final report

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Direct skid mark identification

Stage 2 final report

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Executive summary

This project is looking at reviewing a new technology that may provide a cost effective and reliable means of extending traceability through the plant systems.
The Direct Skid Mark Identification (DSMI) system involves directly forming machine readable codes on the slaughter floor hooks (skids) and gambrels and reading these codes through the system.

Several sheep companies are trialling RFID in hooks and an Australian beef plant has been successfully using this system for a number of years.

Although RFID is one possible solution for traceability, there are technical barriers within an operation that may need to be overcome for a successful system. It would be extremely valuable for industry to have an alternative solution to evaluate.

The potential benefits of a DSMI system over RFID include:

1. DSMI is not affected by electrical interference, i.e. harmonics and electrical noise.
2. DSMI is based on well proven Direct Mark Identification technology as currently used in the automotive and military industries.
3. DSMI is a visible medium, meaning permanent and temporary marking can be viewed by eye as well as being machine readable, this may be advantageous if human readable text or symbols were to be printed as well as barcodes.
4. DSMI is designed to provide a means of applying a temporary marking to a skid and through the existing skid washing process have the patch removed with minimal additional work or effort.
5. DSMI is designed to be used on any type of skids, stainless steel, aluminium, white and black plastic and steel.

Cumberland Systems have already undertaken extensive clean room testing of the printing and reading of both plastic and metal skids with success.
This report and the accompanying movie represent the final milestone for project P.PSH.0274 Direct Skid Mark Identification System development and Demonstration – Stage 2. For technical information please refer to document SCT.025 Direct Skid mark identification – Stage 1. Figure. 1 provides an overview of the trial methodology.

The Direct Skid mark Identification IP is owned by Kevin Robert Wilkie and is covered by NZ Patent Application No. 547036.
The printing of the skids was carried out in the workshop, the skids were first washed and sterilised prior to being placed in bags and taken to the workshop. The skids were then sprayed with the patch material and printed by the laser. Each skid was printed with a unique barcode and number.
Once printed, the skids were then verified with a barcode reader and the data stored in a database. This ensured all skids used in the trial were valid and could be read with a barcode reader.

The skids were then introduced into the existing processing system at the gambling up point, the Foreleg – Main conveyor transition. From this point the skids remained within the usual path for carcass processing, for example condemned and detain where required, weighing and grading, carcass washing, chilling, marshalling, boning and skid wash. We will call this the barcode lifecycle.
The project provided us with the opportunity to evaluate the patch / laser marking methodology, the cameras and the patch removal in the skid wash process. We are satisfied that the overall

technical feasibility of the Direct Skid Mark Identification System has been confirmed. Our only misgiving is that inline application of the patch and laser printing was not included in this project. However we are confident that this will included in any future trails.

Contents

1 Formal Objectives

Cumberland Systems Ltd will have completed the following to the MLA's satisfaction and conduct trials to demonstrate the technical feasibility of DSMI to operate within a commercial environment.

The trial will include evaluation of:

- Laser technology
- Methods of ink application for printing laser marking patch
- Lifetime of the ink (in particular chiller and freezer longevity)
- Ink removal in skid washing systems
- Readability with moisture on skid
- Abrasion resistance
- Adherence to the skid substrate material
- Cost analysis of the Laser printing method
- Health and Safety issues
- Maintenance issues including ongoing cost and maintenance plan

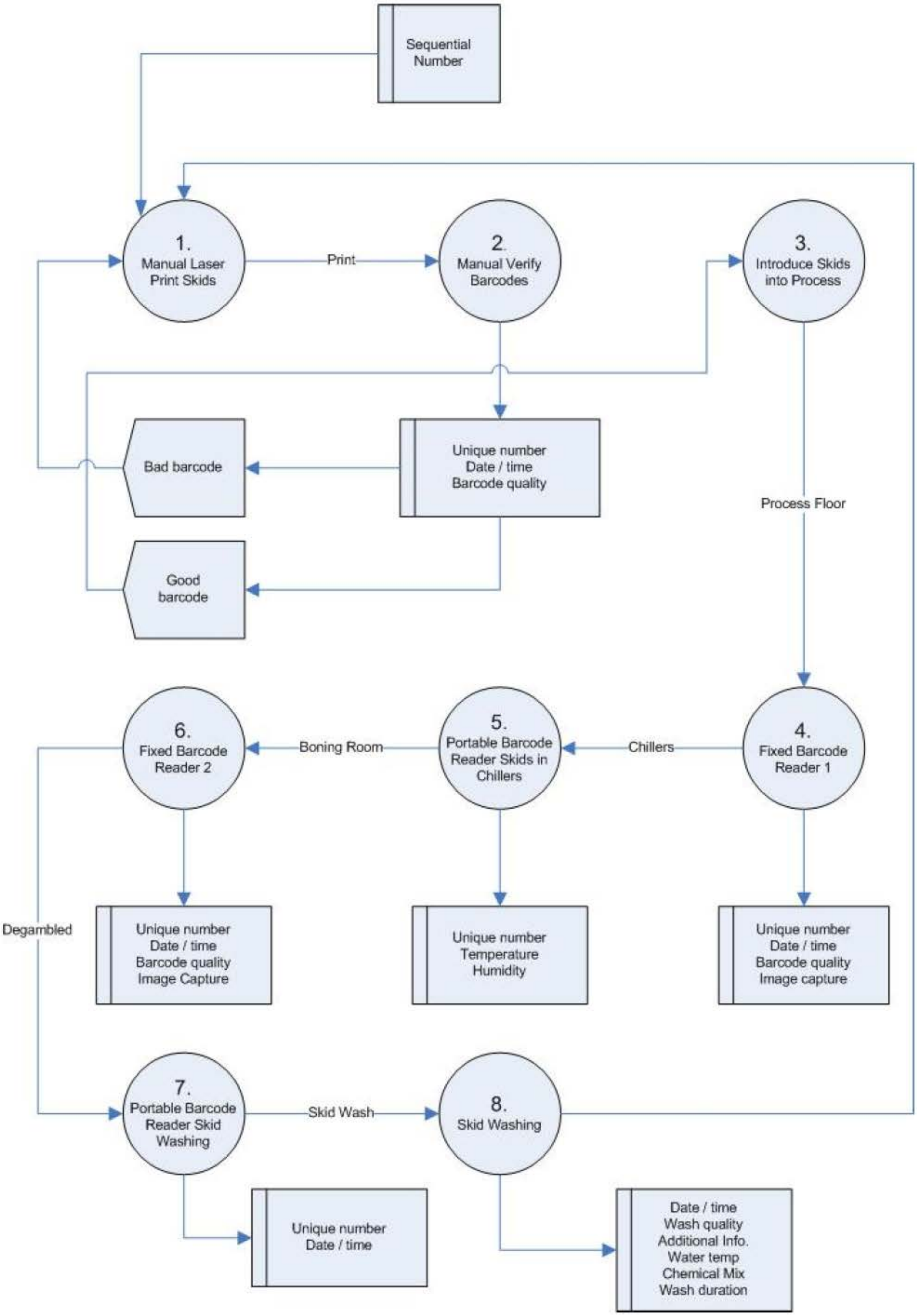


Figure 1: Flow Chart showing the proposed states for printing, tracking and washing the skids

2 Trial Results by Item

2.1 Laser technology

The laser system being used in this trial is a MACSA 10W CO2 laser c/w proprietary software and a fume extraction system.

Image 1: MACSA Laser mounted on stand with fume extraction system alongside

The laser print image is produced using proprietary software supplied by MACSA laser.

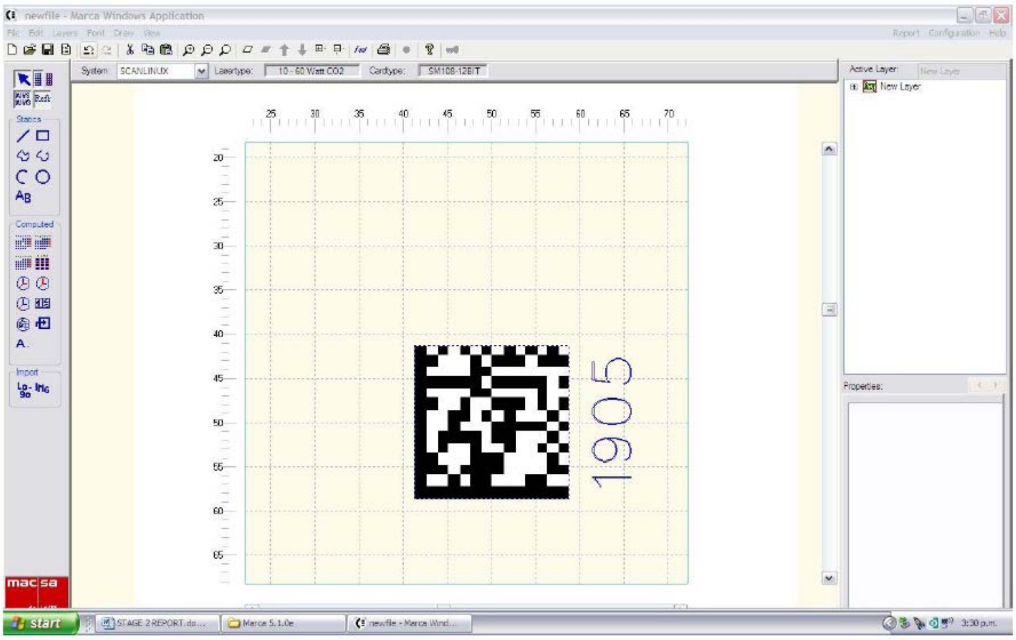


Image 2: MACSA application software environment

The laser printing is initiated through the MACSA software in the PC which is connected to the laser via a 10Mbit Ethernet connection. We would like to state at this point that the static printing the barcode was a means to an end, and in a fully installed system the skid would be printed while on the Main Conveyor.

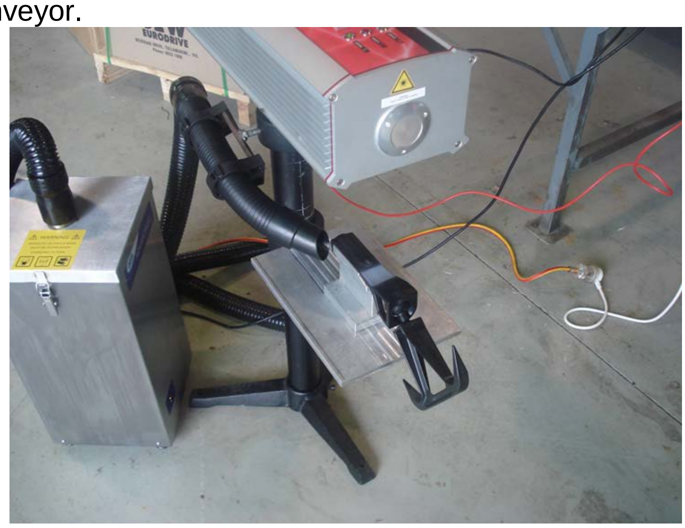


Image 3: Laser is ready to print with skid sitting in the cradle

Each barcode and number printed was sequentially numbered and printed statically in the cradle for the purpose of this trial.

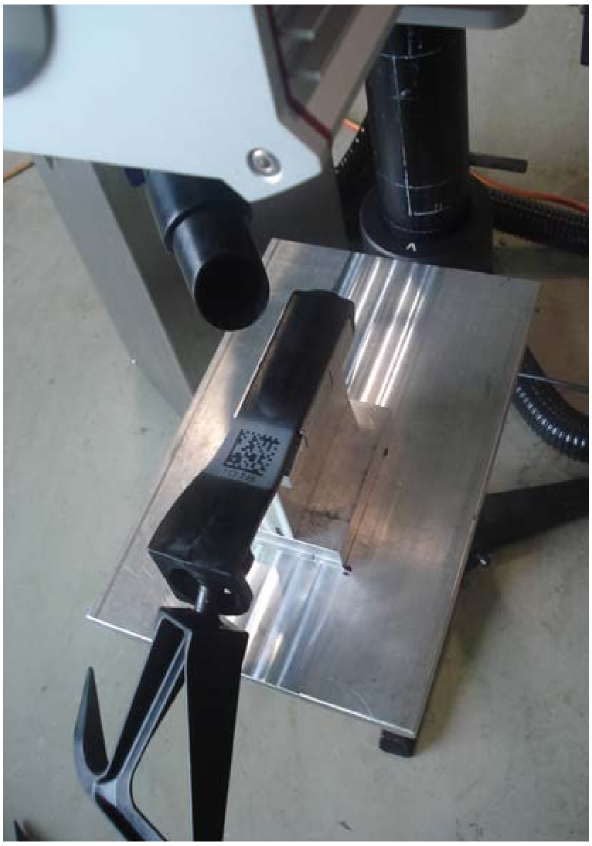


Image 4: Printed skid sitting in cradle

The completed skids with 2D Data Matrix (ECC 200) barcode and matching number printed onto the patch.

Image 5: Skids with patch and Data Matrix barcode and matching sequential number The completed skids were then placed in boxes ready for use.

Image 6: Skids placed into boxes

Over the course of this trial nearly 2,000 skids were printed and put into the process. Typically skids were prepared in bulk and introduced into the process in lots of 50 or 100 and the resulting read rate logged into the database software.

Image 7: Prepared skids ready for use in the process

Tests were also carried out on printing skids with multiple prints of the same barcode to further improve read rates should a skid get damaged.

Image 8: Skid with barcode printed twice

Image 9: Skid with barcode printed four times

The barcode printed is identical, the camera when triggered will find the first barcode it sees and decode it, and any further reads are not decoded. This is a relatively simple way of ensuring the maximum read rate is always possible.

Another means of maintaining 100% read rate was also used during this trial. The camera has the ability to determine the ‘cell damage’ (barcode damage). We provided a means for the cameras to send a captured image of each barcode that had cell damage of greater than zero percent.

Image 10: The following group of bitmap images demonstrate what the camera is able to output to a computer system

Additionally the camera can also provide the same images for a ‘NO READ’ scenario, when the camera has been trigger but has not been able to find a readable barcode. The resultant bitmap image may also be read using OCR (optical character recognition) technology to decode the number printed under the barcode. Please refer to document SCT.025 for the section using OCR technology to decode the NLIS eartag number, page 35.

Application of Laser marking “Patch’

The application of the patch for this trial was sprayed onto the skid using a conventional automotive spray gun. We would like to state at this point that this application method was a means to an end, and in a fully installed system the patch would be applied to the skid using inkjet printing technology while attached to the Main Conveyor.

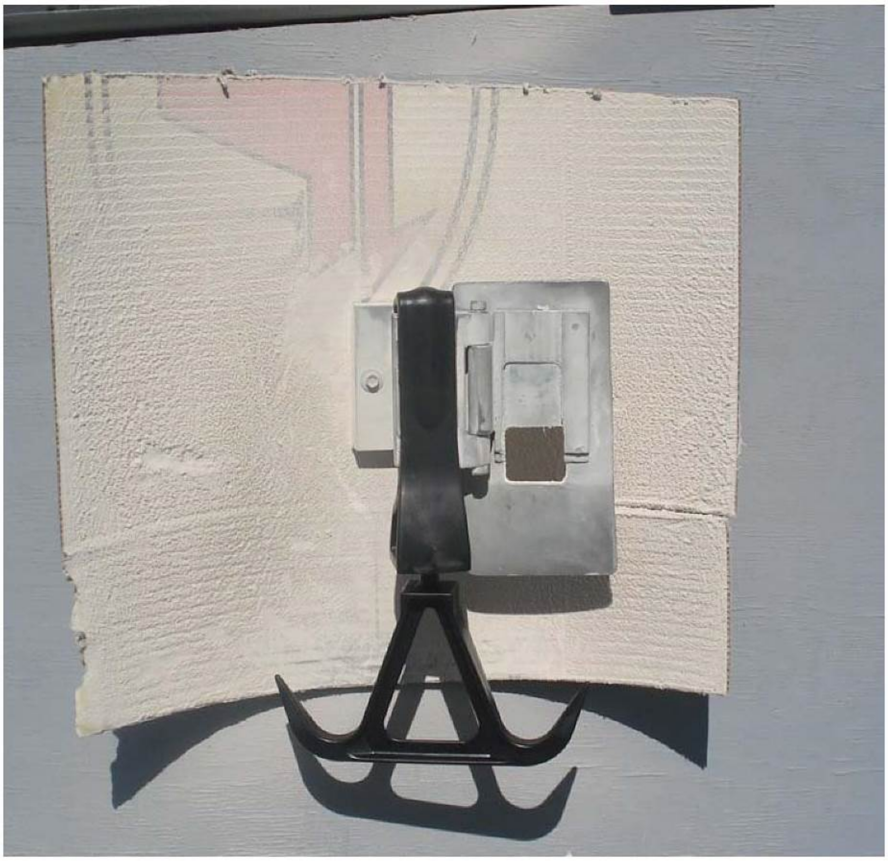


Image 11: Skid Patch application cradle with masking cover open

When the skid has been placed onto the cradle the masking cover is closed and the spraying process proceeds. The spray area is obviously larger than the cutout on the masking cover.

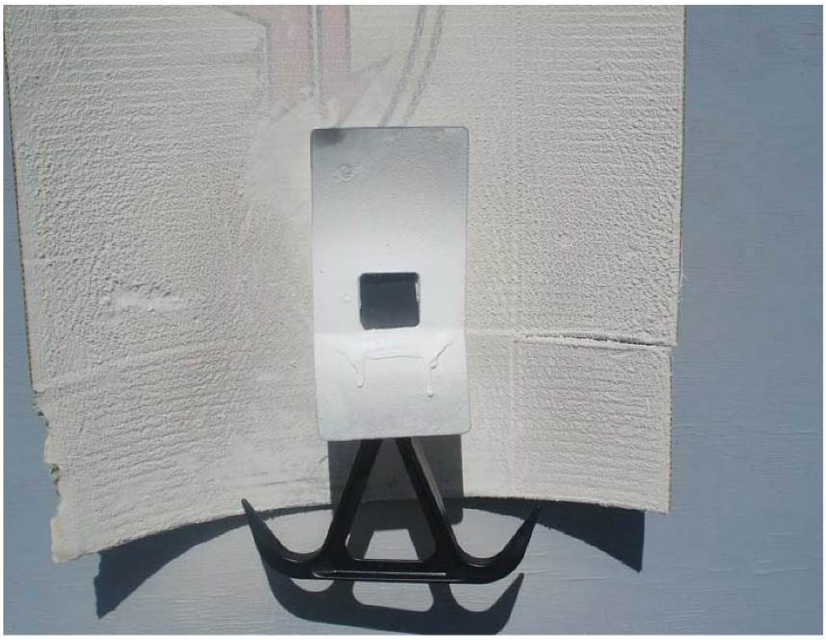


Image 12: Cradle with masking door closed

Once applied the patch was left to air dry, however the patch could be printed on almost immediately after the patch was sprayed on.

Image 13: Patched skids air drying

During the trial two different types of patch were trialled. Although they looked identical the abrasion resistance of each was markedly different. We identified each type by name, High strength and Low strength. Prior to application of the patch all skids had been washed in the detergent wash and sterilised in the 82deg bath in the Skid Room.

Both patches adhered to the surface of the skids and seemed to have little trouble keying to the smooth surface of the skid.
Once applied to the skid the Low Strength patch was able to be handled and rubbed by a smooth surface, however it could be scratched by a sharp object. The High Strength patch was able to be handled and had good resistance to scratching by a sharp object.

After an initial trial just running skids through the process, very little damage or interference from mechanical conveying systems was evident on the patches. Hence it was decided to use the Low Strength patch initially to see if any damage was evident over a longer period of time.

During this trail we can report one damaged patch was found, the damage appeared to have been done by a piece of steel along the top of the patch. The barcode itself wasn't damaged.

After this period both High strength and Low strength patches were used, alternating from day to day. This also allowed us to look at the skid washing on a daily basis and know which skids were coming through this phase.

2.2 Reading the Barcodes

The barcodes printed onto the skids were read by two cameras located in the plant. The first camera was located in the Process Floor. The second camera was located in the Marshalling Area.

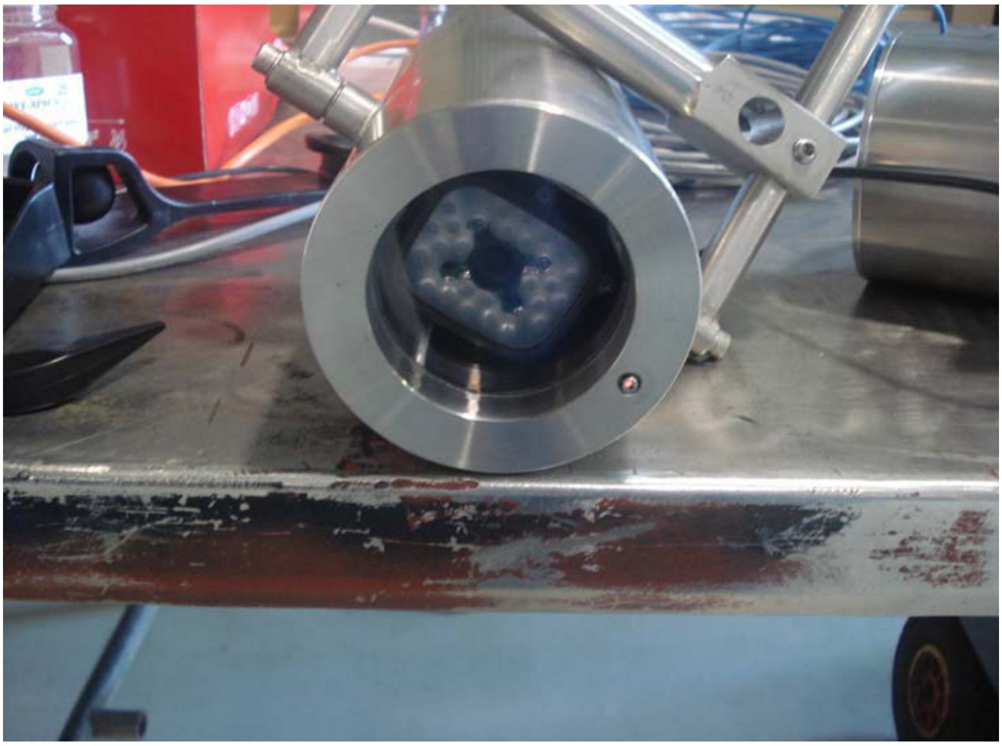


Image 14: Camera contained within stainless steel housing and trigger photocell

The cameras are housed in specially designed stainless steel enclosures with fully adjustable mountings and internal fibre-optic trigger photocell. The cameras have internal LED light source that illuminate the target skid when a trigger signal is detected. The illumination level is fully adjustable; however it is normally setup automatically by the camera when it is in calibration mode.

Image 15: The Process Floor camera located prior to the detain gate

The camera has two modes for capturing the barcode, Rapid mode and Continuous mode.

- Rapid mode operates when triggered by the photocell, there is an adjustable dwell time that allows the skid to travel from the triggering photocell to directly in front of the camera. At this point the illumination LED's will flash to illuminate the skid at the predetermined intensity. Once the dwell time has elapsed and the LED's are illuminated up to 8 image captures of the barcode, again with adjustable dwell timing between captures can be acquired by the camera and decoded. This is great for difficult to read barcodes and is ideally suited to fixed speed conveyor systems.
- Continuous mode operates when triggered by the photocell, there is an adjustable dwell time that allows the skid to travel to a predetermined position in from of the camera. Once the dwell time has elapsed the LED's will flash constantly at a high rate until a barcode is illuminated and decoded. This is great for variable speed conveying systems.

During the trial both capture methods were tried. Both methods proved effective with little detectable difference in read rates evident. However it must be noted that we did not detect any change in the Main conveyor speed either even though this is possible.

Figure 2: camera has been triggered and the LEDs are illuminated

Additionally the cameras can be setup to give a visual indication of a good read, by means of a green flash from the LED's immediately after the barcode has been decoded. This can be very helpful when setting up or for continual monitoring of the DSMI system health.

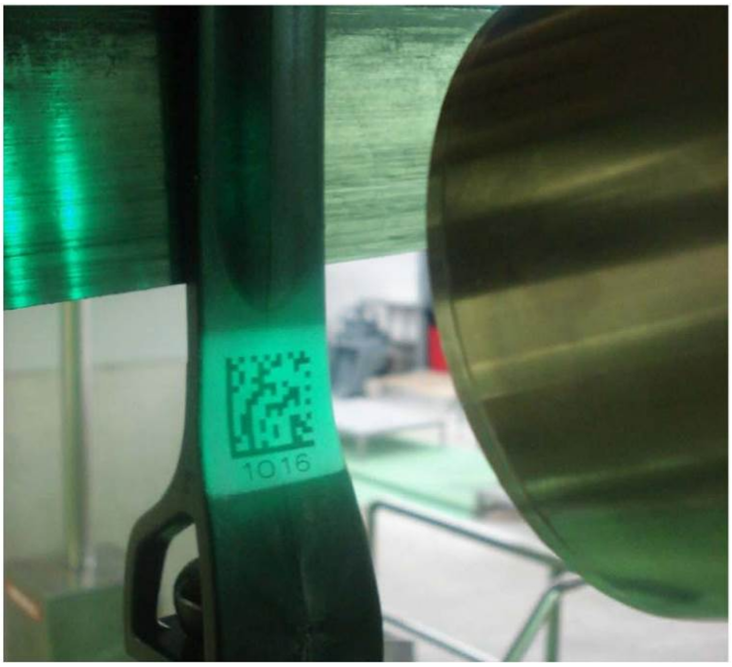


Figure 3: Camera LED's flashing green for a good read indication

The Marshalling Area camera is mounted on the out-feed conveyor system.

Image 16: Marshalling Area camera mounted on the out-feed conveyor

The out-feed conveyor provides a loop where trimming can be carried out. The carcasses are stored in the chillers for a minimum period of 12 hours. They are then unloaded from the Chillers and placed n rows in the Marshalling Area. As they are required by the Boning Room production schedule they proceed by conveyor to the Boning Room.

As the carcasses proceed along the Marshalling Area unloading conveyor they pass the second camera.

Image 17: Marshalling Area camera during load out to the Boning Room

The overall read rate recorded was 97%. We believe this is acceptable considering the manner in which the skids were printed, introduced into the system and the temporary nature of the installation. We are very confident a 100% read rate is achievable for a fully automated installation.

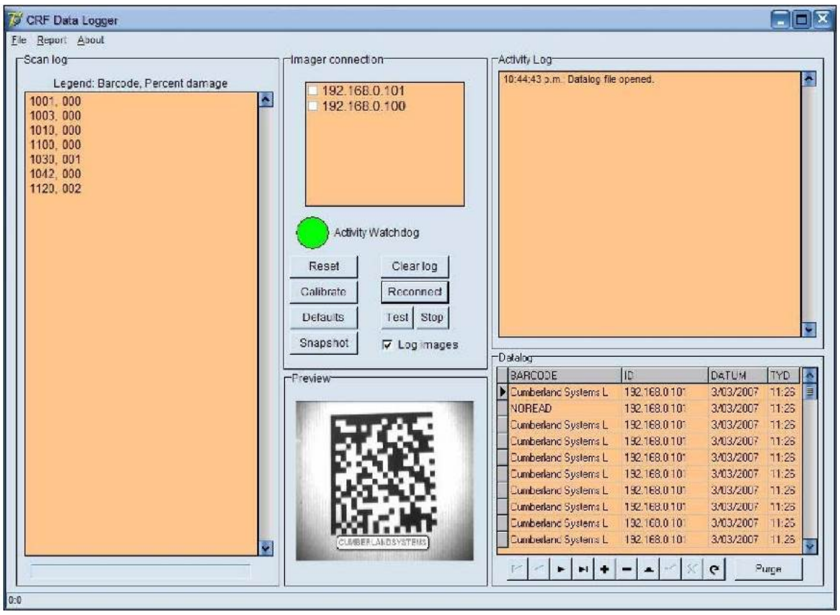


Image 18: Data Logger and Barcode capture software

The data logging software has been developed by Cumberland Systems Ltd specifically for this trial. The software has the ability to do the following:

- Connect to up to 10 cameras simultaneously via Ethernet.
- Maintain connection to each camera.
- Provide a means of calibrating all cameras.
- Receive bitmap images of faulty barcodes.
- Capture all barcode reads and store them in a database.
- Capture barcode 'percent damage' ditto.
- Additionally save data to a daily .CSV file.

Some time was devoted to testing the read rate of damaged barcodes. Using Reed Solomon error correction, the printed Data Matrix symbol can also withstand damage without causing loss of data. This high level of error correction is far more advanced than one dimensional barcodes with check digits. The sample barcodes shown in images 19 and 20 were both readable. Data Matrix codes can reconstruct up to 20% of damaged characters while 1 dimensional barcodes have absolutely no error correction providing simply a check digit for basic error detection. If the 1 dimensional barcode is damaged or looses any characters, those characters are lost forever. This enables Data Matrix codes to guarantee a fast and accurate reading where misreading is almost a thing of the past.

Image 19: Skid 1882 with barcode damage, reads okay

Image 22: Skid 1881 with barcode damage, reads okay.

2.3 Lifetime of Patch (Chillers and Freezer longevity)

In order to gather information on the environmental conditions the skids were subjected to we placed three temperature / % RH data-loggers into the areas where the cameras were located or where the skids where located.

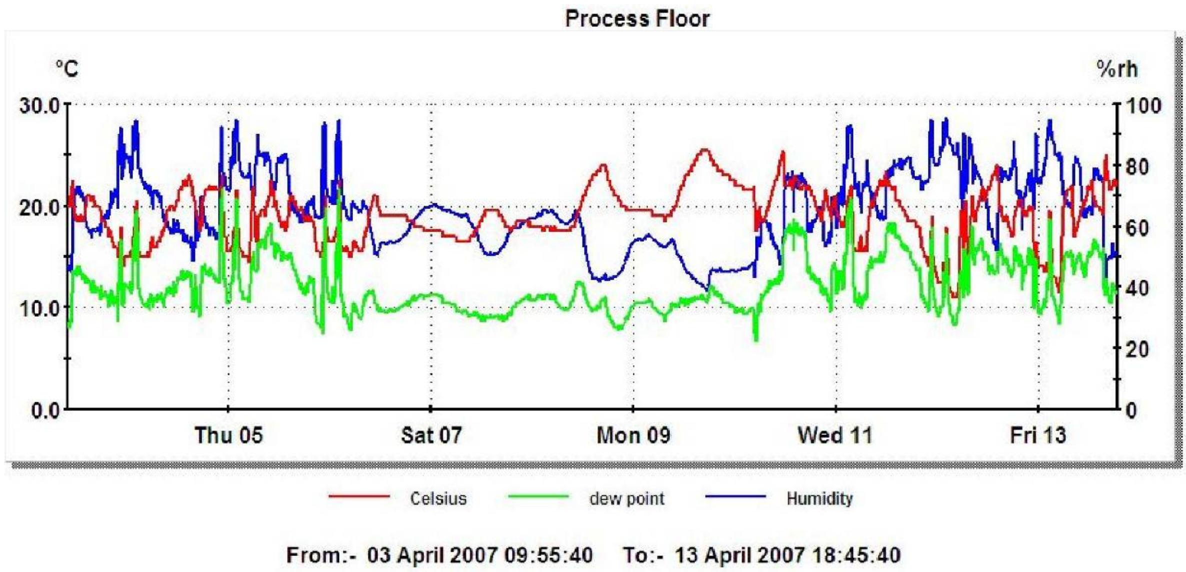


Image 21: Trend for the Process Floor showing Temperature, Humidity and Dew point

The average temperature for the Process Floor over this period was 19.00 deg C, the average humidity was 76.33 %RH.

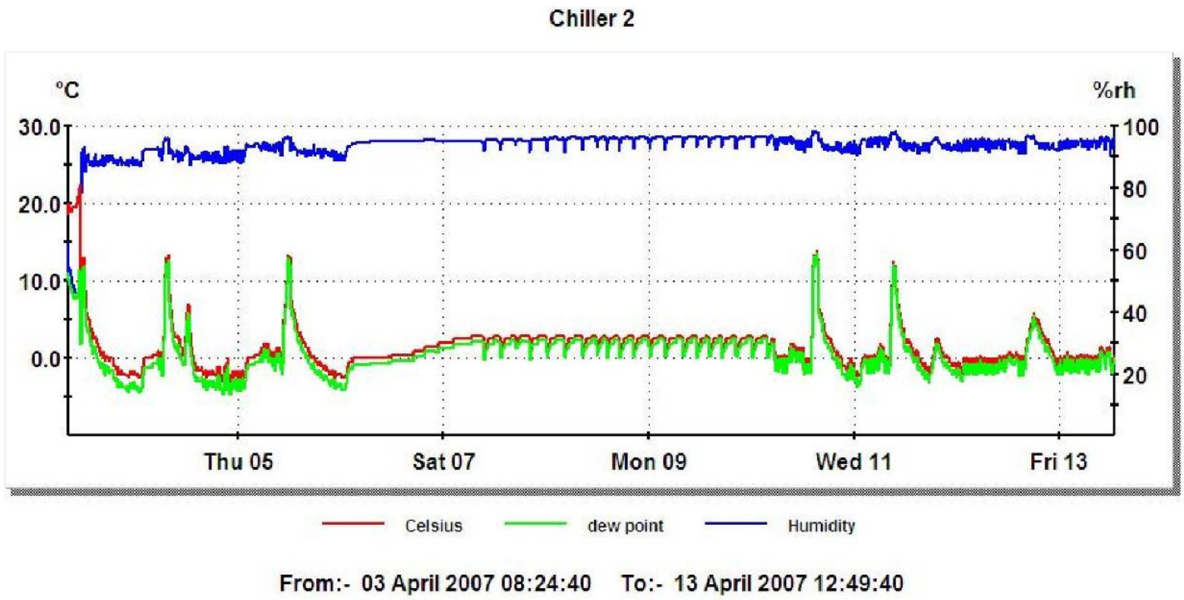
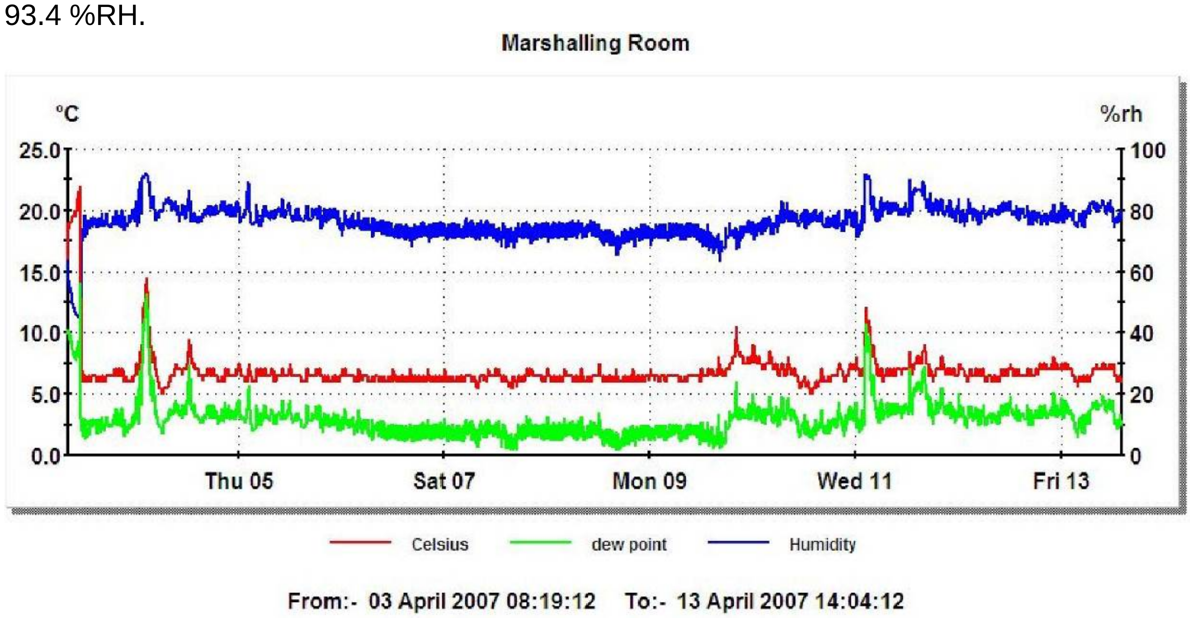


Image 22: Trend for Chiller no.2 showing Temperature, Humidity and Dew point

The average temperature for Chiller 2 over this period was 1.59 deg C, the average humidity was 93.4 %RH.



The average temperature for the Marshalling room over this period was 6.85 deg C, the average humidity was 76.3 %RH.

Image 23: Skids in the Chillers

The patches survived the chillers environment exceedingly well, the barcodes did not appear to be affected by the humidity or the temperature at all.

Several skids were placed into the freezer for a 48 hour period. No visible deterioration could be seen on the patches.

Image 24: Two skids with each type of patch were subjected to 48 hrs at -20 deg C, note the ice on the skids

Having tested the printed skids in the Chillers and the freezer we are very confident with the ability of the patch to maintain adhesion to the surface of the skid and remain in excellent condition with no noticeable deterioration in readability.

2.4 Patch Removal in Skid Wash

The final phase of the DSMI system is the skid washing. This is where the patch is removed and the skid is available for re-patching and printing.

Image 25: One of three skid washing tubs

Each tub contains approximately 1600 litres of water, and 75 litres of Applied Chemicals Pty Ltd, F50 heavy duty cleaner and degreaser.

Image 26: Weekly cleaning of tub and re-charging with detergent

The temperature of the water in the tubs is relative to the ambient temperature and would range from 10 deg C to 18 deg C depending on the time of year. The skids are returned from the Boning Room in a large steel container and a pre-washed in 82degC water and then tipped into the detergent soak tubs.

Image 27: Skids soaking in tub

The Low Strength patch begins to soften and bubble almost immediately.

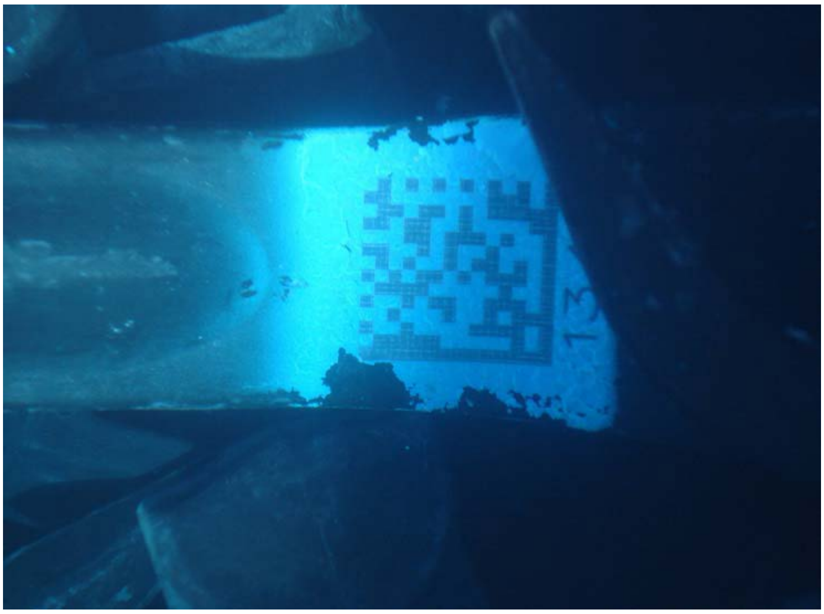


Image 28: The patch softens and dissolves in the detergent

Even though the water temperature was around 15 deg C the patch removal was very successful on the Low Strength patches. Any residual patch material could be readily removed with the addition of a simple wiping mechanism located on the skid return system.

The High Strength patch maintained a very good adherence to the skid through the process. Subsequently the skid washing had less effect on removing the patch. This we determined to be mainly because of the low water temperature in the soaking tubs.

Image 29: Skids with High Strength patches being tested in the soak tubs

Several tests were conducted to find out what was required to remove the High Strength patches. The most successful test was done using the detergent and 82 deg C water temperature, the patch softened considerably and could be seen to be dissolving over a period of time.

The transporting of the skids after the washing process is done by hand, skids are pulled from the tubs and placed into wheel barrows and taken to the skid room.

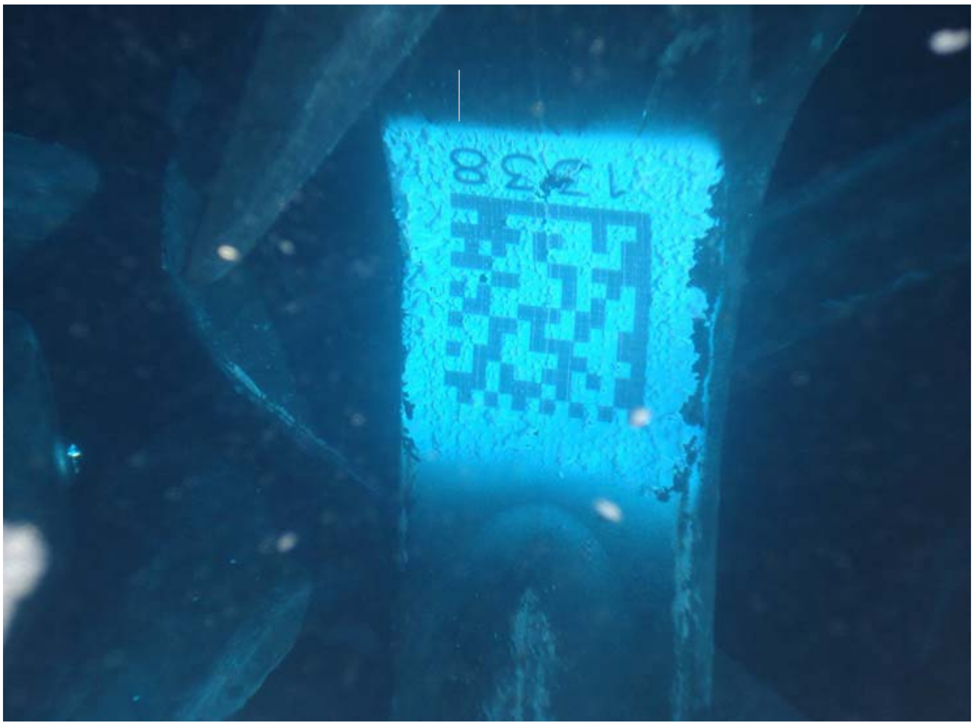


Image 30: Skid with Low Strength patch after 2 hours in soak tub

When the soaking period is completed, which can be anywhere from two to eight hours the skids are removed from the tubs and put into wheel barrows and taken to the skid room.
The skids are then placed onto the skid conveyor and elevated to the Processing Floor for re-use.

Image 31: The Skid Supply conveyor transfers skids from the skid room to the Processing Floor

2.5 Extensions for Skid Printing

During the course of this trial it became apparent that the principal of printing an identification symbol or barcode onto the skid could be used to add further information directly onto the skid. The obvious candidate for this is the existing method of attaching the carcass weighing and grading paper ticket to the carcass. We prepared several sample skids with the same information that is currently printed onto the paper ticket.

Image 32: Skid printed with the carcass ticket data and an additional Data Matrix barcode

As shown in Image 33 the skid is printed with the same data as per the paper ticket, the advantage of the printing onto the skid being it can be done without any human intervention, similarly the current practice of manually reading the barcode would be rendered extinct as the skid can be machine read. Based on the manning used at CRF there may be potential to save two staff per shift by employing this method of carcass ticketing.

3 Costings for Stage 3

The following section details the estimated costs for the labour and materials associated with carrying out stage 3.

Stage 3 Main Sections Summary

Stage 3 Summary		
Item	**Description**	**Amount AUD**
1	IT Technology Development	77,380.00
2	Printer Technology Development	13,200.00
3	Camera Technology Development	23,680.00
4	Skid and Hook Identification	7,250.00
5	Skid Washing Trials	15,950.00
6	RFID Data Transfer	7,100.00
7	Project Management	90,440.00
	Total Stage 2	**235,000.00**

Stage 3 Breakdown

Stage 3 Item 1		
Item	**Description**	**Amount AUD**
1	Supply of Computers and Touch Screens	13,700.00
1	Field Wiring — Power and Network	19,040.00
1	Infrastructure Location Design	4,000.00
1	Installation of Equipment — Test PC's, Consoles	4,000.00
1	Test Installation — Test Infrastructure	1,840.00
1	Identify Process Models	800.00
1	Plan — Identify each Software Application	4,800.00
1	Analysis — Look at Requirements of Application	4,800.00
1	Design — Write the Software	15,600.00
1	Test — Perform Controlled and Unit based Testing	5,600.00
1	Formal User Requirements	1,600.00
1	Determine User Requirements for Software	1,600.00
	Subtotal	**77,380.00**

Stage 3 Items 3 - 6		
Item	**Description**	**Amount AUD**
2	Supply of (loan) Printer Equipment	13,200.00
3	Supply of (loan) Camera Equipment	23,680.00
4	Bleed and Foreleg Conveyor Hook Identification	7,250.00
5	Skid washing trials and Final Cleaning Equipment	15,950.00
6	RFID Data transfer	7,100.00

Stage 3 Item 7		
Item	**Description**	**Amount AUD**
7	Trial Analysis	800.00
7	AQIS Consultation	1,200.00
7	External Laboratory Analysis	3,400,00
7	Provision for Ongoing Support	800.00
7	Outside Consultants	16,500.00
7	Report Findings	4,000.00
7	Identify Test Methodology	1,600.00
7	Interview Participating Staff and Management	1,200.00
7	Test Each Step in Isolation	2,800.00
7	Identify Test Parameters & Objectives	800.00
7	Conduct Trials	5,600.00
7	Planning and Site Preparation	3,200.00
7	Administration of the Project	5,600.00
7	Preparation of Project Brief	800.00
7	Preparation of Budgets	800.00
7	Drawings and Documentation	4,000.00
7	Travelling and Accommodation	24,640.00
7	Shipping and Documentation	7,100.00
7	Insurance	5,600.00
	Subtotal	**90,440.00**

Please refer to the Gantt chart tables in the SCT.025 Stage 1 Final Report to obtain more information on the item descriptions.

In addition to the Stage 3, provisional costings the following items have been identified and priced for inclusion in the project if required.

Additional Trial Items		
Item	**Description**	**Amount AUD**
1	AQIS Touchscreen Computers including software	20,000.00
2	Detain Touchscreen including software	11,000.00
3	Additional RFID readers, including alternative OCR camera system	36,000.00
4	Scanvaegt table / Cumberland bleed conveyor live weighing	14,000.00
5	CRF charges	unknown
6	MLA charges (may be 8% of final project price)	unknown
7	Carcass Ticket Printing and Reading in Boning room (loan equipment)	18,000.00

3.1 Purchase Proposal

This price covers the cost for CRF (Colac Otway) to purchase the project if was to remain installed on their site and covers any residual value remaining for the hardware and software for stage 3 for the original items only. Any additional items added would be agreed beforehand.

Stage 3		
Item	**Description**	**Amount AUD**
1	Stage 3 Purchase	70,000.00
	Total Stage 3	70,000.00

3.2 Ongoing Operating Costs

This section deals with the estimated costs for operating such a system.
The direct costs for operating the Direct Skid Mark Identification system are based on the following consumables.

1. Ink, is the only real consumable, depending on the printing technology used, i.e. Inkjet printing or laser/substrate ink and the act that the information to be printed is small in size the costs would be minimal. Estimated costs certainly in the range of 1c per carcass would be what we would be aiming for which is comparable for producing a paper label. We have completed a short long term trial, so we now have some hard data on the ink costs. The ink supply system changeover would be a manual operation, therefore a cost will apply to the labour involved. We envisage a snap in ink cartridge so downtime would be minimal.

Based on the current information we have CRF Colac would process 6,000 livestock per day over 2 shifts and production is carried out for 300 days of the year then we have an estimated total of 1,800,000 livestock per annum. Therefore our ink costs should be in a range from $18,000 - $36,000 per annum.

2. Maintenance of the system is another cost that would need to be budgeted for. The final system would have some diverse equipment ranging from inkjet / laser printers to cameras

and computer equipment. Our suggestion is that the computer equipment and administration of the database would become the care of CRF Colac in time and a maintenance contract for the remaining equipment would need to be negotiated. Typically the laser marking system would

have a life expectancy of in excess of 50,000 hours. As part of the stage 3 software a health system would be incorporated to monitor and report any malfunctions.
Our suggestion would be to carry out a programmed maintenance on the equipment on a monthly basis. This would involve mainly basic housekeeping, such as cleaning and ensuring equipment is not being affected by moisture ingress from hosing and humidity. This would be the single biggest factor in the longevity of the equipment. An estimated cost for doing this would be $20,000 per annum and would be provided ex Melbourne.

4 Health and Safety

The Direct Skid Mark Identification system is comprised of three basis components. The Patch, the Laser and the Cameras. Each part has health and safety requirements.
Patch (abbreviated Material Safety sheet)

- Composition and Information on Ingredients:
  - Synthetic acrylic resin (dry) = 50%
  - Water = 40%
  - Inorganic Pigment = 10%

- Hazards Identification:
  - Not classified as Hazardous according to the dangerous Substances Directive 67/548/EEC.
  - No specific hazard.
  - The product is not classified as flammable.

- First Aid Measures:
  - Eye Contact First Aid
    - Flush eyes with plenty of water or normal saline, occasionally lifting upper and lower lids, until no evidence of chemical remains.
  - Skin Contact First Aid
    - Remove contaminated clothes and shoes. Wash affected area with soap or mild detergent and large amounts of water until no evidence of chemical remains.
  - Inhalation First Aid
    - Remove from exposure area to fresh air. If breathing has stopped, perform artificial respiration. Keep person warm and at rest. Get medical attention.
  - Ingestion First Aid
    - Seek medical advice. If vomiting occurs, keep head lower than hips to prevent aspiration.