Milestone Report – Cost benefit analysis

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Prepared By:	K. Fanning Greenleaf Enterprises
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Milestone Report – Cost benefit analysis of bone belt DEXA OCM mass balance yield DEXA system

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Executive Summary

A cost benefit analysis was undertaken for a DEXA waste belt monitoring system. Measurements of material that could be recovered from the waste belt were undertaken at Teys Beenleigh boning room. The total opportunity (gross) for a system is $15.15/hd, with 67% from recovering trim from fat (improved slicing, trimming and handling performance), 32% meat from bones (improved boning performance) and 1% from recovery of saleable meat/large pieces of trim.

Three levels of system capability were considered for determination of net benefit:

- ‘Alarm only’ – ability to identify pieces of saleable meat and trim and alert supervisor.
- ‘Alarm + CL fat’ – ability to identify pieces of saleable meat and trim, as well as continuous measurement and monitoring of CL of all material on fat belt.
- ‘Alarm + CL fat + CL bone’ – ability to identify pieces of saleable meat and trim, continuous measurement and monitoring of CL of all material on fat belt, as well as continuous measurement and monitoring of CL of all material on bone belt.

The likely net benefit (summarised as midpoint of the ranges for the three sizes of boning room considered) for each system was $0.93/hd (Alarm only), $3.08/hd (Alarm + CL fat), and $4.66/hd (Alarm + CL fat + CL bone). Medium to large boning rooms (≥200,000 hd/annum) would achieve payback within 1.5 years for an ‘Alarm + CL fat’ system. However smaller boning rooms (~100,000) would require the extra benefit of an ‘Alarm + CL fat + CL bone’ system to achieve payback by 1.5 years.

Based on the current functionality of DEXA system tested by Scott Automation, a system could technically continuously measure and monitor CL of material on fat belt. However, continuous measurement and monitoring of CL of bone requires further work, including mechanical singulation of material and development of suitable algorithm and accompanying software to calculate CL. Based on this, it is recommended that a DEXA system, as a first stage, be installed on fat belt. This system would be able to ‘see’ all saleable meat and trim, responsible for 68% of gross opportunity, and operate to alarm supervisor to specific pieces of meat/trim for recovery and alert supervisor when CL threshold of material on belt was reached.

A DEXA system monitoring the fat belt would provide a system fix that would drive improved performance. This system would allow 100% supervision of the fat belt, giving protection to that particular part of the business whilst freeing supervisors from manually monitoring the belts. Furthermore it would provide supervisors with specific examples and performance information to improve suboptimal performance and reward high performance.

Contents

1 Introduction

1.1 Background

The purpose of this project was to carry out a cost benefit analysis on the recently upgraded carton inspection machine at Teys. Earlier milestones in this project were for Scott Automation & Robotics to utilise an existing single energy x-ray (SEXA) carton inspection machine supplied by Teys, overhaul and upgrade it to a dual energy x-ray (DEXA) system and re-install it in a Teys facility to provide a live and continuous red meat, fat and bone on the bone belt on a kilogram measurement basis.[1]

Within a boning room carcases are weighed into the boning room and finished carton product is weighed out of the boning room resulting in an open mass balance yield to be ascertained. Currently most plants run on an open mass balance basis:

- cold carcass weight = saleable product + waste.

There is an approximate acceptable ratio of saleable product to waste for this equation, which varies across a number of factors; including livestock breeds, size ranges and cuts produced. The waste value of this equation is floating and only measured in bulk at rendering and is not an accurate measure at this point.

Introducing a reliable measurement of the waste output closes this equation. By apportioning the masses of bone, fat and meat from the waste stream, a boning room becomes accountable for its performance and output standards. Validation of the amount of red meat sent to waste can identify which cuts and techniques are more or less effective at producing maximum saleable yield. Currently this is done by supervisors within the boning room. This system if successful will assist the supervisors by alarming or stopping the waste belt should a pre-set tolerance be exceeded, this effectively provides 100% supervision of fat and bone waste belts without the need to allocate a supervisor to this task fulltime.

2 Objectives

The overall objective of this milestone was to undertake a cost benefit analysis of a DEXA waste belt monitoring system.

3 Methodology

3.1 Value propositions investigated

In discussion with Teys the areas identified for investigation were:

- Benefit of recovering saleable meat and large pieces of trim
- Benefit of reducing meat left on bones as a result of suboptimal boning performance
- Benefit of recovering/reducing meat that is attached to fat, on fat belt.

[1] P.PIP.0471 final report: Bone belt DEXA OCM mass balance yield system – stage 1. J Cook & M Shirazi, Scott Automation and Robotics. 17 Feb 2017.

3.2 Bone belt measurements

Measurements were undertaken in Teys Beenleigh boning room across 5 shifts (3 morning, 2 afternoon) on 3 separate days (28 July, 3 August, 7 August). A position was assumed on the waste belt to view all bones and fat exiting the boning room and going to render or meal production. The list of measurements undertaken included:

- Weight, type and frequency of saleable meat and/or large pieces of trim (~85CL) that was incorrectly on the bone belt
    - Material was removed from belt, identified and weighed
- Weight of meat left on bones that should have been removed according to a 'good boning performance'
    - Bones were trimmed (meat that should have been removed by boning; bones weren't completely stripped of all meat) and weight of meat was weighed
- Weight of 85CL trim that could be recovered from fat/trim that was on belt and going to render
    - Weight of fat/trim material was estimated by collecting material over a timed period to determine a kg/head of fat/trim on belt
    - Tubs of 20-25 kg of material going to render were collected from belt (Figure 1) and then 85CL trim was recovered and weighed (Figure 2).

Figure 1: Tub of fat/trim collected from bone belt

Figure 2: 85CL trim recovered from tub of fat/trim

- Frequency of clumps of bones and fat, and identification of the various single and multi-layers that were present on the belt.

3.3 Allocation of value to material that could be recovered

The potential value of recovering the meat/trim (as $/head) was calculated as follows.

- Saleable meat/large pieces of trim
    - Weight of material [kg] x ($/kg value of meat/trim - $/kg value of material going to tallow/meal) / (time of collection [hrs] x chain speed [head/hr])
- Meat left on bones (suboptimal boning performance)
    - Sum of weight of material from various bones [kg] x ($/kg value of meat [assumed to be 75CL] - $/kg value of finely texture meat [recovered by bone cannon] - $/kg value of meat going to tallow/meal)
- 85CL trim from fat/trim going to render
    - (Weight of 85CL trim [kg] / weight of fat/trim [kg]) x ($/kg of 85CL trim - $/kg of meat going to meal) x kg/head of fat/trim.

3.4 Assumptions

The following raw material prices, throughput, system performance estimates and costs were used in determining the costs and benefits:

- Shin - $8.24/kg
- Knuckle - $6.70/kg
- 85CL trim - $5.10/kg
- 75CL trim - $4.52/kg
- Finely texture meat (recovered from bones mechanically after leaving boning room) - $1.30/kg

    - Recovered from brisket, neck and backbone
- 85CL going to render - $0.201/kg
    - 85% [lean meat] x 26% dry weight x $0.58/kg [meal]
    - 15% [fat] x 69.8% [tallow yield from fat][2] x $0.65/kg [tallow]
    - 15% [fat] x 5.6% [meal yield from fat][2] x $0.58/kg [meal]
- Head/annum processed through boning room
    - Teys Beenleigh – 343,200
    - Australian beef industry – 8,000,000
- 15% of 85CL trim from fat/trim going to render could be recovered by an alarm system because of the size of these pieces and their positioning as a single layer on the belt or on the top of clumps of fat.
- If a system was in operation whereby CL was being constantly measured and monitored for the belt, it is expected that 25-50% of the total value could be recovered through supervisors following up directly with boning room staff to correct/improve performance (based on discussions with Teys boning room supervisors). The large range in this value is related to the potential range of improvement in performance of the relevant boning room positions.
- In calculating costs and benefits of system:
    - Three throughput rates were used to show range for boning rooms of varying size
        - 100,000 hd/annum
        - 200,000 hd/annum
        - 343,300 hd/annum.
    - Capital costs
        - $430,000 for DEXA system (based on discussion with Scott Automation)
        - $50,000 for infrastructure for adjusting belts etc.
        - $50,000 for x-ray shielding and OH&S compliance
        - $100,000 for mechanical singulation to accommodate bones (based on discussion with Scott Automation).
    - Annual maintenance and operational costs
        - $10,000 for maintenance of DEXA system (based on discussions with Scott Automation)
        - $10,000 for maintenance of other components (based on discussions with Scott Automation)
        - $20,000 for spare parts ($50,000 every 2.5 years; based on discussions with Scott Automation).
    - Equipment life of 10 years and a discount rate of 7%.
    - Labour requirement
        - Alarm only system – 0.2 FTE of supervisor ($35/hr)
        - Alarm + CL fat – 0.3 FTE of supervisor ($35/hr)
        - Alarm + CL fat + CL bone – 0.4 FTE of supervisor ($35/hr).

[2] Meat Research Report 2/92 – By product yields from sheep and cattle. W Spooncer, CSIRO. 1992.

4 Results and discussion

4.1 Frequency of material on bone belt

For the majority of the time, the material on the waste belt is a single layer of bone or fat (Figure 3). However, clumps of fat (of various size and thickness; Figure 4) and clumps of bone (of various bone types and clump size/thickness; Figure 5), occur at an average frequency of 2.2 min and 1.8 min, respectively. This would make determination of CL of material on waste belt very difficult due to the presence of fat, bone and meat together in heterogeneous clumps.[3] Operational considerations for how to handle the material present on the belts is discussed in later sections (4.4.2, 4.4.3).

Figure 3: Examples of single layer on waste belt

[3] P.PIP.0471 final report: Bone belt DEXA OCM mass balance yield system – stage 1. J Cook & M Shirazi, Scott Automation and Robotics. 17 Feb 2017.

Figure 4: Clumps of fat on waste belt

Figure 5: Clumps of bone

4.2 Weight and potential value of recovery from bone belt

4.2.1 Saleable meat and large pieces of trim

A range of saleable meat and large pieces of 85CL trim were collected from the waste belt (Figure 6). This was a case of the raw material ending up on the wrong belt. There was a total of 0.024 kg/hd of saleable meat and large pieces of trim (Figure 7) and the potential value of recovering this was $0.156 kg/head (Figure 8).

Figure 6: Examples of saleable meat (shin and knuckle) and large pieces of trim collected from the bone belt


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Figure 7: Weight of saleable meat and trim that could be recovered from bone belt

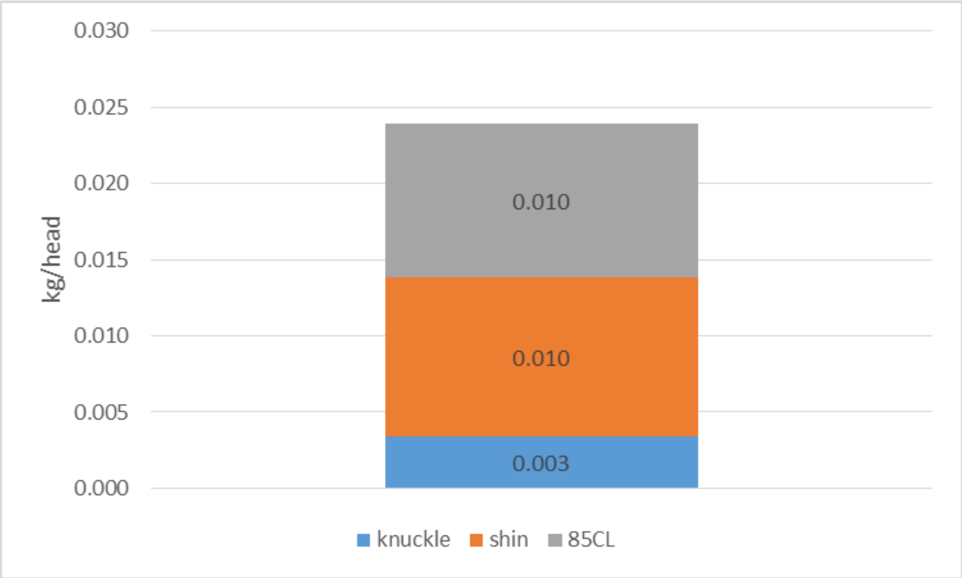
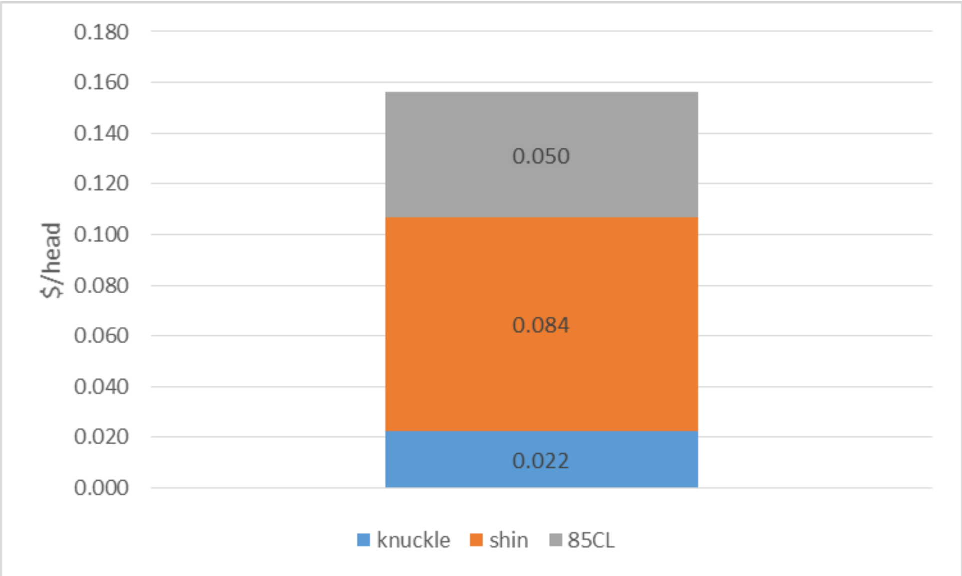


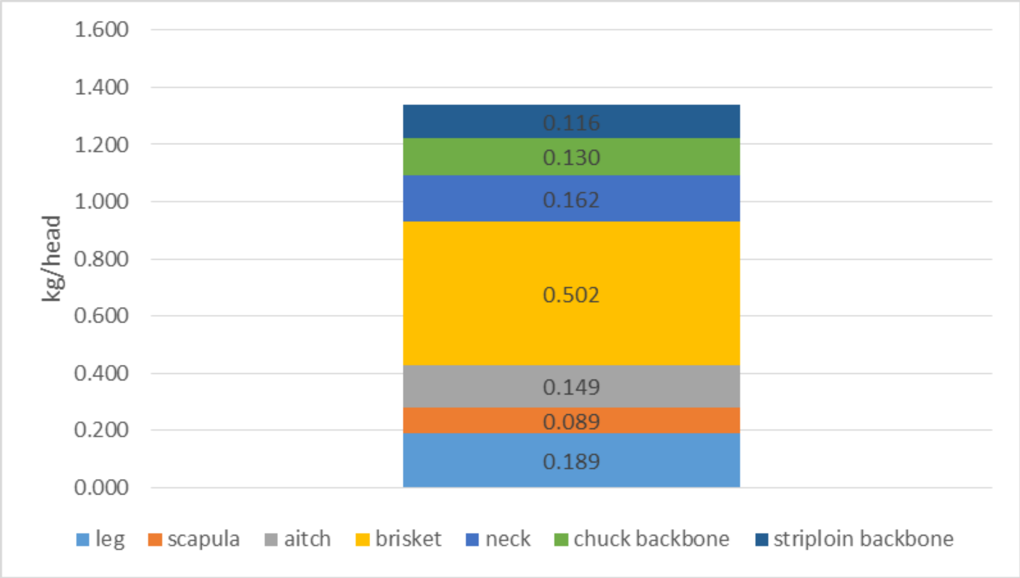
Figure 8: Value of saleable meat and trim recovered from bone belt



4.2.2 Meat left on bones (suboptimal boning performance)

There was meat left on most bones that was determined to reflect suboptimal boning performance. The average weight of this was 1.34 kg/hd (Figure 9) and the potential value of recovering this was $4.76/hd (see 3.3 for method of calculation).

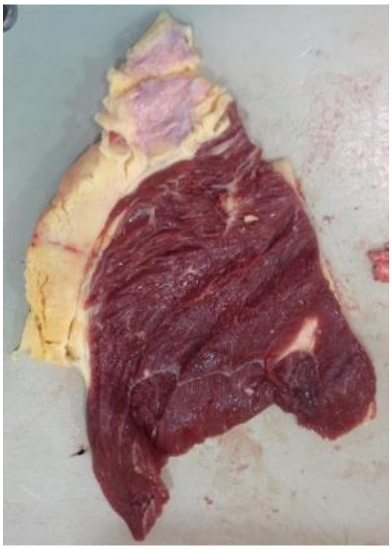
Figure 9: Weight of meat left on bones that could be recovered by 'good' boning performance



4.2.3 85CL trim from fat/trim going to render

The trim recovered from the fat/trim going to render, reflected small pieces of trim that were on the wrong belt, suboptimal trimming/slicing performance and potential opportunity for extra trimming of certain pieces of fat (Figure 10). There was 14.82 kg/hd of fat/trim going to render, on the waste belt, with 14.1% of this being 85CL trim that could be recovered (Figure 2). This is equivalent to 2.089 kg/hd and $10.23/hd.

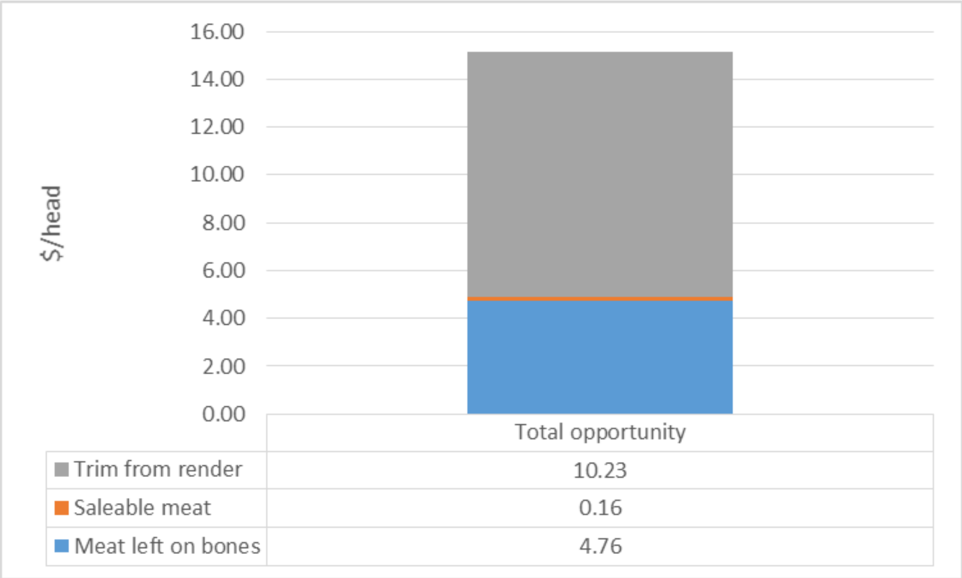
Figure 10: Examples of smaller pieces of trim that were on bone belt



4.2.4 Total opportunity

The total opportunity (gross) is $15.15/hd, with 67% from recovering trim from fat, 32% meat from bones (improved boning performance) and only 1% from recovery of saleable meat/large pieces of trim (Figure 11). For the Teys Beenleigh boning room, and the entire Australian beef processing industry, this equates to an annual potential gross opportunity benefit of $5.21 million and $121 million, respectively.

Figure 11: Total opportunity for recovering value from waste belt



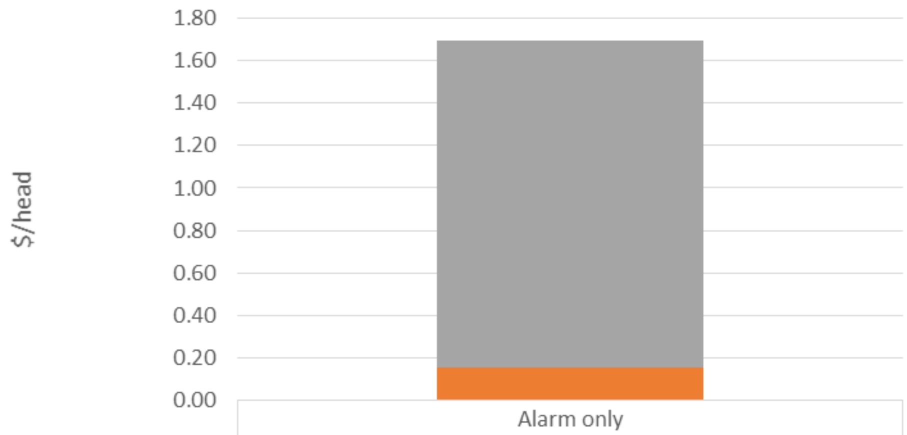
4.3 System considerations and probable value

4.3.1 Alarm only system

The work undertaken by Scott Automation has shown that the stage 1 upgraded carton inspection unit could only operate in an alarm capacity[4]. This system would in principle be set at a threshold above which pieces of meat/trim would alert the supervisor and potentially automatically stop the belt. From the observations of the belt at Teys Beenleigh it is estimated that all of the potential value of recovering saleable meat/large pieces of trim (4.2.1) could be obtained from such a system (all the product recovered in trials was as single layer on belt and not occluded by bone), which would be $0.16/hd (Figure 12). It is also estimated that 15% of trim from material that is going to render (4.2.3), could be recovered due to it being on the top layer of the belt (either single layer or on top layer of material on belt), which would be $1.53/hd (Figure 12). However it is assumed that none of the value from recovering meat left on bones would be recovered by this system (Figure 12).

[4] P.PIP.0471 final report: Bone belt DEXA OCM mass balance yield system – stage 1. J Cook & M Shirazi, Scott Automation and Robotics. 17 Feb 2017.

Figure 12: Value of an alarm-only system

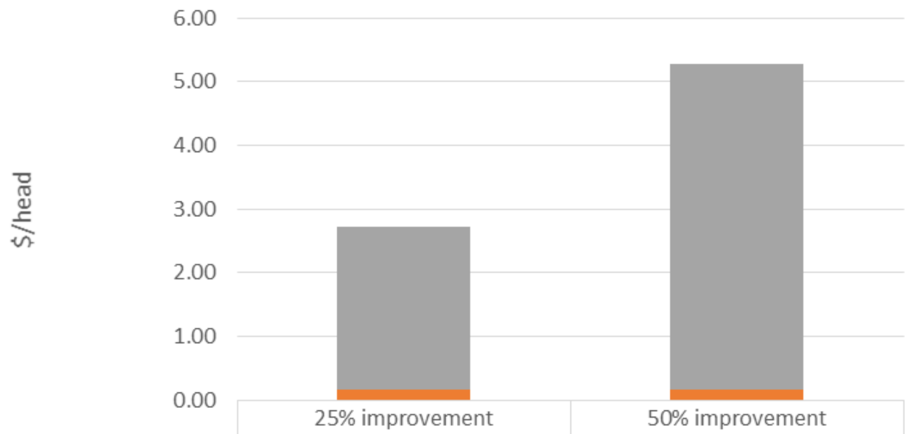


	Alarm only
Trim from render	1.53
Saleable meat	0.16
Meat left on bones	0.00

4.3.2 System that has both alarm and also monitors CL of fat/trim material

If a system could constantly measure and monitor the CL of the fat/trim material that is going to render (as well as acting as an alarm [4.3.1]), it is estimated that a further 10-35% (on top of the 15% from alarm only system; 25-50% of the total value, 4.2.3) of the value of the trim material could be recovered. The total value of this system would be $2.71-$5.27/hd (Figure 13). The large range in this value is related to the estimated potential range of improvement in positions involved in slicing, trimming and handling (3.4). The CL reading would be used as an indicator of the performance of boning room positions involved in slicing, trimming and handling. For example when CL rose above a certain point during a shift then this would alert supervisors to examine the belt and then approach relevant personnel to correct/improve performance and retain the trim that was being 'lost' to render/meal. As performance was corrected/improved the CL would then reduce to below threshold.

Figure 13: Value of an alarm + CL fat

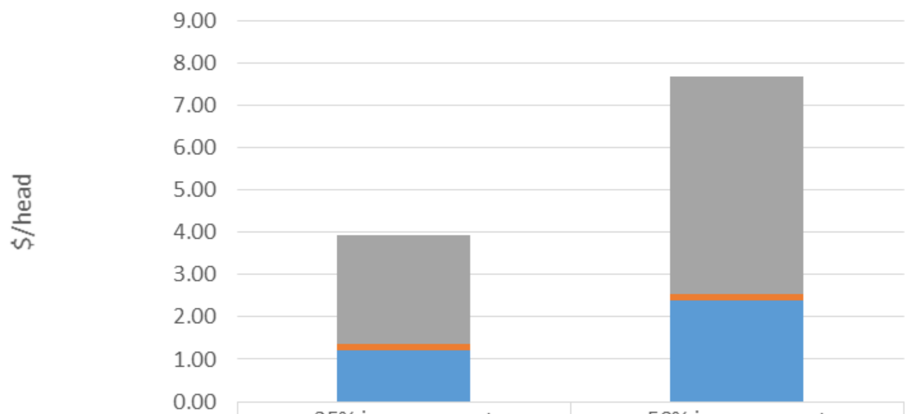


	25% improvement	50% improvement
Trim from render	2.56	5.12
Saleable meat	0.16	0.16
Meat left on bones	0.00	0.00

4.3.3 System that has alarm + CL of fat/trim + CL of bone

For a fully-functional system that could measure and monitor CL of bone (as well as acting as alarm and measuring/monitoring CL fat) the value is predicted to be $3.91-$7.67/hd (Figure 14; based on reducing meat left on bones by 25-50%). The large range in this value is related to the estimated potential range of improvement in boning positions (3.4). The CL reading would be used as an indicator of the performance of boners. For example, when CL rose above a certain point during a shift then this would alert supervisors to examine the belt and then approach relevant personnel to correct/improve performance and thus retain the meat that was being left on the bones. As performance was corrected/improved the CL would then reduce to below threshold.

Figure 14: Value of an alarm + CL fat + CL bone



	25% improvement	50% improvement
Trim from render	2.56	5.12
Saleable meat	0.16	0.16
Meat left on bones	1.20	2.40

4.4 Operational considerations

4.4.1 Supervision of belt

In most boning rooms there are many issues that require supervisors' attention. This is particularly relevant for rooms that have frequent change overs. As a result there is less time that supervision of the bone or fat belts can be sufficiently undertaken. Even though current supervision can result in actions to improve short term performance of boning room staff, in time (as supervisors focus on other competing priorities) performance will return to initial levels and may even trend lower. Furthermore, reduced intrinsic pride in performance and work ethic, and increased staff turnover, are making it increasingly difficult to improve employee performance.

In this context, a DEXA alarm/monitoring system would be a system fix. It would be a system that would drive improved performance. The system would enable the boning room supervisor to know that nothing is being lost on the belts. Currently there is a significant amount of material being lost. Having a DEXA system on the belts would protect that part of the business and allow for supervisors to be free from having to manually monitor the belts. Furthermore it would provide supervisors with specific examples and performance information to improve suboptimal performance and reward high performance.

In discussion with Teys the indication was that there would be no extra labour required for operation of the proposed systems. However, 20-40% of a supervisor's salary has been included in the costing (3.4) to cover boning room scenarios where extra labour may be required.

4.4.2 First stage – installing system on fat belts

It appears that installation of DEXA system should be first undertaken on the fat belts. The reasons for this include:

- All saleable meat and trim would travel along the fat belt, prior to joining with bones on a downstream belt, and thus be able to be 'seen' by the DEXA system (not covered by bone).
- Constant monitoring of fat and meat (on fat belt) can be undertaken using current technology and is much easier to do than situation that also includes bone.
- 68% of the total opportunity ($10.39/hd) is from recovery/reducing loss of saleable meat and trim.
- In discussions with both Teys and Scott Automation, this is seen as the best approach.

This scenario is summarised in Figure 16.

4.4.3 Work to be done

If a DEXA system was being set up on a fat belt, some of the specifications that would need to be determined would include:

- Threshold for size of saleable meat/trim to set off alarm.
- How the alarm system works (e.g. belt stops) and prevention/management of potential issues (such as material backing up).
- CL level of material on the belt at which alarm is sent to supervisor
  - CL thresholds for different animal types would need to be determined.

For a system that included CL of bone, Scott Automation have indicated that mechanical singulation of material would be required. Furthermore a suitable algorithm and accompanying software would need to be developed to calculate CL of material that included bone as well as fat and meat. If this could be achieved the CL threshold for bones would need to be determined for each animal type.

The costs involved in determining thresholds and how the alarm system operates have not been considered in the calculations. However the estimated cost for the mechanical singulation has been included for a system that measures and monitors CL of bone (Figure 17).

4.5 Estimated costs and benefits of systems

The costs and benefits for the three systems (4.3.1, 4.3.2, 4.3.3) for different boning room throughputs are shown in Figures 15-17. Based on an assumed maximum payback period of 1.5 years to justify the capital outlay, larger boning rooms (~343,200 hd/annum) would get suitable return on investment for all three system types. Either 'Alarm + CL fat' (Figure 16) or

'Alarm + CL fat + CL bone' (Figure 17) system would provide payback for medium sized rooms (~200,000 hd/annum). However, small rooms (~100,000 hd/annum) would require a system that monitored CL of fat and bone to achieve an average payback of 1.5 years (Figure 17). Figure 18 shows the total opportunity (gross) for each scenario together with the likely net benefit (summarised as the midpoint of the ranges for the three sizes of plant).

Figure 15: Summary of costs and benefits for 'Alarm only' system

	Alarm only - 100,000 hd		Alarm only - 200,000 hd		Alarm only - 343,200 hd	
Hd / annum	100,000		200,000		343,200	
Production increase with equipment	0.00%		0.00%		0.00%	
	From	To	From	To	From	To
Capital cost (pmt option, upfront)	$530,000		$530,000		$530,000	
Gross return Per head	$1.51	$1.51	$1.51	$1.51	$1.58	$1.58
Total costs Per head	$0.96		$0.49		$0.29	
Net Benefit Per head	$0.55	$0.55	$1.02	$1.02	$1.30	$1.30
Annual Net Benefit for the plant	$ 55,283	$ 55,283	$ 203,634	$ 203,634	$ 445,684	$ 445,684
Annual Net Benefit for the ex cap	$ 108,283	$ 108,283	$ 256,634	$ 256,634	$ 498,684	$ 498,684
Pay back (years)	4.89	4.89	2.07	2.07	1.06	1.06
Net Present Value of investment	$529,754	$529,754	$1,589,509	$1,589,509	$3,289,572	$3,289,572

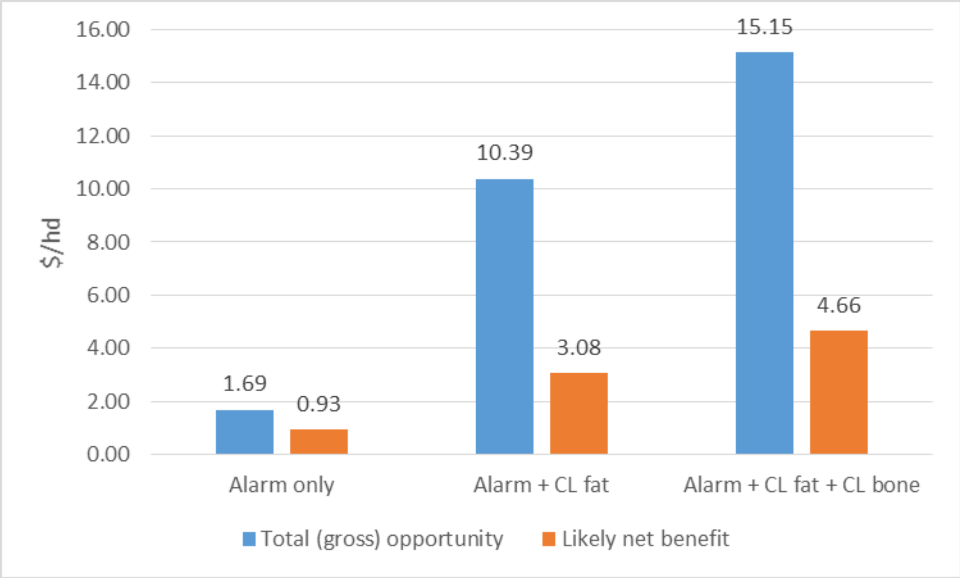
Figure 16: Summary of costs and benefits for 'Alarm + CL of fat' system

	Alarm + CL fat - 100,000 hd		Alarm + CL fat - 200,000 hd		Alarm + CL fat - 343,200 hd	
Hd / annum	100,000		200,000		343,200	
Production increase with equipment	0.00%		0.00%		0.00%	
	From	To	From	To	From	To
Capital cost (pmt option, upfront)	$530,000		$530,000		$530,000	
Gross return Per head	$2.35	$4.91	$2.35	$4.91	$2.50	$5.06
Total costs Per head	$0.96		$0.49		$0.29	
Net Benefit Per head	$1.39	$3.95	$1.86	$4.42	$2.22	$4.77
Annual Net Benefit for the plant	$ 139,422	$ 395,207	$ 371,943	$ 883,514	$ 760,508	$ 1,638,365
Annual Net Benefit for the ex cap	$ 192,422	$ 448,207	$ 424,943	$ 936,514	$ 813,508	$ 1,691,365
Pay back (years)	2.75	1.18	1.25	0.57	0.65	0.31
Net Present Value of investment	$1,120,930	$2,917,460	$2,771,861	$6,364,921	$5,500,981	$11,666,682

Figure 17: Summary of costs and benefits for 'Alarm + CL of fat + CL of bone' system

	Alarm + CL fat + CL bone - 100,000 hd		Alarm + CL fat + CL bone - 200,000 hd		Alarm + CL fat + CL bone - 343,200 hd	
Hd / annum	100,000		200,000		343,200	
Production increase with equipment	0.00%		0.00%		0.00%	
	From	To	From	To	From	To
Capital cost (pmt option, upfront)	$630,000		$630,000		$630,000	
Gross return Per head	$3.36	$7.11	$3.36	$7.11	$3.59	$7.34
Total costs Per head	$1.06		$0.54		$0.32	
Net Benefit Per head	$2.30	$6.05	$2.82	$6.57	$3.27	$7.02
Annual Net Benefit for the plant	$ 230,307	$ 605,154	$ 563,746	$ 1,313,441	$ 1,122,809	$ 2,409,288
Annual Net Benefit for the ex cap	$ 293,307	$ 668,154	$ 626,746	$ 1,376,441	$ 1,185,809	$ 2,472,288
Pay back (years)	2.15	0.94	1.01	0.46	0.53	0.25
Net Present Value of investment	$1,729,737	$4,362,509	$4,089,473	$9,355,017	$8,016,097	$17,051,787

Figure 18: Total opportunity and likely net benefit for each system scenario



5 Appendix

5.1 List of Figures