
	Cube-chuck separation	$1.18	$1.23
	Vertical Scribes	$2.29	$2.58
2. OH&S benefit		$0.00	$0.00
3. Labour benefit		$0.46	$0.46
4. Equipment costs	**Maintenance contract**	-$0.13	-$0.13
	Electricity costs	-$0.02	-$0.02
	$ Benefit per head	**$5.24**	**$5.50**
$ Annual Benefit overall plant		**$2,528,775**	**$2,654,657**

Contents

1 Introduction

Beef scribes, known as the cutdown saw under manual operation, are the first cuts on a side of beef upon entry or just prior to the boning room. During the scribing process, two vertical and two horizontal cuts are performed, being four cuts in total, as shown in Figure 1. The location and orientation of these cuts are pivotal for the boning process, setting the boundary of all products adjacent to these cuts. The accuracy of these scribe/saw cuts, in part drives primal cut yield and commercial value from the saleable meat yield which is influenced by cut accuracy and the quantity of trimming required. Therefore, only highly trained and experienced operators are allocated to this manual operation to ensure optimised saleable meat yield of the higher value cuts.

The processing plant is highly dependent on manual saw operators. This dependence has created issues including:

- Staffing
    - Finding suitable candidates for skilled roles
    - Retaining operators once skilled in the position
    - The cost of training and recruiting operators
    - Increased labour costs
- Consistency of cutting lines
    - Across a whole shift, from start to finish
    - Between shifts (operators)
    - Between the left and right side of the carcass
    - Between changes in carcase specifications
- WHS risks associated with cutting;
    - Strain related injury
    - Laceration from scribing saw
    - Noise greater than 85db

Automated solutions are being developed to address the challenges of this highly skilled task. The following report assesses the current value opportunity that exists for automation within the constraints of existing manual system and estimates the value automation achieves.

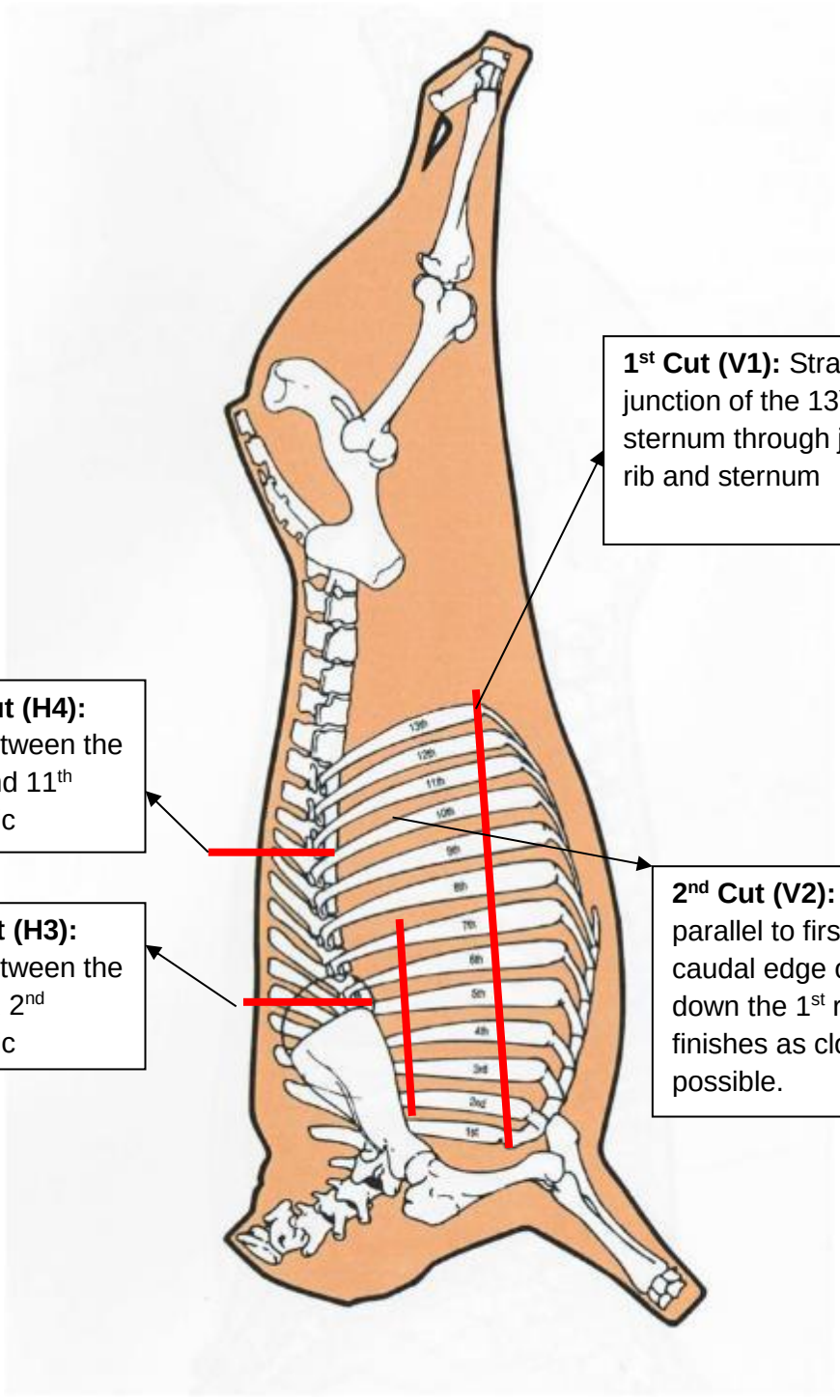

Figure 1: Right hand side of split beef carcass showing location of 4 cutting lines applied by a beef scriber (Source: Greenleaf).

2 Objectives

The objective of this work was to review the manual processing performance against the estimated automation accuracy from the new development of the automated beef boning solution and its impact at the Kilcoy plant including:

- Quantify variance in accuracy of cutting lines completed by the manual operator on each boning chain and shift.
- Quantify the value benefit of the proposed automated system.
- Provide a detailed value benefit and main drivers of return on investment over manual performance, post-automated solution.

3 Methodology

The value created through the installation of an automation systems can be categorised into either processing improvements or increased product value. The processing improvements provides benefits such as increased throughput, WHS cost reductions, labour savings and generally an increased equipment cost. The increasing product value is created by an improvement in accuracy of the location of the cutting line. This improvement tends to provide the highest benefit for the implementation of automation in primary processing areas. The following provides an explanation of the measurements collected during the site visit at KGF's Kilcoy plant.

3.1 Cut accuracy data collection methods

The cutting line accuracy analysis was developed by Greenleaf over the last 10 years. The following outlines the process used to compare millimetre (mm) accuracy to saleable yield of meat on specific cutting lines.

- Development of the cut weight standards: these are a set standard Greenleaf to determine the accuracy across different carcase types. The following process was used for the development of these standards.
    - Cut weight standards require strips of primal cut to be segmented at 5, 10 and 15 mm incasements each side of the cutting line. This facilitates calculating the density of meat either side of the cutting line.
    - The proposed measurements are recorded on this product and aligned with the cut standards to develop regression equations for product weight.
    - The final equation for each cut depends on the variables included in the final accuracy calculation.
- Review of the cut specifications, through discussions with plant staff during the site visit.
    - The customer specification for each cut impacted by automation is reviewed to ensure the anatomical location of measurement aligns with the customer specification.
- Measurements collected to compare accuracy between automation and manual operations to calculate the yield benefit either side of the cutting lines.
    - Standards of measurement are developed. However, measurements collected on the chain may not include all necessary data. Measurements may be refined to ensure data accuracy is maintained.

- The measurements generally follow:
  - Millimetres from an anatomical structure
  - Degrees of cut variation
  - Squareness of cutting lines
  - Area of a cut face

3.1.1 Cube-strip and Cube-chuck separation measurements.

The accuracy of the cube-strip and cube-chuck separation identified the millimetres accuracy from the cranial edge of the 13th rib (1 rib strip) and the caudal edge of the 5th rib (5 rib chuck), as can be seen in Figure 2. Noting that when plants are processing 0 and 3 rib striploins, the location of the measurement changes to reflect the product specification. The measurements completed on these two cutting lines are as follows:

- Width of the total intercostal left between the cutting line and the edge of the rib.
- Width of the remaining intercostal and the rib on the other side of the cutting line.

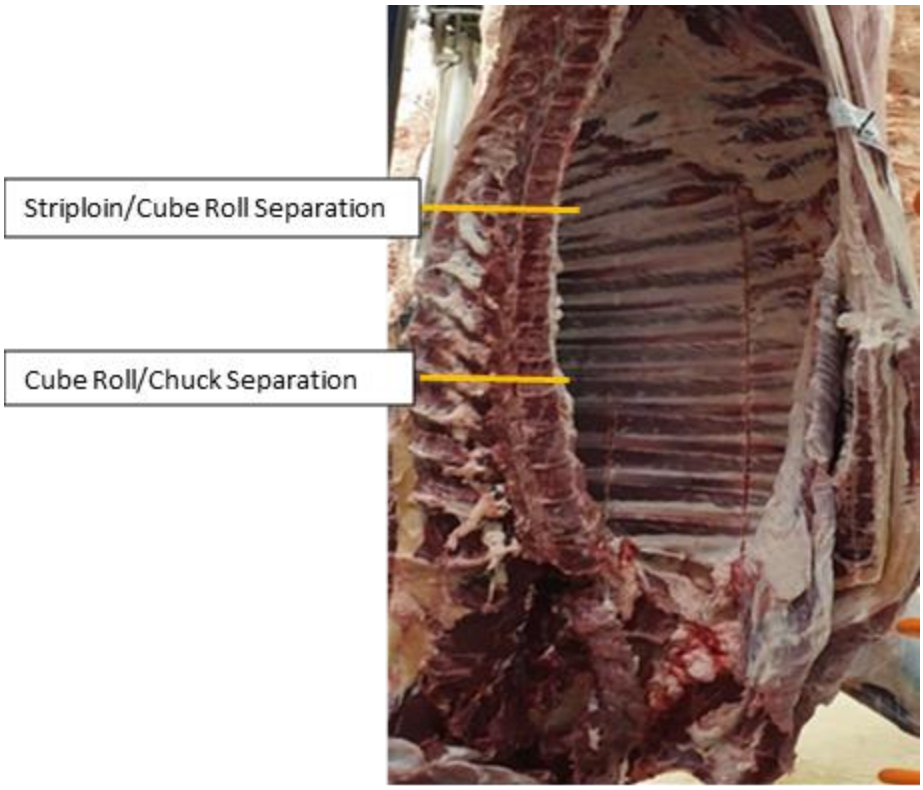

Figure 2: Horizontal and vertical cut accuracy locations (Source: Greenleaf).

3.1.2 Vertical scribes

The accuracy of the two vertical scribes on the carcases impacts on cuts either side of the cutting line and is a more complete calculation. The model has been developed to treat the cap, bone and intercostals on all 13 ribs as a separate entity to ensure the range in product specifications can be calculated for different animal types. The key measurements completed on these cutting lines are as follows:

1. Measurements completed at 1st and 2nd ribs
    a. Distance from brisket scribe to 1st rib-costal arch joint (Figure 3, red arrow)
    b. Distance from chuck/short-rib scribe to edge of vertebrae (Figure 3, green arrow)
    c. Width of chuck rib at 2nd rib (Figure 3, blue arrow)
2. Measurements completed at the 7th rib
    a. Width of brisket (Figure 3, red arrow)
    b. Width of short ribs (Figure 3, blue arrow)
    c. Distance from short ribs to edge of carcases on vertebrae side (Figure 3, green arrow)

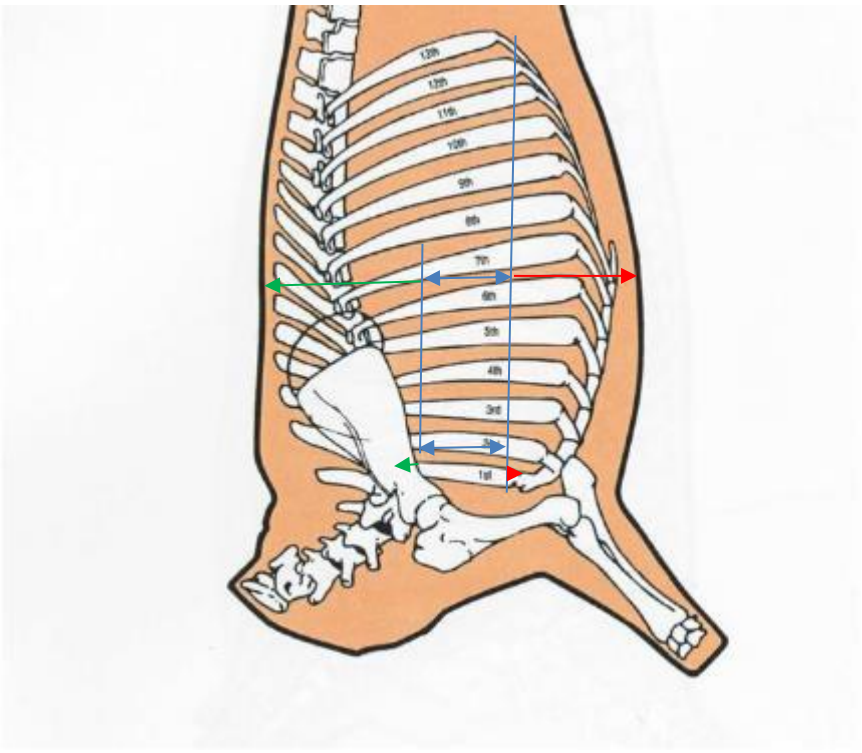

Figure 3: Measurements completed to calculate the accuracy of the vertical scribe cutting lines (Source: Greenleaf).

3.2 Cut pricing

The value of cuts either side of the cutting lines drive the value created by increased cutting accuracy. The cut prices change over time, but the prices shown in Table 3 have been used in the modelling for each animal type. The following split of animals was used to average the benefits accuracy the entire kill.

Table 3: 2024 Cut pricing used for each animal type processed by KGF

Product	Long-fed	Mid-fed	Short-fed
Chuck Flap tail	$ 47.00	$ 16.89	$ 15.49
Chuck Ribs	$ 17.10	$ 11.88	$ 9.90
PE Brisket	$ 14.90	$ 7.38	$ 6.15
NE Brisket	$ 7.83	$ 7.83	$ 6.53
Trim	$ 7.40	$ 7.40	$ 7.40
Intercostals	$ 16.50	$ 16.50	$ 16.50
Brisket bones	$ 1.05	$ 1.05	$ 1.05
Cube roll value	$ 65.97	$ 27.00	$ 21.60
Striploin value	$ 62.89	$ 17.25	$ 13.80
Chuck roll value	$ 33.07	$ 24.80	$ 9.30

3.3 Labour savings

The labour savings associated with the automation system is attributed to removing scribing saw operators from the process, completing their job with the scribing system. Table 4 shows the standard hourly costs for labour at the Kilcoy plant, utilising the level 4 hourly rate in the modelling, with 1 FTE per shift saving for the business.

Table 4: Kilcoy hourly labour rates used in the modelling obtained from the Kilcoy EBA (AG2022/5225).

Employee Classification Level	On the Commencement Date of the Agreement	12 months from Commencement Date of the Agreement	24 months from Commencement Date of the Agreement	36 months from Commencement Date of the Agreement
	$ per hour	$ per hour	$ per hour	$ per hour
Level 7	29.21	30.09	30.99	31.92
Level 6	28.07	28.91	29.78	30.67
Level 5	27.88	28.71	29.58	30.46
Level 4	26.78	27.58	28.41	29.26
Level 3	26.22	27.01	27.82	28.65
Level 2	25.47	26.24	27.02	27.84
Level 1	24.18	24.91	25.65	26.42

3.4 WHS costs

At the time of writing this report there had been no WHS savings included in the benefits. It is anticipated that there would be reduction in strains and sprain injuries and major incidences as part of this project but could not be quantified.

3.5 Fixed model drivers

The benefits achieved by the installation of an automation system is directly linked to the number of animals processed annually through the system. The total weekly volume of 9,650 head with 50 weeks production per year was used in the analysis. Table 5 shows the total volume of animals processed for each scenario modelled. There is no increase in throughput rate achieved by the installation as the boning room is chain driven. Resulting from the location of the scribing saw (between the carcase chillers and the cold marshalling area) there will be no increase in throughput through the boning room.

Table 5: Production figures used for determining production volume base line.

Operation speeds		
	Manual	**Ex-Post Review**
Carcases / min	1.51	1.51
Carcases / Statn./hr	91	91
Carcases / day	1379	1379
Annual days	350	350
Annual # of hd	**482,500**	**482,500**

4 Results

The following outlines the results from the cost benefit analysis from the scribing automation system at the KGF plant.

4.1 Yield analysis – Manual – Ex-Ante Report Detail

The estimated benefit per head and annual gross benefit from the improved accuracy achievable for the installation of the automation system is shown in Table 6. The pre-graded estimated benefit for the automated scribing system is between $3.25 per head and $4.50/head for the automation accuracy of ±5mm and ±2.5mm respectfully. This benefit will be slightly lower if the automation system is installed post grading. The analysis completed in 2011 showed a slightly higher benefit for KGF. The difference is primarily caused by a variation in the value differential for vertical scribing. There has been a general improvement in accuracy, due to process improvements. There is an increased benefit from cube-roll value particularly, which was $1.64/kg, but is now $2.45/kg. Short-fed animals see intercostal values up to $14/kg, short ribs $14.50/kg and brisket $9/kg and brisket bones are $2/kg.

Table 6: Yield gain for the aggregate cut separations for all cuts complete on both sides of the carcase

Benefit from Automation (±5mm)	Total benefit per head	Annual Benefit
Cube/strip separation ($/hd)	$0.89	$428,383
Chuck/cube separation ($/hd)	$1.56	$754,725
Vertical scribing	$0.80	$383,964
Total Benefit	$3.25	$1,567,071

Benefit from Automation (±2.5mm)	Total benefit per head	Annual Benefit
Cube/strip separation ($/hd)	$1.15	$557,272
Chuck/cube separation ($/hd)	$2.42	$1,167,291
Vertical Scribing	$0.92	$445,462
Total Benefit	$4.50	$2,170,025

4.1.1 Cutting line accuracy variation

The manual operators observed at KGF during September 2022 were cutting more accurately than expectations. The automation system is expected to improve the accuracy of cutting lines through advancements in technology. The following section outlines the variance observed between operators on the 4 cutting lines included within this evaluation.

Figure 4 shows the accuracy of the cube-chuck scribing cut completed at entry to the boning room. The accuracy of the night shift operator on Thursday night is cutting more accurately than expectations. The mean improvement accuracy is expected to be between 3.7 and 6.5mm, down to the automation system accuracy of ±5mm, which results in an average of 70 grams additional weight on the cube roll. The 70 grams captures the difference in value between the cube roll and strip loin is $11/kg, for Short-fed animals.

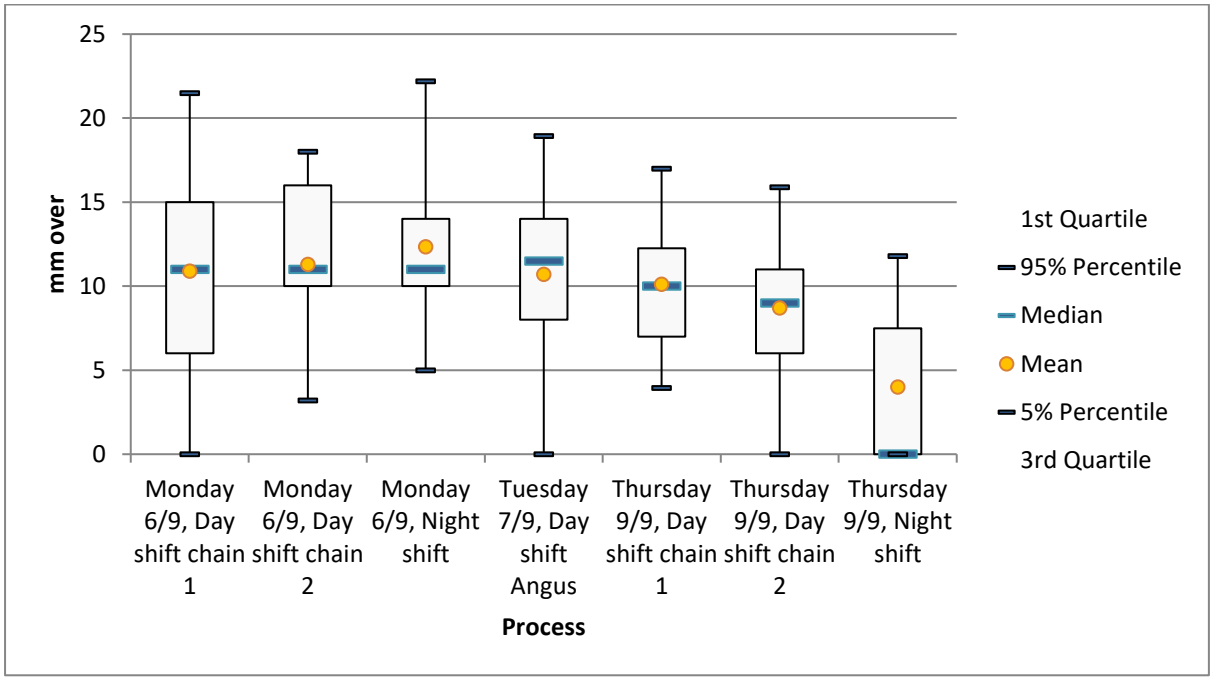

Figure 4: Variation in manual cutting accuracy, cube-chuck separation

Figure 5 and Figure 6 show the variation in accuracy of the cube strip separation, right and left carcase sides, respectfully. The sides of the carcase have been separated to understand the accuracy of the operations on the slaughter floor for the graded side of the carcases and the boning room for the other side. The mean improvement in accuracy of this cutting line is between 4.25 and 13mm of additional yield on the cube roll from the striploin. The value difference between the cube roll and striploin is $8.00/kg resulting in an estimated $0.89 benefit per head.

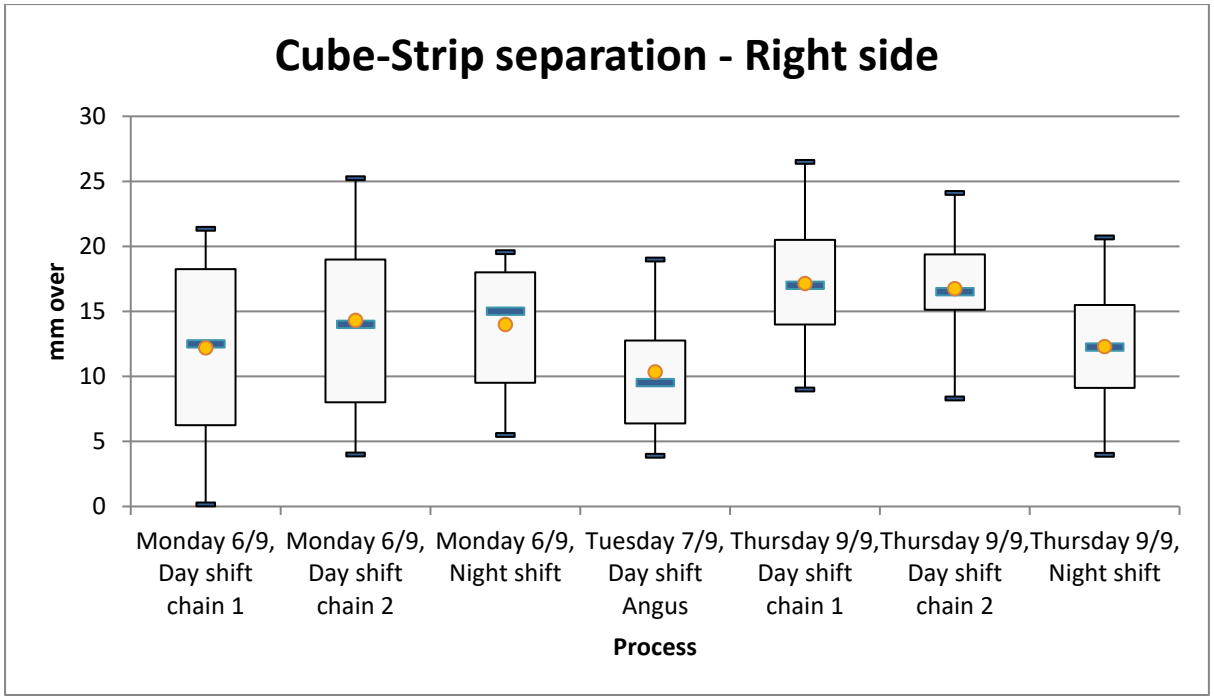

Figure 5: Variation in manual cutting accuracy, right side, cube-strip separation

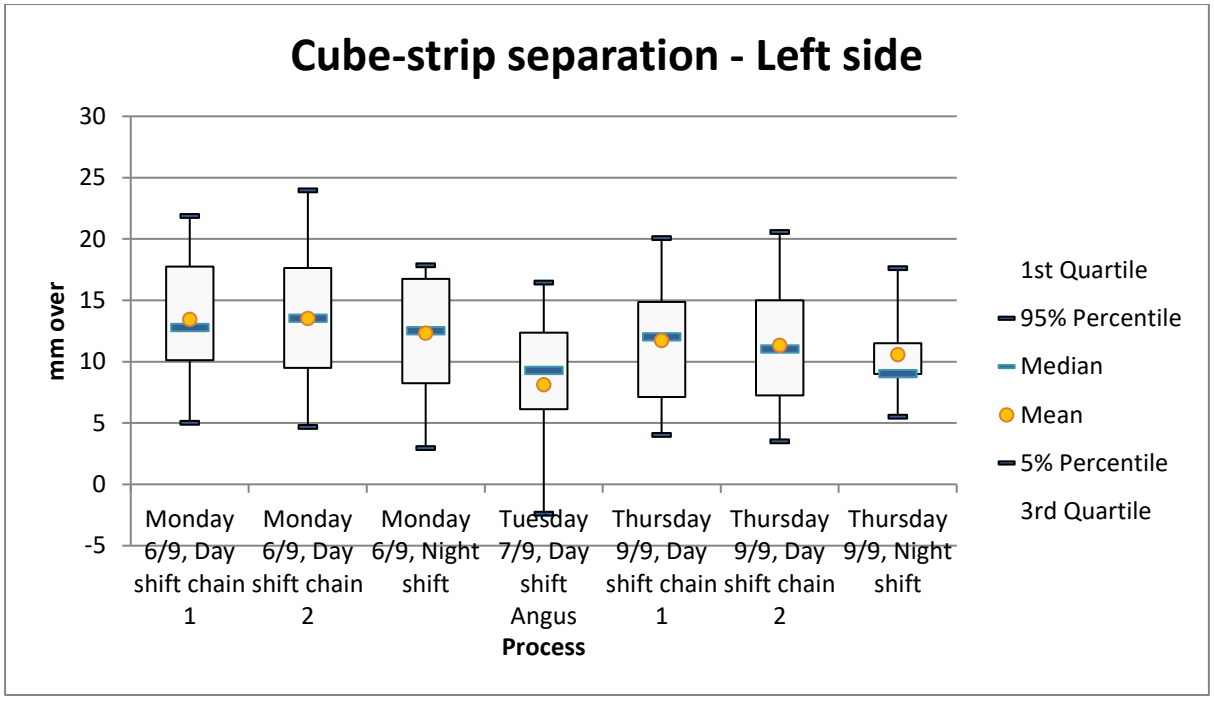

Figure 6: Variation in manual cutting accuracy, left side, cube-strip separation

Figure 7 and Figure 8 show the accuracy of the two vertical scribe lines. There is a minimum gain in value comparing operator accuracy to the expected accuracy of the automation system. The increasing value of the rib section cuts diminishes the benefit achieved through increased accuracy. The estimated $0.80/hd benefits will come by slightly increasing chuck and short rib width, ensuring they stay below 220mm per cut specifications. Most benefit is expected through technology improvement, resulting in increased accuracy, according to observations of operator proficiency and on-site staff discussions.

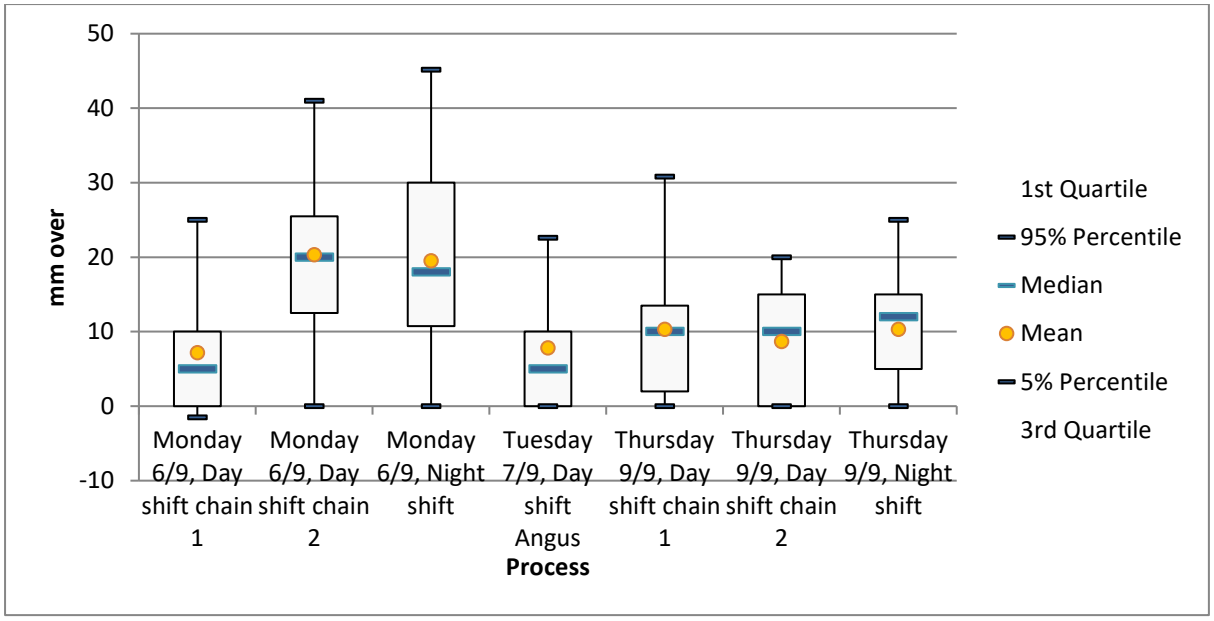

Figure 7: Variation in manual cutting accuracy, brisket scribe

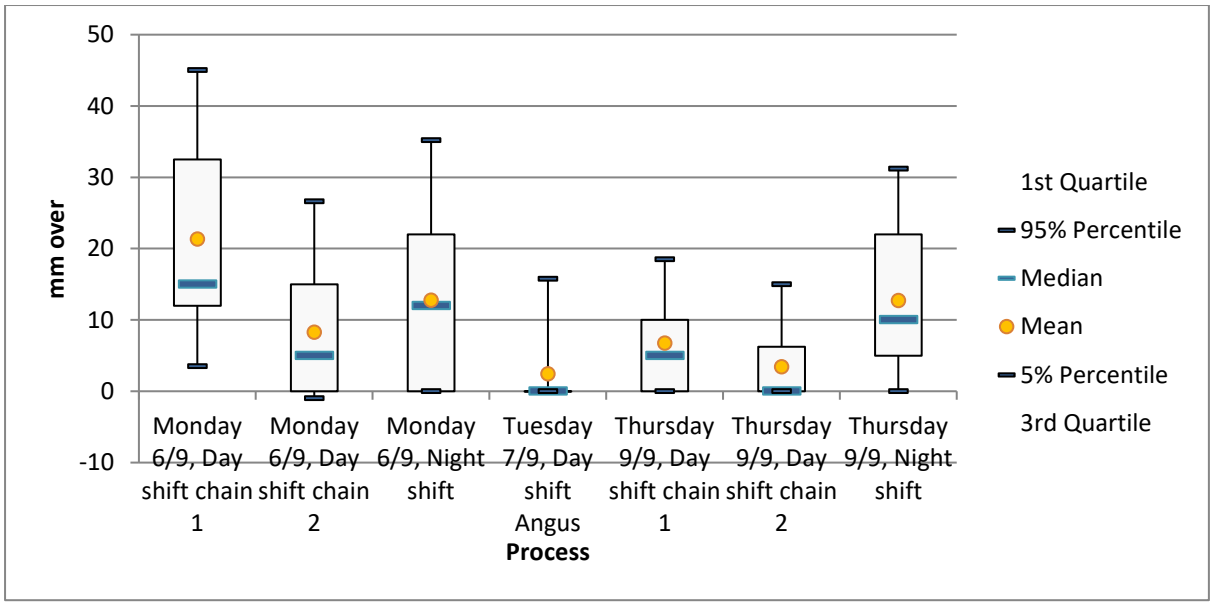

Figure 8: Variation in manual cutting accuracy, short rib scribe

4.2 Cutting line accuracy – Automated vs Manual – Ex-post results

The IR automation system has improved the accuracy of all cutting lines. The following outlines the average benefits for KGF Kilcoy as a result of the overall accuracy improvement for the process. This section of the report outlines the accuracies achieved through the installation of the automated solution.

Table 7: Benefit per head averaged across the three carcase types processed at KGF Kilcoy, which have been pro-rated for the three animal type's production volumes.

TOTAL BENEFIT			
		Ex-Post Review	
Benefit summary		$/hd From	$/hd To
1.1 Accuracy	Cube-strip separation	$1.47	$1.39
	Cube-chuck separation	$1.18	$1.23
	Vertical Scribes	$2.29	$2.58
2. OH&S benefit		$0.00	$0.00
3. Labour benefit		$0.46	$0.46
4. Equipment costs	**Maintenance contract**	-$0.13	-$0.13
	Electricity costs	-$0.02	-$0.02
	$ Benefit per head	**$5.24**	**$5.50**
$ Annual Benefit overall plant		**$2,528,775**	**$2,654,657**

The benefits that have been presented are the result of the accuracy of the automated cutting system. The system is only completing the scribe accuracy the carcases and it needs to be considered that the plant needs to ensure that the boners are utilising the scribe line to maximise the value of the cuts produced from the more accurate marks.

4.2.1 Cube roll-chuck separation

The primary intent of the system is to cut as close to the top of rib 5 as closely as possible to maximise the length of the cube roll. It must also be cut such that a knife can be used to open the cut and separate the cube from the loin. Overcut into the muscle must be minimised.

4.2.1.1 Cut standards development

To calculate the value of the accuracy in cutting lines between the cube roll and the chuck four slices of 10mm each were taken in plant of the cube role on the chuck end to identify the yield weights. These weights were used to calculate the weight different per mm impact that accuracy of the cutting line has between the cube roll and the chuck. The accuracy of each of the animal types processed has almost halved due to the installation of the automation system installation, as seen in Figure 9.

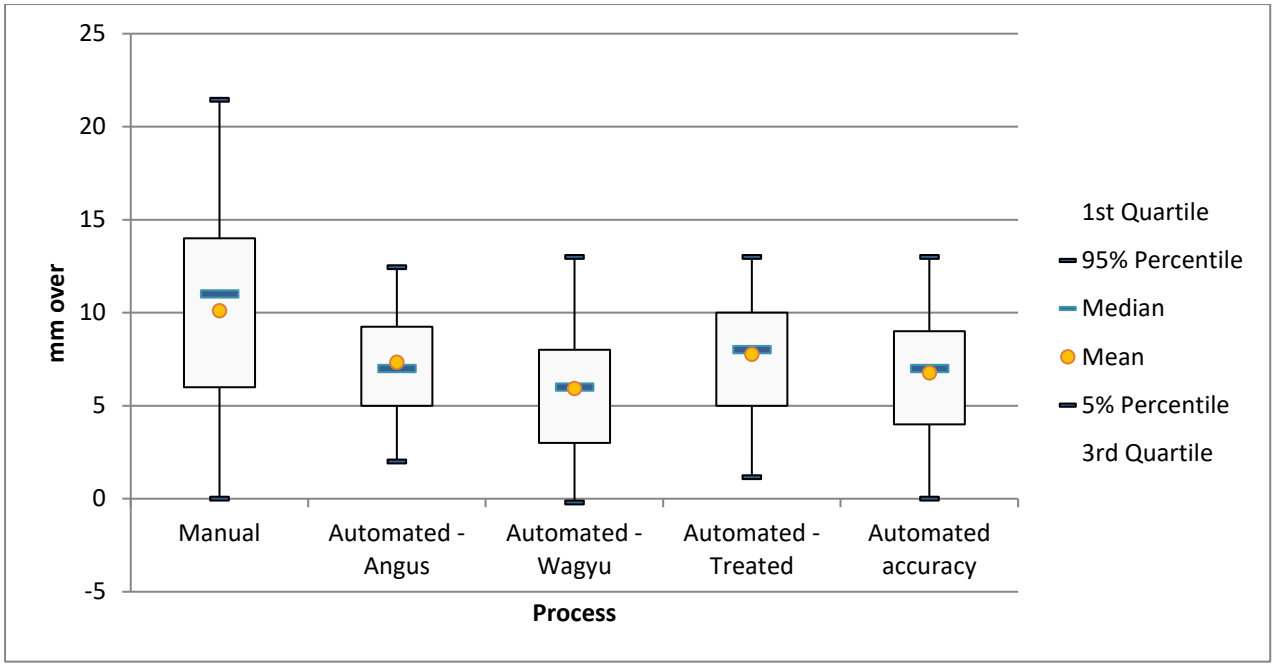

Figure 9: Variation in cutting accuracy for the cube-chuck separation of the automated and manual cutting lines.

4.2.1.2 *Product benefit to plant*

The impact of the cube roll and chuck separation was calculated for each carcase type and presented in Table 8 for the carcases processed at Kilcoy plant.

Table 8: Benefit calculations from the cube-chuck separation

Cube roll to Chuck roll separation			
Variable	**Long-fed**	**Mid-fed**	**Short-fed**
Cube roll value	$ 65.97	$ 27.00	$ 21.60
Chuck roll value	$ 33.07	$ 24.80	$ 9.30
Cube roll cap value (65 CL trim used)	$ 4.28	$ 3.98	$ 4.12
Cube-strip	$ 32.90	$ 2.20	$ 12.30
Cube roll cap -Strip	-$ 28.79	-$ 20.82	-$ 5.18
EMA	96	84	78
EMA ratio	106%	93%	86%
HSCW	442	407	370
Cube cap portion	22%	22%	22%
Weight per mm	16.9	14.8	13.8
Sides per carcases	2.0	2.0	2.0
Manual mean (mm)	8	8	8
Automation mean (mm)	5	5	4
Cube roll yield	2.35	2.78	3.56
Cube weight	0.08	0.08	0.10
Cap-weight	0.02	0.02	0.02
Benefit per head ($)	$ 2.12	-$ 0.20	$ 1.09
Cube roll	$ 2.62	$ 0.18	$ 1.21
Cube roll cap	-$ 0.50	-$ 0.38	-$ 0.11
Number of head processed	25,000	40,000	415,000
Benefit per animal type	$ 52,974	-$ 7,813	$ 453,962
Total Annual benefit			$ 499,124
Overall benefit per head			$ 1.04

4.2.2 Cube-Striploin Separation

The cube-roll striploin separation is the separation of carcases is based off the carcase being scribed between the either the 10/11th, 12/13th or above the 13ths scribe of the carcases, when counting from the forequarter. The system has been developed to scribe the ribs on the caudal edge of the intercostal between the designed rib. The following section outlines the benefits achieved through the improved accuracy from automating the scribing lines.

4.2.2.1 Cut standards development for cube striploin accuracy

To develop the cut standards for the cube and striploin to calculate the impact of accuracy the trim and fat was removed. The separation between the cube roll and the striploin is not a 1 to 1 relationship, as the cube is removed from the cube-roll. As can be seen in Figure 10, the split is about 87%, where 13% of the product is cap packed as fat & trim and the remaining 87% is packed as cube roll. This is factored into the eyelid benefits for this cutting line.

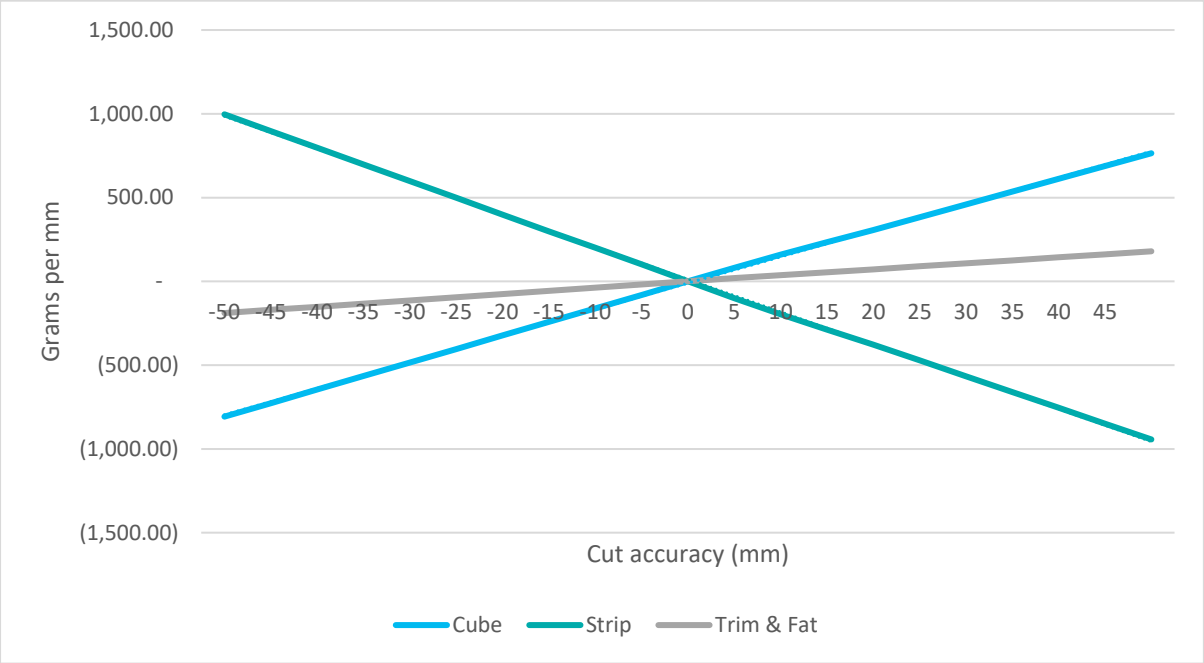

Figure 10: The grams per mm for the cube roll and striploin separation, as seen the cube to striploin is not a 1 to 1 relationship as the cap is removed from the striploin.

4.2.2.2 System accuracy

The zero-rib point is the edge of the rib on the striploin side of the intercostal which allows the boner to accurately separate the cube-chuck when quartering the carcases. The increased variation in Long-fed measurements can be attributed to the variation in rib angle with relation to the vertebrae, resulting in varying heights for the top of the rib tubercle relative to the top of the body of the rib. The heavier forequarters in Long-fed can lead to varying amounts of tearing/stretching in the flank pre-rigor, causing a larger variation in the rib angle. This is coupled with the biology of the Long-fed bodies, being more 'barrel-chested' with deeper rib cages than the other categories of beef processed. As shown in

Figure 11 the overall result for the business is a much greater accuracy and an improved separation of the carcase by cutting lines with all carcases having improved cutting lines due to automated scribing.

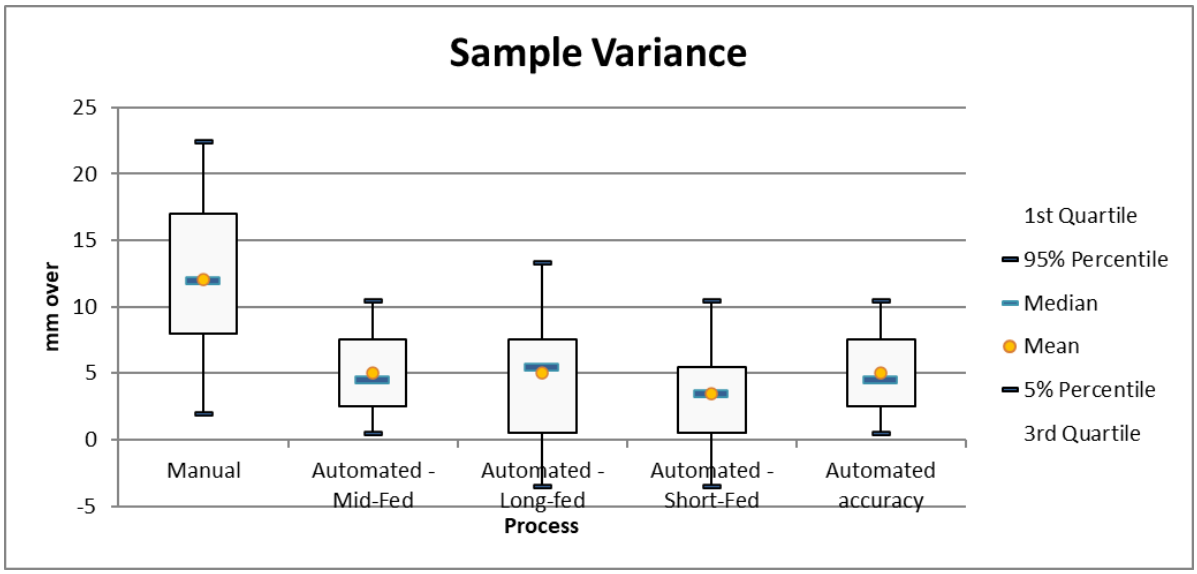

Figure 11: Variation in cutting accuracy for the cube-strip separation of the automated and manual cutting lines

4.2.2.3 Plant benefit for cube and striploin separation

The value differential between the cube and striploin separation was calculated from the grams per mm achieved by both the manual or automated systems for both sides of the carcase and presented in Table 9. The value of the separation between the cube and strip needs to be considered by carcase type. The current setting on the scribing system for the cube strip separation has the saw going through on the caudal edge of the rib which increases the yield and revenue for Mid-Fed and Short-fed carcases. The cutting accuracy on Long-fed is increase the yield of the cube roll however, with the current marketing pricing the positioning is reducing the overall carcases revenue. This is beneficial to the business a the cutting line can be altered between the caudal to the cranial edge of the rib as the market pricing changes. This just requires the operator to be informed on when to change the location of the cutting line from the marketing team as the market prices change.

Table 9: Cube to striploin separation benefit calculations

Cube Roll to Striploin			
Variable	**Long-fed**	**Mid-fed**	**Short-fed**
Cube roll value	$ 65.97	$ 27.00	$ 21.60
Striploin value	$ 62.89	$ 17.25	$ 13.80
Cube roll cap value (65 CL trim used)	$ 7.40	$ 7.40	$ 7.40
Cube-strip	$ 3.08	$ 9.75	$ 7.80
Cube roll cap -strip	-$ 55.49	-$ 9.85	-$ 6.40
EMA	96	84	78
EMA ratio	123%	108%	100%
HSCW	442	407	370
Cube cap portion	19%	19%	19%
Weight per mm	19.6	17.1	15.9
Sides per carcases	2.0	2.0	2.0
Manual mean (mm)	12	12	12
Automation mean (mm)	5	5	3
Cube roll yield	7.03	6.97	8.54
Cube weight	0.28	0.24	0.27
Cap-weight	0.05	0.05	0.05
Benefit per head ($)	-$ 2.05	$ 1.88	$ 1.79
Cube roll	$ 0.85	$ 2.33	$ 2.12
Cube roll cap	-$ 2.90	-$ 0.45	-$ 0.33
Number of head processed	25,000	40,000	415,000
Benefit per animal type	-$ 51,337	$ 75,353	$ 743,166
Total Annual benefit			$ 767,181
Overall benefit per head			$ 1.60

4.2.3 Vertical scribe accuracy

Three vertical scribe settings that can be utilised on the IR scribing system are shown in Figure 12. The first image (image 12.1) is the full scribe on the on the ventral and a part scribe on the dorsal. Image 12.2 on the right is a full scribe on the ventral and the dorsal. Third image (12.3) is a full scribe on the ventral and no scribe on the dorsal. The ventral scribing line isn't changed over the dorsal scribe is altered depending on the cuts being produced. For tomahawks there is no dorsal scribe undertaken. The system is currently not set up to auto select carcases for OP ribs or tomahawks.

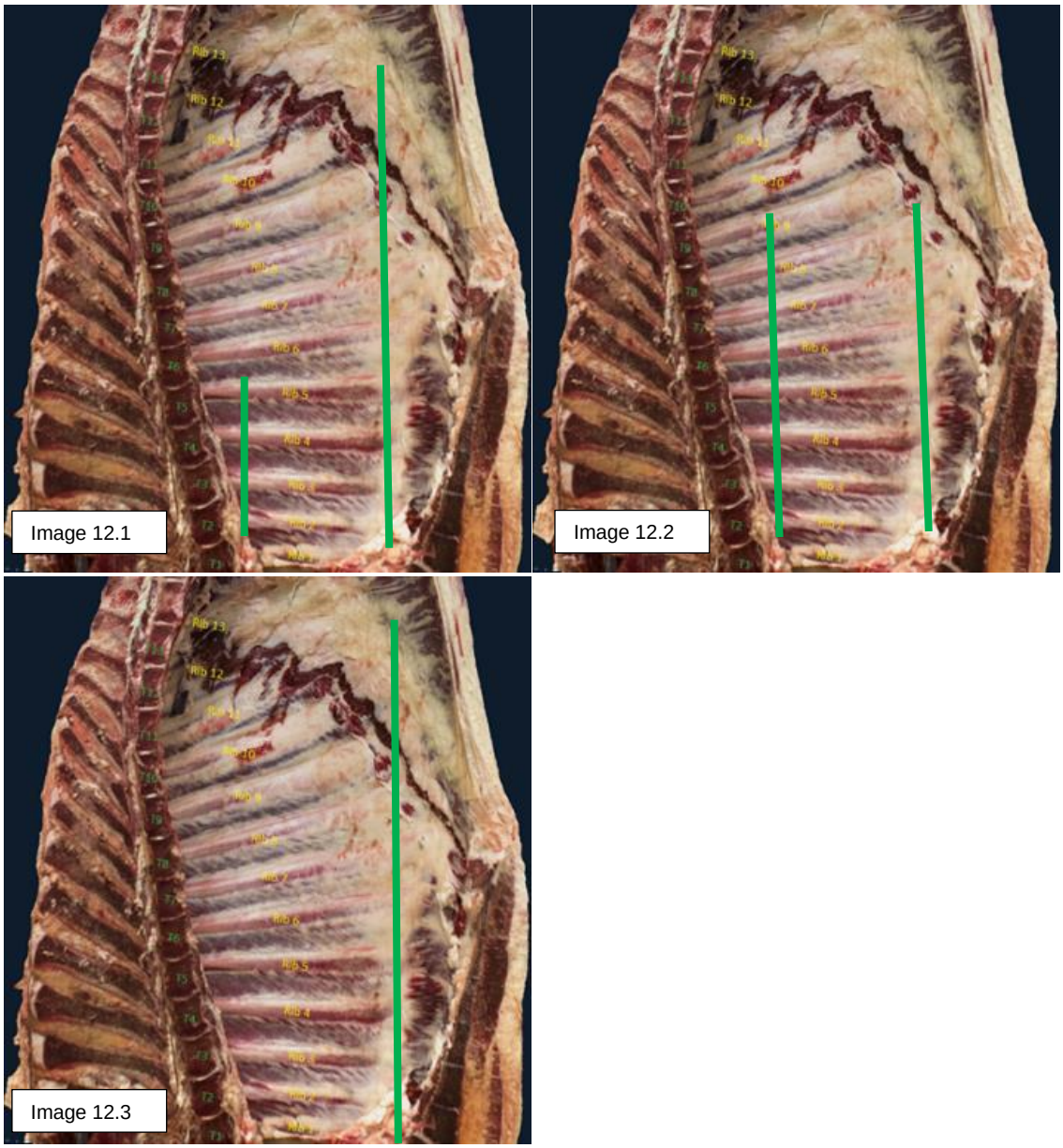

Figure 12: Scribing line options (Source Intelligent Robotics).

4.2.3.1 Standard Development

The standards developed on the two vertical scribing lines has been completed, resulting from the yield gains either side of the chuck and short rib sections. The following outlines the variation in products and weights included within these standards. The standards were developed by removing a 10mm slice from either side of the cutting lines and separating the different products.

- Chuck rib section of the forequarter, see Figure 13. The following are the separation of products between the chucks and other products on the cranial end of the forequarter
    - Dorsal cutting line (shown by line A1 & A2 in figure 13) is from Chuck ribs to rib bones, intercoastal or trim and chuck flap tail. The A1 line shows where the cutting line would have been historically placed with the manual operation, However, with the automated scribing saw the scribe is now positioned closer to the vertebrae as shown in A2.
    - The Ventral cutting line (shown by B in figure 13) goes from Chuck ribs to intercostals, point-end brisket and bones.
- Short rib section of the forequarter, see Figure 14. The following is the split of products from the scribing lines on the caudal end of the forequarter.
    - Dorsal cutting line (see line A on Figure 14) is from short ribs and trim to Trim, intercostals and bone, or back ribs rather than intercostals and bone. This cut is not completed when they are production OP ribs or tomahawk.
    - The ventral cutting line (shown by the cutting line B on Figure 14 is from short ribs and trim to navel end brisket, rib bones and intercostals.

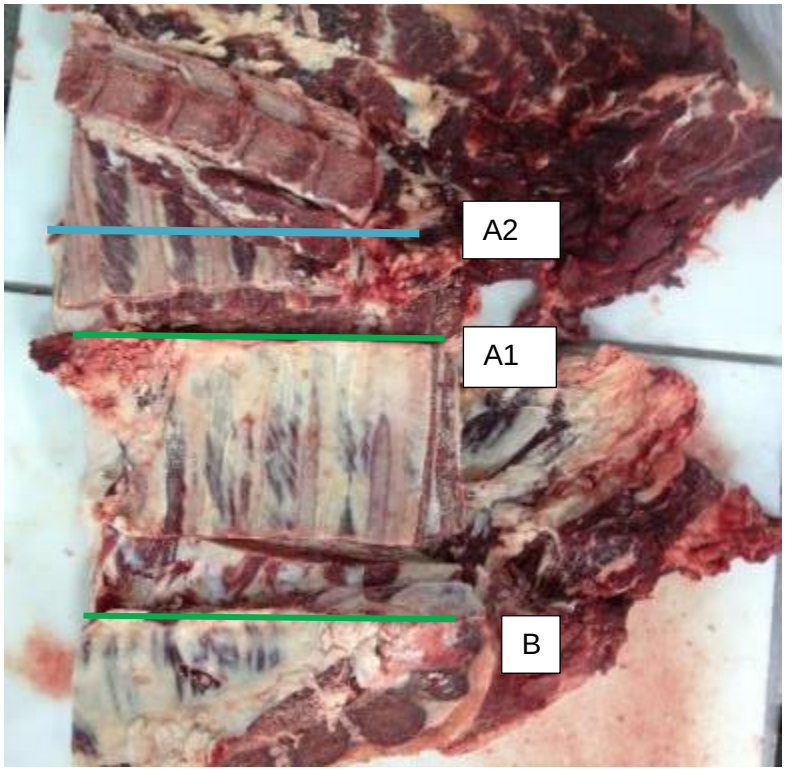

Figure 13: Chuck end of the forequarter breakdown, A represents the Dorsal scribe with the Manual system but the bule line (A2, shows the new position of the scribing line through the installation of the automated system. Line B showing the Ventral scribing line (Source: Greenleaf).

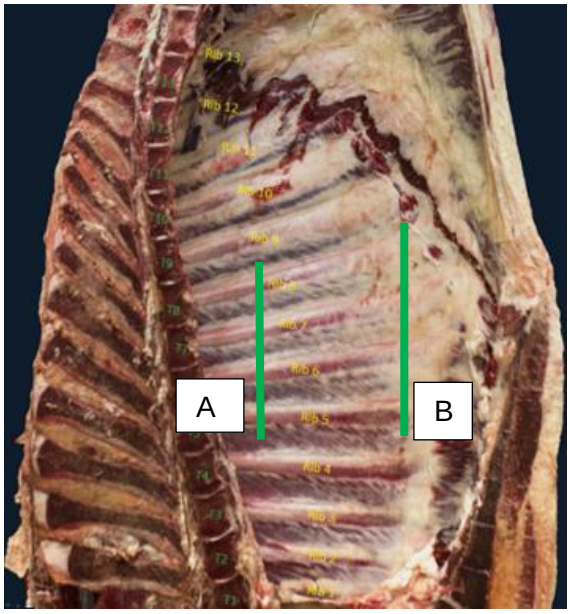

Figure 14: Cutting lines on the caudal end of the forequarter (Source Intelligent Robotics).

4.2.3.2 Cut Accuracy

The accuracy of the vertical scribes by the automated solution has improved the overall accuracy of the cutting lines. Figure 16 shows the accuracy of cutting line through the joint between the first rib and the breastbone and Figure 18 show the accuracy or the short/chuck rib scribe at the first rib.

- Brisket scribe
    - This has always been one of the harder cuts to get accurate but as can be seen in Figure 15 the system has been developed with a high degree of accuracy.
- Chuck-short rib scribe
    - The scribes were not being completed on Long-fed carcases due to them being packed as Tomahawks, thus were excluded from the calculations and results shown in Figure 18.
    - The system has been designed to enable the end affecter to be rotated to allow the scribing saw to get as close to the vertebrae bone as possible. This, in addition, to the ability to see the vertebrae bone very clearly on carcases has enable IR to accurately identify this point and cut closer to this point that a manual operator, which is shown in Figure 18.

Figure 15: Ideal cutting line point for the brisket scribe through the join on the end of the first rib

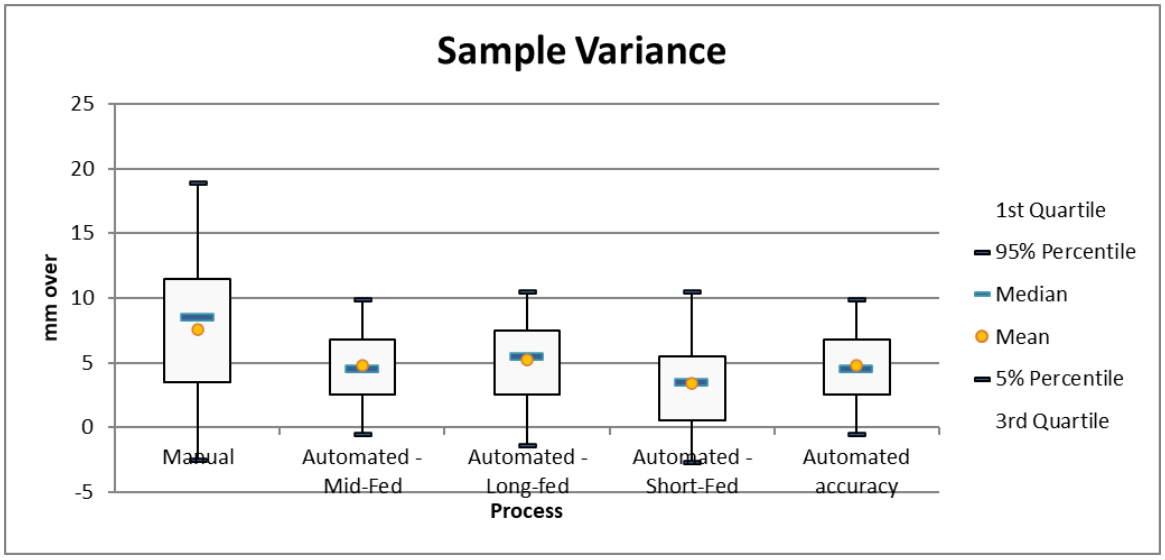

Figure 16: Variation in cutting accuracy for the vertical brisket scribe, based on the joint between the 1st rib and the breastbone

Figure 17: Ideal cutting location of the dorsal scribe of the ribcage.

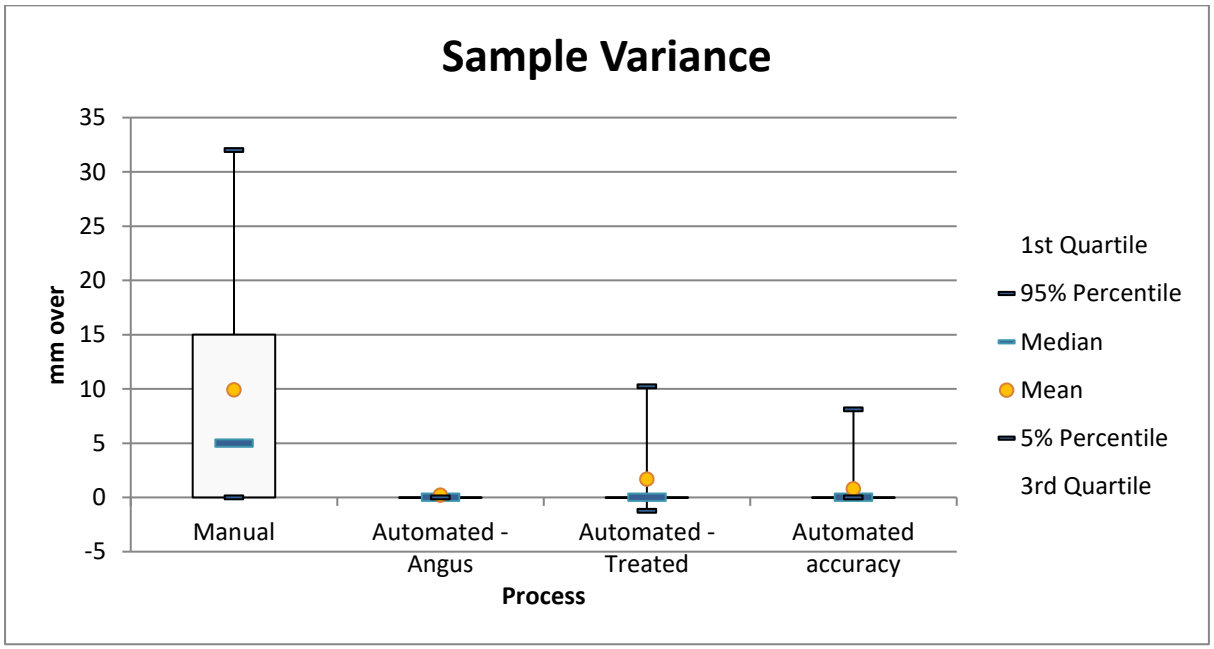

Figure 18: Variation in cutting accuracy for the chuck and short rib scribe, based on the point of the breastbone

4.2.3.3 *Financial Benefits*

The financial benefits for each of the carcase types are provided based on the improvement of accuracy from the IR scribing system. As can be seen in Table 11, the benefit per head for each animal type is between $2.19 and $3.75/head for Mid-Fed and Long-fed respectively. This benefits results from the 2 segments of each cutting line as shown in tables Table 10 and Table 11. The net benefit for this cutting line for the business is $1,097,075/year.

Table 10: Average benefits from the improvement in accuracy of the ventral rib scribe by carcase type

Chuck Ribs to PE Brisket			
Variable	Long-fed	Mid-fed	Short-fed
Chuck rib + PE Brisket	0.19	0.14	0.14
Chuck ribs to bone	0.02	0.02	0.02
Chuck ribs to intercostals	0.02	0.02	0.02
Chuck rib + PE Brisket	$ 0.41	$ 0.61	$ 0.53
Chuck ribs to bone	$ 0.40	$ 0.20	$ 0.17
Chuck ribs to intercostals	-$ 0.04	-$ 0.16	-$ 0.20
Total Benefit	$ 0.77	$ 0.64	$ 0.51

NE Brisket to Short ribs			
Variable	Long-fed	Mid-fed	Short-fed
NE brisket to short ribs	0.04	0.04	0.04
NE Brisket to Trim	0.08	0.08	0.08
Short Ribs to bone	0.06	0.06	0.06
Short Ribs to intercostals	0.01	0.01	0.01
NE brisket to short ribs	$ 1.16	$ 0.50	$ 0.53
NE Brisket to Trim	-$ 0.29	-$ 0.31	-$ 0.19
Short Ribs to bone	$ 1.95	$ 1.05	$ 1.02
Short Ribs to intercostals	$ 0.16	$ 0.03	$ 0.02
Total Benefit	$ 2.98	$ 1.27	$ 1.37

Table 11: Average benefit from the improved accuracy of the dorsal rib scribe by carcase type

Chuck Ribs to Chuck flap tail			
Variable	**Long-fed**	**Mid-fed**	**Short-fed**
Chuck rib + Chuck flap tail	-	0.14	0.12
Chuck ribs to bone	-	0.02	0.02
Chuck ribs to intercostals	-	0.02	0.02
Chuck rib + Chuck Flap Tail	$ -	-$ 0.70	-$ 0.66
Chuck ribs to bone	$ -	$ 0.25	$ 0.17
Chuck ribs to intercostals	$ -	-$ 0.10	-$ 0.13
Total Benefit	$ -	-$ 0.56	-$ 0.62

Cube roll section to Short ribs - 3 ribs only			
Variable	**Long-fed**	**Mid-fed**	**Short-fed**
Trim to short ribs	-	0.03	0.03
Trim to Trim			
Short Ribs to bone	-	0.02	0.02
Short Ribs to intercostals	-	0.01	0.01
Trim to short ribs	$ -	$ 0.50	$ 0.48
Trim to Trim	$ -	$ -	$ -
Short Ribs to bone	$ -	$ 0.44	$ 0.43
Short Ribs to intercostals	$ -	$ 0.03	$ 0.03
Total Benefit	$ -	$ 0.98	$ 0.93
Overall benefit	$ 3.75	$ 2.33	$ 2.19
Annual Benefit	$ 93,726	$ 93,313	$ 910,036

4.3 Equipment costs

The Ex-works capital cost of the automated scribing system was $3.05 million which is the estimated ex-works price provided by Intelligent Robotics. The return on investment is based on these costs. It is also expected that the upkeep cost of the system will be $63,800 per year of the maintenance service contract and $6,730/year increase in electricity costs. The breakdown of these costs can be seen in Table 12. The actual capital costs will vary between plant to plant as a result of the ability to fit the system into the plant. The electricity usage for the automated system is 8.46KW which is based off the actual system usage tested by the plant. The manual usage is based off utilising 2 manual scribing saws.

Table 12: Estimated capital and operating costs of the IR Scribing system

Capital Cost	Manual		Ex-Post Review	
	Cost	Life span	Cost	Life span
Capital Cost of the equipment			$ 3,000,000	20
Essential and insurance spares			$50,000	20
Other Capital install				20
Total			**$3,050,000**	
Service maintenance	**Manual**		**Ex-Post Review**	
	Units	Cost	Units	Cost
Estimated - COSTS				
Electricity	3.40 KW	$0.25 /KWH	8.46 KW	$0.25 /KWH
Maintenance labour (Daily)		0.00 /Yr		$ -
Maintenance labour (Preventative)		0.00 /Yr		$ -
Maintenance labour (Breakdown)		0.00 /Yr		$ 63,800
Maintenance labour (Training)		0.00 /Yr		$ -
Operational		**$4,522**		**$11,252**
Maintenance		**$0**		**$63,800**
Annual Sub Total (excluding major overhaul costs		**$4,522**		**$75,052**

4.4 Cost benefit analysis results

System benefits produce income by an increase in saleable meat yield due to less trimming. Table 13 summarises each scenario benefit and the return on investment the system provides the processing plant. The ROI for the installation of the automated scribing system is between 1.15 and 1.21 years, resulting from a gross benefit per head of $4.92 to $5.19.

Table 13: Summary of benefits for the vertical scribing system

SUMMARY PERFORMANCE MEASURES	
	Ex-Post Review
Hd / annum	482,500

	From	To
Capital cost (pmt option, upfront)	$3,050,000	
Gross return Per head	$5.40	$5.66
Total costs Per head	$0.47	
Net Benefit Per head	$4.92	$5.19
Annual Net Benefit for the plant	$ 2,376,275	$ 2,502,157
Annual Net Benefit for the ex cap	$ 2,528,775	$ 2,654,657
Pay back (years)	1.21	1.15
Net Present Value of investment	$20,719,149	$21,868,273

Equipment Life	20 Years
Discount Rate	9%

The benefits identified can be broadly summarised as driven by increases in product value as shown in Table 14; there is little benefit due to improved processing efficiency. Table 14 shows how product value drives benefit for each scenario. Because processing costs are assumed to be fixed (labour and equipment are shown to be standard across each scenario), product value determines the variation in benefit derived from the scribing system.

Table 14: Breakdown of benefits and costs by area expected as a result of the installation of the system

Benefit Drivers for System		
	Ex-Post Review	
	$/ hd	$/ annum
Processing	$0.30	$145,220
Product value	$5.07	$2,446,496
	$5.37	**$2,591,716**
Cutting accuracy	$5.07	$2,446,496
Throughput	$0.00	$0
OH&S	$0.00	$0
Equipment costs	-$0.16	-$75,052
	$5.37	**$2,591,716**

A summary of the range in costs and benefits for each scenario are included in Table 15.

Table 15: Ex-post costs and benefits breakdown for the current throughput

COST - BENEFIT ANALYSIS OF SYSTEM		
	Ex-Post Review	
Benefit summary	$/hd	
	From	To
$ Accuracy Benefit per head	$4.94	$5.20
$ Technique Benefit per head	$0.00	$0.00
$ Labour Benefit per head	$0.46	$0.46
$ Overall Benefit per head	**$5.40**	**$5.66**

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

COST ASSOCIATED WITH OPERATING SYSTEM	
	$/hd
Capital cost	$0.32
Maintenance	$0.13
Operation	$0.02
Risk of mechanical failure	$0.00
Total cost per head	$0.47
Total cost per head (EX CAP)	$0.16

Table 16 shows the system's expected annual value for one processing plant, based on the assumptions used throughout the report. The cost is calculated as any loss from the maximum possible benefit. Presenting the figures this way in the detailed section of the model demonstrates the total costs involved and highlights areas in which future savings could be generated. Should there be variation in the costs for individual plants, the model can be updated to reflect values consistent with their operating costs.

Table 16: Summary results of individual savings associated with each cut

TOTAL BENEFIT			
		Ex-Post Review	
Benefit summary		$/hd From	$/hd To
1.1 Accuracy	Cube-strip separation	$1.47	$1.39
	Cube-chuck separation	$1.18	$1.23
	Vertical Scribes	$2.29	$2.58
2. OH&S benefit		$0.00	$0.00
3. Labour benefit		$0.46	$0.46
4. Equipment costs	**Maintenance contract**	-$0.13	-$0.13
	Electricity costs	-$0.02	-$0.02
	$ Benefit per head	**$5.24**	**$5.50**
$ Annual Benefit overall plant		**$2,528,775**	**$2,654,657**

5 Key Findings

The IR automated scribing system are the first cuts on the carcase to guide the removal of the primals. The accuracy of these cuts can increase the weight of the primals with higher value and reduce the trimming required. The scribing system has been developed to cut through the vertebrae to support the boners in providing guidance and in reducing the effort required. The IR scribing system has improved accuracy than a manual operator with a payback period of less than 1.21 years.

The dropped flanks and fat thickness of the Long-fed carcases reduce the accuracy for this carcase type compared to the mid-fed and short grain fed carcases. The cutting accuracy on long-fed is increasing the yield of the cube roll however, with the current marketing pricing the positioning is reducing the overall carcases revenue. This is beneficial to the business as the cutting line can be altered between the caudal to the cranial edge of the rib as the market pricing changes.

Improvement of benefits associated with installation of the system include

- Less manual labour for beef scribing / saw operators reducing repetitive strain injury and the dangerous task of saw operation.
- Improved accuracy particularly for the chuck and short rib scribe over manual operators.
- Payback period <2 years which is required by processing sector to invest in new technologies.
- Accurate vertical scribes – equidistant between the scribes
- Ability to maintain chain speed

6 Appendix

6.1 List of Tables

6.2 List of Figures