final report

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Prepared by: C.D.Gardner
Focused Management Strategies Pty Ltd

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Meat and Livestock Australia Limited
PO Box 1961
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Radford 2D Traceability in Smallstock Processing

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Executive Summary

Through its Department of Environment and Primary Industries (DEPI), the Victorian Government has promoted the introduction of small-stock traceability for individual animals. Although a timetable is yet to be announced, implementation of the required legislation appears imminent. Current mob / lot processing does not provide the adequate identification processes to meet the DEPI objective.

Radford's small-stock traceability project is predicated on the application of capture and recovery of animal identifiers via NLIS ear tags. Thus, comparative assessment is limited to other systems that incorporate individual small-stock carcass "tag reading" devices. In this regard, the HookTraka™ system is the only individual small-stock carcass trace system to have attracted any degree of industry support in Australia. However this system is considered both expensive to implement and inordinately expensive to run.

The essence of Radfords' Barcoded Ticketing system is its' simplicity: Post sticking, carcasses are sequentially identified (recorded) numbered and ticketed, retained and returning carcass identifiers are "keyed" back into the data-base and condemned carcasses identified as such and the database adjusted accordingly.

The essential objective of developing a cost effective means for smaller abattoirs to track individual small-stock carcasses has been achieved at a comparatively lower cost than a HookTraka™ installation would achieve. This stated; a critical element of the system's reliability is the attentiveness of the kill-floor operators and, while this attentiveness is generally evident, any intermittent distraction can compromise the system.

Nominally the relative simplicity of the system provides for installation in any sized abattoir – the "mechanics" don't change. However, where step changes are evident, cost effectiveness will be affected.

The projects' secondary objective of information enhancement to essentially improve yields over time has also been facilitated, with all the essential enabling elements for these information enhancements in place and proven.

However in the event that the expected small-stock traceability is not mandated, ancillary objectives and benefits may not in isolation justify the Capex or additional operating costs. Thus Processors and Producers will need to assess whether or not the enhanced data capture, analysis and reporting provided by the system justifies the incremental cost.

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1 Background

1.1 Regulatory Environment

The advent of National Livestock Identification Systems (NLIS) (Sheep, Goat and Cattle) has created unprecedented opportunities for the Australian livestock industry to investigate and implement 'whole of life' identification and tracking.

In the Australian context this situation has led to the uptake of processor carcass traceability systems in cattle and pig processing which are purposely designed to dovetail with producer based NLIS systems to facilitate 'paddock to plate' supply chain traceability. However; this has not been the experience in relation to small stock processing which presents specific challenges in relation to sheep and goats not found in cattle processing (e.g. head removal soon after slaughter and requirement for the carcass to change hooks several times during processing).

Evidenced by its' invitation to Victorian abattoirs to …*apply for Funding for carcass Tracking in Small-stock Plants* (Britt 2014), through its Department of Environment and Primary Industries (DEPI), the Victorian Government has promoted the introduction of small-stock traceability for individual animals. Although a timetable is yet to be announced, implementation of the required legislation appears imminent. Current mob / lot processing does not provide the adequate identification processes to meet the DEPI objective.

1.2 Proffered Solutions

1.2.1 HookTraka™ System

Essentially; the HookTraka™ system is the only individual small-stock carcass trace system to have attracted any degree of industry support in Australia. However this system is considered both expensive to implement and with consistent hook losses and damage, inordinately expensive to run. Thus smaller plants using HookTraka™, are competitively disadvantaged because they do not have the throughput levels of their larger competitors and have to amortize these costs over a smaller base with an attendant higher unit cost.

Reflective of the apparent low industry take-up of the "HookTraka™" system; our initial desk-top searches revealed little by way of local suppliers of RFID embedded Gambrels. Direct inquiry of the CRC for Sheep Industry Innovation (participants in the "Abattoir sheep carcass tracking system at Hillside Meats – MLA Case Study #2/2008) referred Radfords to Professor David Pethick (Murdoch University) who in-turn referred Radfords to Mr. Ken Evers (Livestock Quality – Victoria DEPI). Mr Evers was aware of only two local and one international (New Zealand) manufacturers of the "HookTraka™" assembly.

In assessing the "HookTraka™" assembly, Mr. Evers noted that one manufacturer had initially advocated retrofitting standard plastic assemblies with the transponder, essentially drilling a hole in the skid to house the device. Mr. Evers' concern was that it could come loose / be lost and thereby subvert the integrity of the tracking system. Furthermore; subsequent inquiries indicate that, rather than embedding the transponder in the moulded skid, one manufacturer's product housed the device in a separate moulding which is fixed to the skid with a screw. Given that screws can come loose, this assembly is considered to both heighten the risk to both tracking integrity and product safety.

Our more recent inquiries located ITW Fastex as the only local supplier of moulded plastic skid and gambrel assembly with embedded transponder.

1.2.2 DNA Trace-back

Particularly responding to the BSE crisis experienced in Europe in the late 1990's; a number of DNA based trace system have been developed; prominent examples include the Belgium developed Eurofins-TAG© and the Irish TraceBack™ both of which are targeted at the beef industry, whilst as the name suggest, PorkTrac is a Canadian / US joint venture designed for world-wide traceability of Canadian processed pork.

More relevant to Radford's project; the New Zealand designed multi-species application, easiTrace™ specifically focuses on protecting New Zealand's economically vital sheep-meat export sector. Notably; the SureTrak® system, developed for the Australian beef industry, is essentially the same as easiTrace™.

All these systems rely on the taking and storing of DNA samples for each and every animal either pre-slaughter or immediately post-slaughter and maintaining those samples in a data-base that can, if needed, be matched to subsequent samples, most typically retrieved from suspect primals or cuts.

In practice DNA samples and related to packaging data (retrieved from carcass / carton labels) are sent for laboratory analysis. These data are then matched to production data / records to determine origin of the effected animal. Notably; initially trace-back for primals or cuts is related to the range of carcasses that could have contributed to the carton of meat and these "most likely ranges" are then further analysed to determine an exact match.

Whilst these and other DNA based systems have application in addressing meat industry traceability, Radford's small-stock traceability project is predicated on the application of capture and recovery of animal identifiers via NLIS ear tags. Thus, comparative assessment is limited to other systems that incorporate individual small-stock carcass "tag reading" devices.

1.2.3 Barcode Software adaption

Radford's senior management had both extensive discussions with industry colleagues and conducted a number of site visits to assess alternative small-stock tracking procedures. Radfords concluded that each of these system were either inadequate or inordinately labour intensive. With particular regard to the electronic data-tracking elements of these systems, overt complexity is common and requires frequent human intervention (manual data entry, retrieval, correction, etc.).

Radfords desk-top research confirmed that red-meat traceability developments have been substantially focused (both locally and internationally) on the beef sectors and, with regard to small-stock, substantially restricted to tracking livestock (only) to the point of dispatch.

Accordingly Radfords determined to invest in a Barcode based software and related equipment that would adopt and adapt technologies to provide a system that is simple to operate and control, whilst providing a high degree of accuracy and delivering comparatively substantial cost and operational efficiencies.

2 Projective Objectives

2.1 Efficient and Effective Stock Correlation

This is an MLA/DEPI[*] co-funded project to develop and trial software that uses low cost 2D bar coding to track small stock carcasses through slaughter. This will allow data to be collected for potential use for NLIS, producers and other supply chain participants.

This project will investigate and seek to resolve key technical and processing integration impediments to the development and uptake of cost effective solutions for SME processors to the automated correlation of live animal ID with carcass tracking in small-stock processing.

It is related to, but differs, from a similar MLA/DEPI funded project at AL Colac, as the latter is based on use of more expensive RFID based tracking within the processing plant.

Mid-size abattoirs such as Radfords typically process small-stock lots in pre-defined order, individual carcasses graded and grouped by weight range.

Radfords have identified (and scoped) an innovative system for the efficient and cost-effective delivery of small-stock traceability throughout the entire small stock chain processing.

The system is simple and user friendly and Radfords are confident that it maintains full integrity with traceability and correlation.

Essentially the proposed system introduces an RFID reader on the small-stock chain after sticking as the initiating point of the body count. Thereafter at the point of inspection carcasses are either passed fit and continue to the grading/weigh station or are retained. If retained, a computer produced “Retained” ticket encoded with and displaying the body number and barcoded identifiers is attached to the affected carcass. Notably; the Retained ticket will be brightly coloured, providing immediate and constant visual identification / monitoring of affected carcasses.

Assuming a retained carcass is subsequently passed “fit”, the coloured ticket remains on the carcass which is conveyed to the grading station. The ticket is then scanned to “recapture” the barcoded identifiers. The carcass is weighed and graded and a new (comprehensive) ticket printed and attached to the carcass; the Retained ticket is removed.

The inspector’s computer is a component of the animal heath station which will record pathology and condemnations for any retained carcass. If a carcass is condemned, the inspector will prompt the inspection computer to inform the grading station computer.

Thus, passed-fit carcasses are automatically correlated into the correct lot and body number and individually ticketed with mandatory and optional identifications, whilst condemned carcasses identified as such in the database and deleted from the sequence.

[*] Effective 1 January 2015, DEPI (Victoria) amalgamated with other Government Departments to form the Department of Environment, Land Water and Planning (DELWP)

The software and associated hardware to be developed in this system is based on 2D bar code technology, rather than RFID. The software (primary output being funded by MLA) is an add-on module to the existing ITP software suite.

The 2D bar code approach will demonstrate a more cost effective solution for SME processors (as compared to RFID) to maintain the correlation of an animal's NLIS accredited electronic ear tag with its carcase from the point of slaughter until at least the final grading station inclusive of retain rails, animal health inspection points and condemnation exits.

The installed system will be able to automatically assemble for each carcase the following information:

- Establishment number
- Chain number
- RFID number for animals with an electronic NLIS tag
- Date of slaughter
- Body number
- Carcase weight (HSCW)
- Time stamp
- Fat depth (if recorded for sheep and goats)
- For sheep and goats, animal health information such as grass seed damage, pleurisy, sheep measles and other common carcase defects where recorded

2.2 Cost Effectiveness

The alternative "HookTraka™" system is considered both expensive to implement and with regular assembly losses and damage, inordinately expensive to run. Moreover smaller plants are competitively disadvantaged because they do not have the throughput levels of those enjoyed by larger processors and therefore have to amortize these costs over a smaller base with an attendant higher unit cost.

As an industry roll-out, the (individual site) implementation cost of the system now proposed will be significantly reduced (R&D, software development and "debugging" having been absorbed by this project) and replacement of RFID transponders, through hook losses, avoided.

Anecdotal evidence (discussions with industry colleagues) confirms the commonality of logistical inefficiencies incurred when servicing late orders, "Shop" drops and deliveries to boning rooms. The proposed system will provide domestic abattoirs with the ability to cost-effectively maintain small-stock correlation when these types of interruptions occur.

2.3 Enhanced Information

For Abattoir – The system provides touch-screen menu input to capture data related to the condition of each animal. By association with the PIC, the abattoir is able to differentiate Producers of either consistently desirable or undesirable livestock and modify their purchasing accordingly. Thus over time significantly improved yields should accrue.

For Producers – The primary objective is to identifying and expediently notify producers of any disease or food safety issue. The data collecting, analysis and reporting functions also offer scope for feedback to producers to improve their livestock management; for example,

fat ratios and carcass weights could be accurately assessed against various feed and diet regimes.

For Customers – The scope offered by the project to efficiently capture and report an array of information will enable Retail Butchers, Food Service and the like the ability to authoritatively promote to their consumers, the distinctive attributes and provenance of their particular sheep-meat offerings. Collaborative marketing between Customers and Producers may provide opportunities for shared amortisation of marketing and promotional campaigns.

3 Methodology

3.1 General Scope

The project responded to the expectation that small-stock trace (RFID) will be mandated throughout Victoria post 2014/15. Accordingly; the project sought to enhance proven electronic data capture, management and reporting technology to provide highly reliable and cost effective small-stock traceability, integrating any needed kill-chain carcass retention (for condemnation or return), whilst maintaining body correlation. Fig.1 provides a representation of the Small-stock chain incorporating the proposed system.

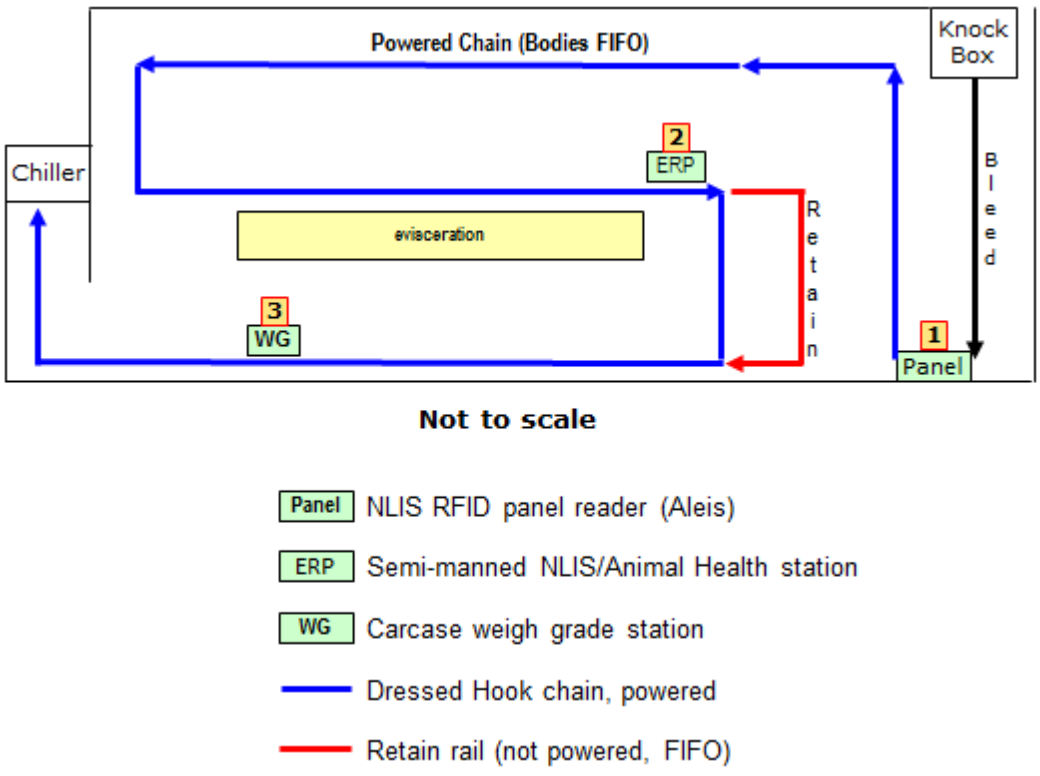

Fig.1 – Radford Small-stock Chain

3.1.1 Data Capture and Management

With reference to Fig.1; following elaborates on the data capture and management activities performed at the identified stations:

1. NLIS (RFID) number automatically recorded prior to the head removal.

2. Extended Residue Program (ERP) detection (visual or audible alarm) and recording station, enabling effected carcass to be "shunted" onto the retain rail for assessment and recovery or condemnation.

   Retained carcasses have an individual identifying number replicated and attached to the carcass prior to the NLIS station. To maintain correlation; if the carcase is passed as fit for human consumption it is returned to the chain, if condemned it is removed and the NLIS data-base adjusted.

3. Carcase grading, weigh and ticket print station – tickets display (text and/or bar-code as appropriate) mandatory and optional information.

3.2 Quantification

Table 1 schedules Radford's Forecast 2014/15 total small-stock throughput and expected RFID tagged throughput for each of the five years to 2019/20.

The schedule extrapolates expected 2014/15 total throughput for the given Average Annual Growth rates (AAG%) and applies a ratio of RFID tagged livestock. The determined "Tag Ratio" equates to the ratios of livestock currently sourced by Radfords from Victorian producers.[†]

Table 1: Forecast RFID Tagged Small-stock Annual Throughput

Throughput Forecast				**RFID Tagged Throughput (head)**				
Stock Type	Head	AAG%	Tag Ratio	Head	Head	Head	Head	Head
	2014/15			2015/16	2016/17	2017/18	2018/19	2019/20
a) Sheep	1310	15%	85%	1281	1473	1693	1948	2240
b) Lambs	102281	15%	85%	99980	114977	132223	152057	174865
c) Goats	1798	20%	100%	2158	2589	3107	3728	4474
d) Calves	384	5%	75%	302	318	333	350	368
Total	105773			103720	119356	137357	158083	181946

3.3 Software Design

Following were identified as the essential attributes required of the proposed small-stock tracking system:

- Smallstock sheep carcase correlation solution that maintains FIFO traceability across kill-floor to chiller.

[†] Actual 2014/15 small-stock throughput totalled 108,112

- Integrated NLIS system to update NLIS/ERP status and provide defect reporting.
- Provide for AusMeat carcass ticketing and ability to add optional information.
- Enable trace-back by end user to processor site and (potentially) source name of producer.
- Avoid high recurring cost attendant to RFID based systems.
- Provision of CCTV system at carcass receival and race to monitor the compliance requirements (such as segregation of certified organic livestock).
- Capability to expand and integrate the CCTV view with carcase loadout to identify and review processing issues.

3.4 Integration with existing on-floor and administrative systems

The proposed system had to be integrated with four existing IT systems:

- I-leader® carcass sequence monitoring and display
- Carcass load-out, incorporating deliveries and returns
- Inventory Control, incorporating stock additions (from kill-floor into chillers), sales and returns
- NLIS Data Base

4 Results

4.1 Traceability

ABARES (2013) defines Traceability as *… the proportion of animals that can be successfully traced between defined points in the supply chain or over time*. The project's success in ensuring comprehensive carcass traceability across the Kill-floor to Chiller (inventory) has been achieved through incorporating the essential elements of maintaining Stock Correlation and capture, retention and reporting of individual animal data:

4.1.1 Stock Correlation

Ensuring traceability across the Kill-floor to Chiller relies on maintaining "First In, First Out" (FIFO) stock correlation. In particular; the system has to comprehend sequential interruptions for carcass movements to and from the retain rail and for any condemned carcass (not returned to the chain).

Stock correlation is activated by (the gambrel) tripping a "stick" switch positioned immediately after the RFID Panel Reader. On reaching the Animal Health Station, a second stick switch activate recording of any carcass "shunted" to the Retained Rail and an individual identifying bar-coded ticket is attached to the retained carcase. To maintain correlation; if the retained carcase is subsequently passed as fit for human consumption it is returned to the chain, re-entered into sequence at the Weigh / grade Station and the "Retained" ticket replaced with a common ticket. If the retained carcass is subsequently condemned, it is removed and the data-base adjusted by the Animal Health Station operator.

Operationally; correlation has been maintained for all stock processed.

4.1.2 Data Capture and Enhanced Supply Chain Communications

Table 2 schedules the Mandatory, Optional and Summary data captured by the system and documented / displayed in the Carcass Detail Report. Fig 2.1 Carcass Detail Report and Fig.2.2 Carcass Fault Report, provide examples of the enhanced Supply Chain reporting generated from the project.

Whereas mandatory data records all the identifiers required by the NLIS, optional data provides for recording those elements that can assist supply chain participants to improve the quality of livestock. In particular the Carcass Fault Report identifies precise animal health information and, in the case of condemnation, generates a specific alert to the producer. Summary data provides the quantitative metrics of each lot processed.

Table 2: Carcass Detail Report – Data / Information Slate

Mandatory Data	Optional Data	Summary Data
Body number	Sex	Total number of bodies
PIC number	Dentention	Average Fat scores
Assigned RFID code	Breed	Average Weight
Stock Type (**L**amb, **M**utton, **G**oat)	Butt Shape	Total Weight
Product (grouped by weight range)	Ear Tag / Button ID	
HSCW	Conformation	
Condemnation (True or False)	Fat Class	
	Fat Score	
	NLIS Number	

Kill Date	Species	Chain	Operator	LOT	Stock Type	Vendor	Source	Buyer
28-Jun-2016	Sheep	2	ORG	5	L	16-709	RONALDSON	BEACY

Body	Breed	B.S.	Ear Tag	Sex	Den	Con	Fat Cls	Fat	PIC	RFID	NLIS Number	Grade	Product	HSCW	Condemn	Time
377				N	0				3WLQJ024			L	ORGG	22.40	False	11:22 AM
378				N	0				3WLQJ024			L	ORGG	21.80	False	11:22 AM
379				N	0				3WLQJ024			L	ORGG	28.60	False	11:23 AM
380				N	0				3WLQJ024			L	ORGG	18.40	False	11:24 AM
Total: 4.00								Avg Fat:		Avg Wgt: 22.80		Total Wgt: 91.20				

Kill Date	Species	Chain	Operator	LOT	Stock Type	Vendor	Source	Buyer
28-Jun-2016	Sheep	2	PRIV	6	L		Y/VALLEY	D/CREEK

Body	Breed	B.S.	Ear Tag	Sex	Den	Con	Fat Cls	Fat	PIC	RFID	NLIS Number	Grade	Product	HSCW	Condemn	Time
381				N	0				3YRHF193			L	PRIVL	22.00	False	11:24 AM
382				N	0				3YRHF193			L	PRIVL	19.60	False	11:25 AM
383				N	0				3YRHF193			L	PRIVL	18.80	False	11:26 AM
384				N	0				3YRHF193			L	PRIVL	20.80	False	11:26 AM
385				N	0				3YRHF193			L	PRIVL	21.00	False	11:27 AM
Total: 5.00								Avg Fat:		Avg Wgt: 20.44		Total Wgt: 102.20				

Fig 2.1 Carcass Detail Report

Carcase Faults

Production Date: 28 Jun 2016 - 28 Jun 2016

Chain: SMALLSTOCK CHAIN

Kill Date	Mob	Operator	Body No.	Faults	Grade	Hot Wgt
28 Jun 2016	1	RADF	8	Ingesta Contamination	L	28.20
			9	Urine	L	18.40
			10	Faecal Contamination, Ingesta Contamination	L	18.60
			41	Arthritis	L	22.00
			62	CLA	L	17.40
			63	Arthritis	L	19.60
			64	CLA	L	19.60
			68	Ingesta Contamination	L	22.60
			77	Plurisy	L	21.00
			89	Urine	L	21.20
			90	Dog Bites, Bruising	L	17.40
			101	Plurisy	L	26.60
			118	Plurisy	L	21.80
			130	Arthritis	L	14.60
			Total			**289.00**
	2	RADF	141	Ingesta Contamination	L	15.60

Fig 2.2 Carcass Faults Report

As the expected mandating of small-stock trace throughout Victoria has yet to occur, opportunities to assess the data capture elements of the system have been limited to stock processed for those few producers who voluntarily apply RFID buttons, and to orchestrated trials.

Selected producers (Cameron McDonald and Cleveland Meats) participated in trials, over two days, where some 300 (buttoned) lambs were processed. Providing system validation, these trials were observed by DEDJTR[‡] advising consultants Achieve AG Solutions. Post-trial comments and observations from McDonalds' and Clevelands' have expressed a high level of satisfaction with the system's reporting capabilities.

The system has successfully integrated with I-leader® monitoring and the National Livestock Identification System current Mob Based reporting. Integration with load-out and inventory control has been deferred pending completion of general upgrades to the management, accounting and reporting system.

[‡] (Vic.) Department of Economic Development, Jobs, Transport and Resources.

4.2 Cost Assessment

The project responds to two essential aspects of small-stock traceability - the expected mandating by the Victorian Government (DEDJTR) to trace individual animals (rather than mobs) and, the need for a facilitating system that is cost effective for SME abattoirs.

As elaborated at 1.2; both inquiry of other processors and desktop research indicates that the HookTraka™ system is the only other system that provides for the capture and recovery of animal identifiers via NLIS ear tags. Thus; this assessment is limited to a comparison with HookTraka™.

Essentially HookTraka™ is the only individual small-stock carcass trace system to have attracted any significant industry support. However this system is considered both expensive to implement and with consistent hook losses and damage, inordinately expensive to run. In particular smaller plants are competitively disadvantaged because they do not have the throughput levels enjoyed by their larger competitors and have to amortize these costs over a smaller base with an attendant higher unit cost.

4.2.1 Processing Labour

Barcoded Ticketing

Operationally, and in comparison to mob processing; in order to print and attach identifying ticket for each individual carcass, the system requires an additional full-time employee. Based on Radford's 2014/15 small-stock throughput of 108,000 head, this additional operation adds $0.31 per head.

Imbedded RFID Transponders

Whilst desk top research reveals numerous proprietary claims by system developers and promoters, perhaps somewhat understandably, none of these make reference to additional or potential operating costs associated with system based on Impeded RFID Transponders.

Thus in determining the need for any associated additional labour we in-part rely upon relevant MLA published studies and reports on local HookTraka™ installations:

Hillside Meats – Narrogin WA

While (Shepard, McFarlane & O'Halloran 2007) assessment of the HookTraka™ system installed at Hillside Meats concluded that …*The principals of the tracking system can be adapted to most small animal abattoirs*, that Case Study and the earlier report by (Rowe 2005) do not assess the comparative cost of implementing or maintaining the system.[§]

Most notably recent telephone inquiries of Hillside revealed that they had abandoned the HookTraka™ system some years ago, sighting the frequency and labour cost of hook change-overs as the system's principal impediment.

Frewstal Processing – Stawell Vic

This installed system utilizes electronic ear tags (inserted by the abattoir) and HookTraka™ gambrels/skids to facilitate Frews' promotion of full traceability in their export markets.

[§] The report by Shepard, McFarlane & O'Halloran includes reference to a 2005 report by (Wind) detailing the Costing of the Hillside installation. Web search failed to locate that report and attempts to contact (telephone) the author received no response.

Importantly; when interviewed (Cumming 2009) plant manager Greg Nicholls' remarks include*"…the system does not provide a cost or time saving for the company now. In fact, an extra worker is requires on the kill chain to test the plastic electronic hooks before placing them in the carcase"*.

To recover the relatively expensive HookTraka™ gambrel, it needs to be changed over to conventional "iron". Notionally change-over would (certainly) occur before carcasses are loaded-out and (to minimize inventory of these expensive assemblies), most likely before chiller storage.

Having regard to the additional labour required to move carcasses from HookTraka™ gambrel to conventional iron or stringing, safe-handle the removal and secure inventory of the gambrel and set for reuse, Radfords have calculated additional handling time to be 45 seconds per carcass, equating to an additional $0.34 per carcass.

Radfords enjoy near 95% "key access" to their local retail customers allowing them to deliver out-of-hours, which in turn maximizes recovery of their "iron". Thus, and predominately representing deliveries into Sydney, less than ten percent of Radfords lamb carcasses are re-hung (on strings). Adjusting for this (90%) factor, determines the comparable additional labour cost of HookTraka™ to be $0.306 (0.34 x 0.90), which is essentially the same as the added labour cost associated with the installed Barcoded Ticketing system (which does not introduce any additional hook changer-over).

4.2.2 Suspension devices (Skid and Gambrel)

Barcoded Ticketing

The robustness of conventional mild steel assemblies substantially mitigates damage or discard associated with equally robust handling and cleaning processes. In concert with Radfords 95% "key access" to customer premises (and attendant industry-high level of "iron" recovery), has enabled Radfords to sustain a net attrition of skids and gambrels (determined over several years) at a modest 2.4%. The Barcoded Ticketing system utilizes existing iron and retains these cost advantages.

Radfords annual throughput of 108,000 small stock requires an inventory of some 2,000 skid and gambrel assemblies, thus; annual replacements are less than 50 assemblies (2,000 x 2.4%). At current cost of $3.40 per assembly ($2.20 per skid and $1.20 per gambrel), annual replacement cost totals $170.00; equating to $0.0016 per head.

Imbedded RFID Transponders

Inquiry of (one of two) local manufacturers / suppliers of moulded plastic assemblies determined the following:

- Unit price of $7.90 - on minimum order of 10,000 units (five-times the inventory quantity needed by Radfords)
- A product life of 6 to 12 months under typical handling conditions
- A nominal product life of 60 to 72 months (5 to 6 years) *if stock is handled with the utmost care.*

Assuming the quoted average 9 months typical product life and Radfords in-use quantity of 2,000 units, notional annual amortised cost to Radfords would be $21,066 (2,000 x $7.9 ÷ 0.75); equating to $0.1951 per head.

Moreover; the $77,025 cost of "excess" 9,750 assemblies (10,000 min order less 250 required over five years) infers an amortization period of 146 years ((9,750) ÷ (50 ÷ 0.75)).

Alternatively; assuming an average product life of 66 months, annual amortised full cost is $14,364 (($79,000 ÷ 66) x 12)); equating to $0.1330 per head. Notably; while it is beyond the scope of this report to measure the incremental labour cost attendant to stock [being] handled with the utmost care, this statement suggests that Radford's calculated additional handling cost of $0.306 may be understated for labour time.

In either case, the annual cost of assemblies under a HookTraka™ system is many times that of the Barcoded Ticketing system.

Other Costs

Given the near identical incremental labour hours / wages, no comparisons of on-costs are deemed necessary or helpful. Similarly, inquiry of the project IT providers indicates that the cost of Hardware and Software would be much the same under HookTraka™ as has been incurred for the Barcoded Ticketing system.

Cost Savings

Time savings for QA staff, load out supervisor and marketing activities identified by (Bryan, Webb & Green, 2015), are assessed as equally applicable to both Barcoded ticketing and HookTraka™ and therefore, this report makes no comparison of these elements.

Thus; Table 3 table assumes annual small-stock processing of 108,000 head and summarises and compares the incremental unit costs attendant to the install (Ticketing) system and the HookTraka™ alternative.

Table 3: Comparative Incremental Costs

Activity	Ticketed $	HookTraka $	Variance $
Processing Labour	0.310	0.306	-0.004
Suspension devices	0.002	0.195	0.193
Total	**0.312**	**0.501**	**0.189**
Annual Incremental Cost	$33,695	$54,108	$20,413

Essentially; Barcoded Ticketing provides Radfords with annual cost savings of some $20,400 when compared to the alternative HookTraka™ system.

5 Discussion

The following section assesses the project outcomes relative to the stated objectives.

5.1 Efficient and Effective Stock Correlation

The essence of the barcoded ticketing system is its' simplicity. Post sticking, carcasses are sequentially identified (recorded) numbered and ticketed, retained and returning carcass identifiers are "keyed" back into the data-base and condemned carcasses identified as such in the database.

Whilst generally the system has met the project objective, not surprisingly, some unplanned system and plant modifications have been required:

5.1.1 EID ear tag and RFID panel reader alignment

Initially the distance between the RFID reader and passing head / EID ear tag was some 500mm. It was determined that this resulted in some ear tags being "missed".

The RFID panel reader has been repositioned to within 150mm of the passing head (150mm – 300mm of the ear tag) and two diagonally aligned vertical "paddles", have been installed to manipulate passing bodies to ensure the head is properly aligned with the RFID reader.

Subsequent testing confirms all ear tags are now read.

5.1.2 Body count record continuity

Notwithstanding that all ear tag data captured by the RFID panel reader were properly recorded, a particular Producer reported that two ear tags had been incorrectly associated with his PIC.

Responding to this concern, Radford conducted a trial where a total of forty-three bodies were processed, with the first and last nine bodies' ear tagged and the intervening twenty-five bodies sans ear tags.

This trail results revealed that, whilst RFID data was properly captured from the first nine ear tags, the system "ignored" the next processed non-tagged twenty-five bodies and consequentially assigned the next ear tag data (from body thirty-five) to body ten.

Whilst close monitoring allows this problem to be overcome, work continues to rectify the software programming.

5.1.3 Electro-magnetic noise

Random fluctuation in EID signals and consequentially, incorrect / missed ear tag data reads was attributed to interference from electro-magnetic "noise".

This is a typical problem experienced where numerous electronic motors are working in close proximity and was overcome by shielding / enclosing the effected cable in plastic with a grounded conductive metal wire to intercept any noise signals.

5.1.4 Condemned Carcass

A critical element of the system's reliability is the attentiveness of the kill-floor operators and, while this attentiveness is generally evident, any intermittent distraction can compromise the system.

A particular incident best demonstrates this. When a carcass/body is retained, it is so recorded via the Animal Health station. If a retained body is subsequently condemned, its' removal must be recorded at the Weigh Grade station. On one occasion, condemnation of a retained body was "given effect" via the Animal Health station, the result of which was to expunge the existence of that body.

Procedures have now been revised to specifically address this issue and all operators appropriately instructed.

5.2 Cost Effectiveness

5.2.1 Development Cost

The essential objective of developing a cost effective means for smaller abattoirs to track individual small-stock carcasses has been achieved.

Table 4 and the accompanying notes, summarises and compares the project Budget with Actual expenditures:

Table 4: Development Cost Actual: Budget

	Hardware $	Software $	R&D $	Other $		Total
Project Budget	79,090	35,030	69,660	44,495		$228,275
Actual Expenditure	128,683	36,968	76,129	89,873		$331,653
Variance	**-49,593**	**-1,938**	**-6,469**	**-45,378**		**-$103,378**
Variance due to:						
Unplanned site Server upgrade	-44,000					-$44,000
Develop System modifications	-5593	-1938	-6,469			-$14,000
Unplanned plant modifications				-45,378		-$45,378
Total	**-$49,593**	**-$1,938**	**-$6,469**	**-$45,378**		**-$103,378**

- Server upgrade - An assessment of existing Radfords' IT operating system determined that Servers (numerous individual servers dedicated to individual applications), would not provide an adequate structure or sufficient reliability to support the project. Accordingly, a "Highly Available" (multi-redundancy levels) Server has been installed.

  Notably; given that other Radford functions benefit from the Server upgrade, it could be argued that this cost should be apportioned to those functions.

  Installation of HookTraka™ or any other alternative software would also incur the cost of Server upgrade.

- System modifications - Equating to just over six percent of the project budget, the $14,000 required for System modifications is within acceptable variance levels.

- Plant modifications – Essentially to improve conveyor access for process operators and to avoid intermittent “double-ups” (scan of two adjoined carcasses being interpreted as one); significant alterations to rail position and incline were required.

5.2.2 Operating Costs

Table 5 schedules the incremental operating cost given in Table 2, with other costs / savings determined by (Bryan, Webb & Green, 2015) and the above Development Cost per head (amortised over an effective project life of five years), to determine total unit cost per head and expected annual cost.

Table 5: Total system cost per head and per annum

Activity	**$ per head**
Additional Processing Labour	0.310
On-cost (31%)	0.096
Reduced Maintenance Labour	(0.362)
On-cost (31%)	(0.112)
Total (reduced) labour cost	**(0.068)**
Amortised development cost	0.614
Total incremental cost per head	**0.546**
Annual Incremental Cost (assuming 108,000 head)	$58,987

Notably Radfords are currently assessing investment in both “Auto Vac” and “Auto Wash” plant, with a view to substantially eliminating the Additional Processing Labour introduced by the project. At a budget cost of $80,000 ($0.148 per head over five years), this investment would reduce overall incremental unit cost to $0.288 ($0.546 + $0.148 – $0.310 - $0.096), with a revised annual incremental cost of $31,104.

5.3 Enhanced Information

By capturing, storing and reporting an array of detail information, the system allows the abattoir to associate and differentiate livestock quality by PIC, expediently notify Producers (and authorities) of any disease or food safety issue, and facilitating Customers to authoritatively promote to consumers, the distinctive attributes and provenance of their particular sheep-meat offerings.

- All the essential enabling elements for these information enhancements are now in place and proven. Radfords are fully-utilizing the available data, whilst Producer feedback has initiated further enhancements to reported information, most notably; expanding the content of the Carcass Fault Report to indicate where a “Faulty” carcass has been subsequently condemned.

- Web based Producer access will be facilitated by Radfords’ general Administrative computer system upgrade, now scheduled for July 2016 implementation.

- The proposed livestock valuation and payment incentives and regional benchmarking functions of the system will evolve consistent with the accumulation of sufficient data.

Notably; the project's implementation has stimulated other efficiencies, including the installation of a computer terminal and I-Leader® display in Drover's office. This provides for direct and more immediate data entry on receiving livestock, and the "Stock Receival Form" (Form 6B) to be generated electronically.

5.4 Resource allocation

Radfords typically schedule small-stock processing for two or three days per week, nominally allowing plant modifications to be implemented on the "off days". However; unprecedented production levels throughout 2014/15 and 2015/16 required that Radfords defer system installation until downtime on the small-stock line could be better accommodated.

Moreover; whilst budget administration and project reporting functions were contracted to others, day-to-day project management was vested with Radfords senior management personnel.

Both of itself and by absorbing additional management time, the volume and intensity of a 30% lift in production significantly impeded the projects' timely completion.

The project's timely implementation would have been better-served by engaging a dedicated Capex project manager.

6 Conclusions/Recommendations

6.1 Cost revision

Development of the system was predicated on the assumption of imminent mandating by the Victorian Government of individual small-stock traceability and the offer of funding support for Radfords to undertake the project. Other ancillary objectives and benefits, such as information enhancements, may not in isolation justify the Capex or additional operating costs.

However, given that the R&D cost have been absorbed by the Radford project, and in the absence of major unforeseen expenditures, such as the need for Server Upgrade and extensive plant modification, the expected cost for other plants to adopt the system would be significantly less and, even if individual small-stock traceability is not mandated, may justify investment by others in similar systems.

Accordingly after deducting $76,129 R&D, $44,000 Server Upgrade and $45,378 Plant Modification, Table 6 "normalises" the unit costs that an abattoir of similar size / throughput and operating cost structure to Radfords could expect to incur.

Table 6: Normalised system cost per head and per annum

Activity	$ per head
Additional Processing Labour	0.310
On-cost (31%)	0.096
Reduced Maintenance Labour	(0.362)
On-cost (31%)	(0.112)
Total (reduced) labour cost	**(0.068)**
Amortised development cost	0.308
Total incremental cost per head	**0.239**
Annual Incremental Cost (assuming 108,000 head)	$25,885

6.2 Electronic National Vendor Declaration

The system includes daily up-loading of relevant data to the NLIS and could be accessed / adapted to generate a “confirmation” that the livestock declared as consigned had been received.

Notably bar-codes have been successfully scanned and replicated into Stock Receival Form (Form 6B). Notionally E-Dec data base could be accessed to directly populate the Form 6B.

6.3 Load-out integration

Installation and integration with load-out functions will significantly reduce labour required for stock counting and control, and improve both the depth and immediacy of management information.

7 Key Messages

7.1 Scalability

Nominally the relative simplicity of the system provides for installation in any sized abattoir – the “mechanics” don’t change. However where step changes are evident, cost effectiveness will be affected.

For example, and with reference to Table 4; whereas the unit cost for an abattoir annually processing (say) 150,000 head would reduce to $0.393, the unit cost for very small abattoir will be much greater than the $0.546 per head calculated for Radfords. Similarly; installing the system in a very large abattoir, will attract additional labour and infrastructure cost in order to handle the additional throughput.

7.2 Cost Justification

Development of the system was predicated on the assumption of imminent mandating by the Victorian Government of individual small-stock traceability and the offer of funding support for Radfords to undertake the project. Other ancillary objectives and benefits, such as

information enhancements, would not in isolation justify the Capex or additional operating costs.

In the absence of such mandatory requirement, Processors and Producers will need to assess whether or not the enhanced data capture, analysis and reporting provided by the system, justifies the incremental cost. Such determination will be largely influenced by the number of suppliers / producers to any particular abattoir who “come on board”, i.e. Amortising the cost over total throughput (because all suppliers want livestock improvement feedback), will be more cost effective than if demand for the system’s output is constrained to something less than total processing.

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