final report

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A.SCT.0029 39 42 44 47 49 50 51 56 58 Supply Chain Objective Carcase Measurement - supporting activities

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Abstract

The A.SCT.00xx series of company managed activities into red meat objective carcase measurement OCM technologies, contributed to and informed the following project reports:

A.TEC.0058

A.TEC.0080

A.TEC.0083

A.TEC.0085

A.TEC.0094

A.TEC.0095

A.TEC.0096

P.PSH.0306

P.PSH.0360

P.PSH.0417

P.PSH.0603

In addition, please also refer to OCM Workshop April 2009.pdf which encapsulates all of the learnings of this body of work.

Contents

1 **A.SCT.0029** Objective Assessment of Detail Carcase Characteristics -Phase 2 Preliminary Data Gathering and Technical Specification Development

1.1 Purpose and description

This project is to assess the opportunities and technological solutions to objectively measure beef and lamb carcases key characteristics on the slaughter floor and provide the information needed to the specific sections of the processing supply chain.

Phase 2
In phase 1 all stakeholders received a report of the outcomes of the technology that is available and its suitability to fit with the combined need of the stakeholders. This stage will see the formation of an overall plan and
agreement between stake holders as to the path forward and to develop detailed project briefs with the associated time frames and budgets to complete the research. This stage will also see contacts drawn up ready for signing by the nominated and selected parties to be involved in undertaking the research and development which will be the focus of Stage 3. (Cost estimate to be prepared in Phase 1)

This variation is to cover an approximate $1,000 shortfall that has now appeared as a result of the final invoice being received by MLA for this CMA. The project will be closed after the final invoice is paid.

2 A.SCT.0039 Objective Carcase Measurement Development (X-Ray and CT Scanning) - Stage 2 (External Project Management)

2.1 Purpose and description

Australian X-Ray Technologies (AXT), have subcontracted Hytec Inc in Los Alamos, New Mexico, to complete initial trials using cone beam CT technology to image a lamb carcase. Relevant Cooperative Research Organisations and other technically competent organisations will assess the image quality as to their suitability for input into 3-Dimensional Imaging software. Matrix Professionals is required to monitor their progress and to coordinate the assessment.

In addition, Matrix Professionals will ensure that potential developers of the software to analyse these images are undertaking the initial evaluation and are able to respond appropriately to any technical questions they might have.

AXT are also undertaking trials of conventional X-Ray machines to image carcase, with a view to installing these baggage screening X-Ray machines into Australian Meat processing plants to collect data for review, upon successful completion of the trials. Matrix Professionals will monitor this trial and ensure these tasks are progressed and appropriate decision points regarding go or no go based on image

suitability will be made.

Various organisations are needed to have input to make these decisions and this will be managed by Matrix Professionals during the absence of key MLA staff (Sean Starling and Rebecca Underwood) during January 2007.

Milestones

Achievement Criteria	
1.	Monitor the Cone Beam CT Hardware Image collection and ensure the images are distributed to relevant Cooperative Research Organisations
2.	Ensure the above images are reviewed and the CRC Organisations (Beef and Sheep) have made comment as to their suitability. MLA received comment from CRC
3.	Provide these images to the Mayo Clinic Software experts for assessment as to the difficulty of finding the 4th rib. Images provide to Mayo Clinic
4.	Assess the images in conjunction with the CRCs, to determine whether the baggage Scanning X-Ray unit is a worthwhile project to undertake. Discuss the images with AXT. Report to MLA on all 4 milestones including recommendations on future actions to be taken.

Outcomes informing various reports, refer to A.TEC.058, 80.

3 A.SCT.0042 Objective Carcass Measurement Development (X-Ray and CT Scanning) - Stage 3 (Industry Dissemination of Findings and Futures Meeting)

3.1 Purpose and description

The purpose of this project is continue to manage the development work started with Australian X-Ray Technologies (AXT) who have subcontracted trials with Hytec Inc in Los Alamos, New Mexico on the initial development trials using cone beam CT technology to image a lamb carcase. Further work is now required to monitor the progress of AXT and Hytec and the other organisations who are looking at the feasibility of undertaking work on MLAs behalf. There is also a need to coordinate the involvement by the relevant Cooperative research to ensure that they are familiar with the developments and concur in the general direction the project is heading form a technical and meat processing perspective.

This is an especially critical time as Sean Starling is out of the country leading up to a critical industry briefing and workshop.

This project is now ready for review by Industry MLA and the key research organisation within the meat industry. Preparation for this meeting is critical as there will be representatives from the major beef and lamb processors who have indicated a need for this technology as well as from Meat Processing companies and Meat Industry representatives from New Zealand.

Milestones

Achievement Criteria	
1.	Prepare for and meet with R Trett of AXT to develop the technical format of a system for use in a meat processing facility and to understand the limitations that such a system may have. Develop a "First Pass" budget based on experience and what is known. Distribute images
2.	Report on Current status combining information from R Trett and personal knowledge into a combined overall document and develop into a Power Point Presentation for delivery at an industry meeting. Provide assistance as needed to develop the background material for this meeting and dispatch to attendees.
3.	Continue liaising with Mayo Clinic and Tomographix IP Ltd re software cost estimates to locate skeletal positions from captured Diacom images. Proposals received from Mayo Clinic and Tomographix Ltd
4.	Travel with AXT and Hytec representative visiting Australia to CRF and progress the negotiations regarding their involvement and potential costing. Proposals received from Hytec regarding their future involvement.
5.	Follow up with notes and actions from the meeting in Sydney on 16th May. Report to MLA on all milestones including recommendations on next steps.

4 A.SCT.0044 Objective Carcass Measurement Development (X-Ray and CT Scanning) – Stage 3(Collection of Data from X-Ray system for Predictive Carcass Skeletal Model)

4.1 Purpose and description

This project seeks to determine if measurements of easily identifiable skeletal points of a carcase that show up in X-Rays can be used to improve the precision of the predicted lengths to such a degree that these predicted lengths could then be used as either:-

- Measurements in their own right and feed directly into the control logic of the guillotines performing the three way cut.
- As a means of providing the image analysis software with an initial guide or seed point so that the software can correctly find the correct skeletal positions with a higher correct frequency

The purpose of this project is to continue on with the work undertaken by 2 students under the 2006-2007 MLA student program. It comes about as a result of the difficulties being experienced in the location of key anatomical carcase skeletal locations in order to provide the input into automatic guillotining machinery. This project seeks to determine if the accuracy of prediction using easily measured carcase dimensions be found by using a higher level of sophistication as the measuring medium, in this case X-Rays, and therefore be useful to assist the image analysis software in locating the skeletal points.

Milestones

Achievement Criteria	
1.	Understand the limitations and the outputs that are coming from the X-Ray system now. Determine appropriate dimensions to measure. Protocol written
2.	Collect the images and undertake the measurements. Data in excel table and data to Murdoch University
3.	Statistical analysis and report to MLA

❖ Report on Contract

Note the milestones of this contract were modified to Engage with IMTEC inc of New Mexico and Assist with the initial base trial of Computer Tomography (CT) technology using Cone Beam CT on Samples of beef and lamb

❖ Introduction.

The initial contract was initially written to undertake measurements of Lamb Carcase dimensions based on X-Ray images as captured by Scott Automation. Scott Automation have been developing an "online X-Ray" system for use with their robotic Quartering process in a lamb processing facility.

This program was initially to commence some 12 months previous but due to concerns by Scott Automation and a reluctance to grasp the benefits of the project it has been delayed in the start date.

During the time that this project was delayed, significant developments have been achieved in the use of Cone Bean CT. The Cone Beam CT process delivers a 3 dimensional image of a Carcase allowing the components of meat; fat and bone to be segmented individually. This allows many more benefits to be derived compared with the simplistic 2-dimensional X-Ray that at best can provide dimensional outputs that enable robotic quartering. Troubles with identifying 100% of the lamb carcases with accurate dimensional information has dogged the development of the Scott Technology for some time. The Cone Beam CT technology has the potential to usurp the need for the X-Ray system and to provide significantly more information that what straight 2-Dimemsiaonal X-Ray can provide. These benefits include:-

- Carcase Composition allowing better market allocation decisions by the processor
- Payment systems to producers base don Carcase composition refecting true carcase value
- Health ad safety issues associated with the early detection in the process line of diseases and other sanitary issues related with the carcase.

As a result of all of this and in conjunction with Sean starling the project changed focus to look at the initial development and what CT could deliver to a meat processor as an early benefit.

To this end Greg Palmer travelled to the IMTEC Inc. Offices in Boulder Colorado and to Los Alamos New Mexico.

❖ The Project

The objective of the project now became a need to identify the key attributes among the list of variables that can be adjusted with Cone Beam Ct that are key to delivering the best output image in the limited time available

The key times were :-

- 5 seconds for lamb
- 20 seconds for beef.

Whilst it was believed that good images could be captured at these rates based on preliminary trials done by Imtec in early 2007, it was necessary to understand what were the key physical settings and parameters of the hardware and image acquisition software that would deliver the image that would enable the greatest amount of information and therefore benefit, to be recovered.

❖ Project Description

During the work at Imtec, the focus was based on an experimental design that had been developed prior to arrival. It was unfortunate that Imtec technical staff had not spent the time needed studying this plan and much time was lost early in the visit as Imtec technical people came up to speed with understanding of the needs of the Experimental design.

Samples of meat, both Beef and lamb were purchased as were sample containers, so sized to suit the meat sample size. The sample containers were so sized that the meat samples were able to be "squeezed" into the container and not need repositioning.

The sample sizes were much smaller that was desired based on the small detector size- 200 mm x 250 mm. This will need to be addressed at later stages in the project and a much larger detector made available so that the impact of larger cuts of meat such as a full carcase cross section can be tested.

❖ The Tests

The tests were carried out in accordance with the parameters as laid down in "Experiment 1". The Experimental Protocols and the Test recording spreadsheet are include as attachments to this document.

The higher energy trials of the 200kV and 300 kV were not able to be undertaken. The detector being used was only capable of receiving energies up to 150 kV but it was decided to stretch the specification and allow this detector to accept 200kV energies and fortunately it was able to withstand this energy level.

The images were acquired and then post analysed. The images were saved after their 3-D reconstruction and a section of the image was reviewed. This section was chosen at similar locations on each sample .A Line Profile across a typical position of each sample was then plotted on a cross sectional image of the sample.

This line profile gave a representation of the changes in Density across the sample. It was expected that the muscle would be a similar density all over, the fat levels would be less and the bone would be significantly higher in density level.

What was observed as that the edges of the sample had one value of density for muscle and the inner areas of the image had a very different, significantly less value for muscle. This effect is known as Beam Scatter and can be improved with various techniques.

The biggest issue with the range of density variations was the variability of the muscle being so great that it overshadowed the value of fat. Hence it would be not possible to discriminate meat and fat. Under the current settings Bone was able to be distinguished but not always. Another process which removed all of the values of measured density incrementally was applied. This eroded the density values until the area that was known to be bone just began to be eroded. The amount of muscle that was still in the image was a very visual review of how well the image was performing under the acquisition parameters.

In all cases in the initial tests the Beam Scatter effect was so large that there was not one image that could have served a useful purpose. There was too much mixing of densities where what was obviously muscle had a density value that was now the same as bone. In all views including the high image quality "Gold Standard", significant scattering was occurring. Scattering is primarily caused be excess radiation impacting on the detector which has not followed a straight forward path through the part. Sources of scatter are :-

- The part being imaged itself – more X-rays are reflected from the harder, more reflective bone than muscle and fat
- Reflected X-Rays from the walls of the X-Ray Cabinet

To test the amount of scatter in the image and what it meant to the initial research target of the identification of bone, an erosion process was undertaken which eroded the less dense pixels leaving the heavier denser pixels. The pixels were increasingly eroded until there was just the hint of the beginning of bone erosion.

The image that was left in all cases included bone and meat. This means that there has been sufficient scatter of X-Rays to distort the value of the meat particle so that it now looks as though it is the same density as bone.

The amount of Scatter increased as the speed of rotation and pixel size increased, however this did not appear to a linear relationship and it appeared as though the amount of scatter reached a peak and went no further.

It was obvious that unless the scatter could be controlled then the project was not going to go any further.

It should be noted that these images were collected with only a single thickness of Copper as the filter.

❖ What was the Cause of Scatter?

Tests were undertaken to determine how much scatter was coming from X--rays bouncing around inside the cabinet.

A piece of Tungsten was placed in direct line with the beam to prevent any X-Rays hitting the Detector. Any X-Rays that did reach the detector must have come from a reflection from the internal walls and equipment within the Cabinet.

This was not considered to be disastrous however to reduce any effects that the cabinet may have been imparting to the scatter problem, a collimator was installed which consisted of a frame of lead placed in front of the X-Ray source. This blocking lead frame had a small rectangular slot in the X-Ray beam path which was so sized so that X-Rays could pass through and only hit the target meat sample in a direct line of sight.

Some simple tests were also carried out making use of a “Scatter” filter in the reconstruction Software. To do this accurately, the scatter had to be characterised which was achieved by imaging a circular container of water which was approximately the same size as the Meat Sample. The scatter from this could be measured with the range of densities less than 1 measured. This could then be fed into the Scatter filter.

This also demonstrated some improvements in the range of densities in a sample image.

The real problem was in the amount, type and combination of filter material. This needs more research to determine which is the optimum combination for these meat samples. This needs to be determined urgently.

As a way of understanding the potential improvement that could be gained by the most appropriate selection of filter material, a combination of Copper, Molybdenum and Aluminium was tried as a first pass based on the experience of Joe Romero.

These metals in combination appeared to offer some significant improvement in reducing Scatter.

A sample at 1 mm pixel size, ½ Nyquest, 4 frame averaging and was tested. This scan period consisted of 94 images over a 6 second period. An erosion process was again undertaken which resulted in the image below.

It can be seen from this image that the bone has just begun to be eroded and almost all of the muscle in the image has been removed. This is certainly a clear enough image for software to be able to identify the skeleton within the carcase and provide the input into a robotic cutting system

❖ The next Steps

The next steps are to identify the best combination of filters for these samples of meat product.

A new series of scans can then be done after this has been determined.

In addition to this IMTEC have a software filter called a “dark Filter” which has been developed by one of the Los Alamos team. This filter needs to be applied to the raw data after it is acquired during the images acquisition part of the process.

This filter was developed specifically for the removal of Scatter type artefacts.

In the current "6 second" image, the Software scatter algorithm that was applied to the existing Images and was applied after reconstruction and not before. The Dark filter needs to be applied to the raw data after acquisition and can be a separate process and will not form part of the image acquisition time.

It is also believed that the processing of the raw images will enable faster cycle times during the acquisition cycle.

❖ In Summary the next steps are :-

- ❖ Determine the Best Filter Combination
- ❖ Capture mores cans as part of a new design based on the results of the last trial
- ❖ Capture the Raw images from these Scans
- ❖ Apply a dark filter to the raw data to remove Scatter
- ❖ Reconstruct the image
- ❖ Review the image for Scatter measurement
- ❖ Possibly use more software again to remove more scatter if needed

The objective here is to try and have the scatter reduced so that the Fat, meat and bone are all with discrete density ranges and are mutually exclusive. In this way an erosion algorithm can be applied to isolate either fat or meat and bone. This will mean that the second level of need could be considered achievable, ie predicting overall carcase composition.

❖ Other issues

IMTEC, at this stage, do not have a large enough CT machine to handle the size of sample that will be required to be imaged in the near future. The current 20 x 25 Panel is the largest detector that is available and this is only coping with the small mat samples being imaged. It is hoped that a "pair" of **Lamb legs**, representing the upper part of the lamb that is left after the Scott Automation Robots have completed their process can be imaged in a combination image. This would be a simulated test and it hoped to have this completed prior to the meeting on the 9th April. If this is possible, this will engender processor with greater confidence that CT is technically viable. It is not believed that the processors will get the level of confidence from the images that have been captured to date, to derive the enthusiasm and shared vision of the path forward needed to really get behind this project.

Greg Palmer had the opportunity to discuss the use of Scintillator materials and their potential as a large detector for use in this application. Some work has already been done by IMTEC on the applicability of these materials and Tony is well down the track on this investigation. IMTEC at this point do not have any Scintillator type detectors within the organisation apart from those on appraisal.

The planned research is directed at Scintillators because:-

- ❖ They can withstand higher energy levels (kV) and any electronics that are likely to be destroyed by the high energy can be mounted remotely and out of the X-Ray Path.

- The new Scintillator Materials have a higher Image acquisition rate than the current Varian Digital panels as do the CCD cameras that are also from part of the "Scintillator System"
- Newer technologies such as the micro-channel plate are being considered. These devices are used to amplify the signal coming from night vision goggles and enable the image to be seen by the wearer. The other benefit of such technologies is the ability to achieve higher imaging speeds.
- The university of Tennessee are undertaking research into scintillator technologies in their scientific laboratories. It would be worth of an MLA person visiting these Labs next time someone is available to do so.

Summary

- The trials from Experiment 1, have given some confidence that the first part of the need of Meat processors, the identification of the skeleton, can be undertaken at reasonable productions speeds.
- There are still some better technologies that could be incorporated this that will either allow the image quality to improve or allow a higher production rate
- IMTEC will need to investigate other detector technologies if larger samples of meat are going to be imaged and this will most likely need to be available as soon after the 9th April as possible.

5 A.SCT.0047 Objective Carcass Measurement – Phil Green

5.1 Purpose and description

Phil Green has worked with MLA on the objective carcase measurement program since its inception and has worked with Cargill, NCMC, CRF and WAMMCO to understand the business proposition for these four clients with respect to the benefits of CT and where and how it should be integrated with their sites (i.e. he has spent at least a week with each site gathering all of their sensitive data). Phil is now required to work with at IMTEC in the US to assist in assuring the IMTEC board that there is value in this proposition and then develop the R&D plan.

IMTEC and MLA are currently developing an R&D project that will develop a Mobile Primal Pilot CT machine. This machine although not able to automatically process an animal will enable IMTEC, MLA, the four participating processing companies and researchers to sample and test various aspects of both beef and sheep carcases to confirm all the possibilities for CT as identified in the technology matrix. During this stage algorithms will be developed and scale up data collected that will enable full scale systems (automatic and full body carcase size) to be installed in Australian meat processing plants.

It is envisaged that the system will spend approximately 3 months at each of the four initial participating processing companies sites. After this period the system will be maintained for meat industry use for an additional two years. During this time it will be located in a newly (to be formed) IMTEC Australian operation location. The system during this time can be used for further data collection, trying new algorithms, trying new resolution and power

hardware as they evolve or relocation to other meat processing companies as a marketing and site readiness tool for future processors who engage in the OCM concept.

The project will recruit a new Australian graduate during these three years who will own the portable CT system and undertake all trial work at the participating sites.

It is anticipated at this early stage that the budget will be approximately $2 million with the project budget being shared by MLA and IMTEC equally.

Phil Green is working with MLA on this project and has been appointed the role of Project Manager Business Proposition & Integration. As such Phil will accompany MLA (Sean Starling and Christine Pitt) to IMTEC to assist in answering any IMTEC Board questions and developing the R&D program/plan for the first 12 months.

1. Present with MLA to the IMTEC board to ensure all parties agree on the benefit of the developments and the commitment required for all participants
2. Work with MLA and IMTEC to develop the R&D plan for the first 12 months
3. Accompany MLA and IMTEC to the Mayo clinic to determine that assistance that the Mayo clinic and their software may be able to provide the IMTEC/MLA project.

Milestones

Achievement Criteria	
1	Participate in IMTEC trip with MLA
2	Trip report and submission of Phil's contribution to the OCM strategy

6 A.SCT.0049 Objective Carcass Measurement Development (X-Ray and CT Scanning) – Stage 3 IMTEC Workshop (External Project Management)

6.1 Purpose and description

MLA has entered into a contact with IMTEC Inc. of Los Alamos New Mexico to begin the development process leading towards a purpose designed CT System to suit Australian Meat Processing Plants for beef and Lamb.
They have now commenced the initial phase of the investigation which is due for completion in August this year.

The objective of this contract is to provide resources to project manage this project and co-ordinate the activities that are necessary to be undertaken in Australia and to be instrumental in driving the communications between MLA and the OCM Steering committee processors so that they are kept informed and involved.
This will involve visiting IMTEC at their subsidiary offices in Melbourne and making decisions with IMTEC's technical specialists as to the direction of the project. IMTEC have a senior Engineering resource based in Australia and he will become a main point of technical

contact regarding this project..

This project will also include liaising with the members of the processing sector who are part of the Objective Carcase Measurement (OCM) Steering Committee and to this end the Consultant will also organise a Workshop where all of the key technical Industry stakeholders will participate. This will include the OCM Steering Committee members as well as MLA Stakeholders.
During the time of this workshop senior IMTEC people will be travelling to Australia. At this time, the opportunity will be taken for a graduate Engineer or similar to be interviewed for a position working in the US with IMTEC. The consultant will organise and orchestrate the interviewing and prequalify the candidates in readiness for these interviews times.

Project manage the project with input from Sean Starling and Phil green.
2. Provide minutes of regular meetings with IMTEC and MLA technical representatives regarding the project progress and place these minutes on the MLA WIKI OCM web site
3. To meet with IMTEC Technical resources on a regular basis in Melbourne and update the project plan accordingly after discussions regarding progress.
4. To organise a Workshop with the members of the OCM steering Committee and their CEO's with senior IMTEC people to report on progress and seek approval for future directions
5. Organise for the advertising and prequalification and selection of a number of candidates for the Graduate Engineers position which is to be located at IMTEC's offices in Los Alamo and orchestrate the interviews for this position during the time of the Industry workshop

MLA has been involved in driving improvements in efficiency within the meat processing sector and particularly in the area of automation. One of the reasons for this emphasis is because of a lack of available skilled labour. One key area of interest has been in automating some of the initial processes as the carcase enters the boning room. To be successful these automatic processes need to have as an input, information about the skeletal positions where the carcase is to be divided. This has come from an operator input in the past but this is hindering productivity and human error is lowering efficiency.

MLA has facilitated the development of X-Ray technology however this 2 dimensional objective measure also has shortcoming when working with a 3 dimensional carcase. A research project into the available technologies that were appropriate for use in a meat processing plant was completed earlier this year and identified that Computer Tomography (CT) had the greatest potential for providing a solution to the carcase breakdown automation needs of locating in 3 dimensional space the key skeletal positions.

CT also has the ability if successful to identify where the muscle is on the carcase and how big a particular muscle is. It can also be used to measure the amount of fat within a carcase, how large the carcase bone structure is and information on the density of the muscles and hence may provide indicators of on-line, real-time eating quality.

All of this objective information can be turned into better decisions by the meat processor. Information from CT will potentially allow for
· Better decisions on which market the carcase is ideally suited to
· Payment and information feed back systems to suppliers based on the real value of the

carcase to the processor
· Systems that grade a carcase into the likely eating experience by the consumer based on the CT Measurements

These benefits will bring significant cost savings to a processor providing the cost of the development and the equipment and capital and operating cots are low enough to justify the investment. CT, particularly Medical CT is notoriously expensive but the industrialised versions of CT systems are significantly cheaper. During the research into the available technologies several experienced and competent industrial CT manufacturers were identified. One of these Imtec Corp. from Los Alamos, New Mexico in the United States has a methodology that, if applicable, will make the capital and operating costs of such systems within easy reach of commercial viability. Imtec is the only company of several approached, that is recommending this technology as applicable for use on lamb and beef and also be capable of operating at commercial throughput speeds of a modern meat processing plant.

The further progression of the understanding of this technology and its strengths and limitations now requires close cooperation and involvement of Imtec and MLA. IMTEC are now commencing work on the research and development of understanding the needs of the Meat processing sector and what Cone Beam Ct systems are capable of delivering to the Meat processing sector in the near and medium term. One of the outcomes of this project with imtec will be a specification for further work to develop the hardware so that the Cone Beam Ct can deliver one or several of the immediate needs of Meat processors to their business.
Other work has already been undertaken which identifies the Cost Benefits to a processor if Ct can deliver for example:-
· Skeletal positioning so that robotics could be used to cut a carcase
· Carcase composition and the benefits of better decision making or pricing systems for raw materials
· Marbling in a hot carcase
· Identification of diseases prior to evisceration of the carcase.

The importance of progressing the development of the CT Technology and it's application to the meat industry cannot be overstated. MLA has held industry forums to present their findings on the suitability of the technology and has support from a number of lamb and beef processors. It is believed that the development path for the technology itself will be short given that CT technology is commonplace within many industries however the application in the meat industry is yet to be applied and this is an area of significant risk. It is also hoped that within 12 months there will be CT systems installed at 2 lamb processors and at 2 beef processing plants within the next 2 years.
Imtec is prepared to fund 50% of this initial investigatory stage and other key commercial industry businesses such as MAR, have also indicated their keenness to share some of the commercial risk.

MLA has received strong support and initial tentative commitments from the following companies:-
· CRF a lamb processor Colac Victoria,
· WAMMCO a Lamb processor at Katanning in WA
· Cargill Beef Australia with plants at Wagga and Tamworth

· Northern Co-operative Meat Company Ltd a beef processor in Casino NSW
· Teys Bros. Pty ltd. A major beef Processor in beenleigh

All of these processors need to understand the capabilities of the technology now and what it will be capable of in 6 and 12 months time and in 5 years as continued research improves the capability to deliver specific benefits to meat processors.

Milestones

Achievement Criteria	
1.	Organise Regular meetings with MLA representatives and IMTEC regarding progress and for input into critical decisions and forward planning. Post meeting minutes on MLA OCM WIKI site
2.	Undertake regular visits with IMTEC Inc. technical resources in Melbourne and progress the project timelines..
3.	Work with Sean Starling of MLA to screen and prequalify applicants for a graduate position with IMTEC> This will involve meeting initially if necessary key applicants before organizing for them to be interviewed by MLA and IMTEC when the Industry workshop is held (see below).
4.	Organise a Workshop with Key IMTEC people as presenters and with the OCM Steering group to attend along with the Supporting Industry CEO's. Provide outcome report and future direction Summary to all participants.

7 A.SCT.0050 Objective Carcase Measurement – Support Work

7.1 Purpose

To underpin the Objective Carcase Measurement program, MLA would like to CAT scan sheep live and then as carcasses to provide the images for software houses internationally to start to understand what diseases may be identified in live and dead animals using CAT scanning technology. The cost of animal purchase and scanning will be covered under this CMA.

Secondly an undergraduate will be appointed to Sean Starling and based at University of New England to scan pieces of meat to continue to build MLA's knowhow in the area of potential and limitations of CAT scanning. Predominantly continue to obtain data that can be used to refine commercial full scale models. CMA will cove the cost of the undergraduate, rental of equipment and associated meat costs.

Thirdly the CMA will be used to cover the costs of understanding the potential benefits of newly developed Mico-CAT scanning technology that is now available at one university in Australia. Need to cover meat costs and use of machine.

8 A.SCT.0051 OCM Processor CEO Update visits

8.1 Purpose and description

MLA has organised 2 meetings with the Meat Processor working group of the 4 interested Meat Processors.
At the first meeting MLA presented the most suitable technologies that would bring the fastest benefit to the red meat processors. The working group approved MLA to proceed to identify organisations who would be suitable to work with in the development of the technology.
At the second meeting MLA introduced IMTEC of Los Alamos New Mexico USA who had developed industrial CT machines and were using the Cone Beam CT technology and whom MLA considered had the best opportunity of developing specific equipment to satisfy the perceived initial needs of the Processors.

The working part approved MLA to:

- · Undertake a cost benefit of the benefits of using Objective Carcase Measurement Technologies (OCMT) within the Beef and Lamb processing systems.
- · Work with IMTEC to test the various capabilities of the Standard IMTEC technologies with a view to applying this to the design and development of a piece of equipment suitable for use with Lamb and Beef.
  Both of these tasks have now been completed. Processors have not yet had feedback on the results of the CT scanning work or the implications this will have on the cost benefit work within their processing facilities.

PURPOSE
Another workshop with processors to progress the larger OCM/CT scanning development project is required.
As it has been almost one year since the work was initiated, the processors involved in the project require an update about the progress made. The processors require a briefing on the challenges that will need to be addressed at the next workshop to continue effective project development. This contract will achieve the necessary briefing to prepare the CEO's for the next meeting.

A further series of CT scanning trials are being planned to occur between now and the next CEO's workshop to quantify CT's ability to detect some specific Meat Science measurements. The scope of this contract also involves the setup of CT scanning testing objectives at the University of New England to be conducted over the Christmas holiday period in preparation for the CEO's workshop in early 2009.

1. Update CEO's on the financial costings done at the plants and to ensure the processors are still in agreement with the results obtained 12 months ago
2. Update CEO's on the outcomes of CT scanning work done at IMTEC, the things that can be measured, what still looks possible and what looks unlikely (in the next 5 years).
3. Review the impact of point 2. outcomes on cost beneifit analysis
4. Inform them of the challenges going forward to fund future R&D given the change in

ownership of IMTEC (the CT R&D provider) and field thoughts from them on how this might be progressed

Meet with IMTEC at UNE with John Thompson to agree on the CT testing outcomes to be achieved from the CT scanning work to be completed by a student at UNE before the CEO's workshop in early 2009.

Milestones

Achievement Criteria	
1	Briefings with Cargill completed
2	Briefings with CRF completed
3	Finalise Students CT scanning objectives with UNE and IMTEC

9 A.SCT.0056 CT OCM Project - Risk 2, 5 and 10 further mitigation

9.1 Purpose and description

MLA has been investigating the potential for CT scanning technology to be used in the meat processing industry to deliver objective measurement of carcase traits. Work over the past two years has demonstrated CT technology in human medical field has enormous potential. Using four CEOs as guides (NCMC, Cargill, CRF and WAMMCO) Industry has confirmed there would be real economic benefits if technology can be adapted to the meat processing environment to provide a range of benefits. These potential benefits are varied but include reduction in labour costs through automation, quality assessment earlier in the production process to save costs, more accurate measurements to improve management decisions that reduce cost or add value to the finished product.

RISKS

The risks/unknowns identified in applying CT to the meat industry are:

1. Value Proposition
    a. How big is the opportunity? Is it worth chasing? What are the minimum attributes that justify the investment?
2. Meat Science
    a. Do animals 'behave' in a repeatable way under a CT scanner
3. CT ability to differentiate meat parameters
    a. Can CT system measure all of the required parameters
4. CT Platform
    a. Medical, Industrial, Cone Beam, Spiral, Scintillator
5. Speed
    a. Medical scanners at the time of opportunity conceptualising could not process a human body any faster than 2 minutes with the required resolution. This

project needs to aim at a 6 second scan for sheep and 20 second scan for beef.

6. Software
    a. Can the system be automated? What level of skills and support is required at processing level?
7. Data Handling
    a. How much data? How is it handled? Who owns it?
8. Process integration
    a. Where will it integrate? How will it integrate? Stainless Steel and lead considerations? Who will do this integration work?
9. Adequate technologist, suppliers, system integrators and support companies
    a. What companies do we need at the table? How will they relate and interact with each other?
10. Will the industry accept if risks 1-6 are mitigated.

Risk 1 was mitigated 18 months ago via Phil Green working exclusively with the four processing CEOs to determine the CBA for each of their companies. This data was then used by all four CEOs to provide support to MLA to continue investigation into this area and opportunity. The value proposition model developed will be continually updated for each of the four companies as MLA understands more and more about how this technology works and will integrate into the supply chain.

Risk 2 has been substantially mitigated by MLA research conducted by a student during Dec 08 – Feb 09 involving a series of tests to confirm whether meat behaves in such a repeatable fashion that a CT system could automatically differentiate between fat, muscle, bone, marbling and find seams in order to deliver the benefits available to the red meat supply chain that were identified in an earlier MLA project investigation with processors. Due to the short nature of access to the student there are some addition results that MLA would like to further evaluation pertaining to allowing for chemical fat/lean analysis to be factored into the raw data to see how this (if at all) impacts on the already positive results. This Project Will investigate this further

Risk 3 has been increasingly mitigated by the same study described in Risk 1 (above). During this project Kate Killen was able to demonstrate that a medical CT scanner could differentiate between:

Category A

- Fat
- Meat
- Bone
- Intramuscular Fat (marbelling)
- Silverskin (i.e. membrane between muscles)

This in turn enabled the project team to confirm that the following can be computed by the above attributes being found:

Category A

- Lean meat yield
- Hump height
- Saleable meat yield
- Cut size and weight
- Ossification
- Dentition

The remaining attributes to be confirmed include:

Category B

- Eating quality
- Tenderness
- Colour

Category C

- Cysts
- Abscesses
- Disease
- Contamination

Category D (unknown)

More recently rapid advancements in medical CT imaging are enabling image quality as small as a nanometer. NanoCT is able to differentiate muscle and cell structures down to the sarcomere. International research indicates it could be possible to differentiate quality attributes like taste, meat colour and composition of fat from a single CT scan. The Australian National University (ANU) based in Canberra has developed a NanoCT lab that is capable of conducting research scans to this level of detail. Part of this project will be to explore the wider opportunities for NanoCT in the meat industry with respect to additional measurement parameters not before considered.

Risk 4 mitigation strategy has commenced by having two simultaneous projects underway. The first was with IMTEC using industrial cone beam CT scanners and the second was Kate's project using a medical spiral scanner. The results are inconclusive at the moment in the sense that the medical scanner appears to differentiate the meat attributes on the image and the analysed data, whereas the industrial scanner appears to differentiate the attributes in the visual image but not the extrapolated data.

ANU (see above under Risk 2) additionally is using Scintillator materials in conjunction with high quality cameras to capture and reconstruct the CT data. This is of particular interest to MLA as this type of system has been identified as a possible cheaper alternative for a commercial meat processing system than the standard medical CT detectors.

Risk 5 mitigation strategy has been one of focusing on industrial scanners. However recently Siemens has developed a '666' machine that can scan a 6 foot 6 inch human being in less than 6 seconds. This recent development has provided the project team with confidence that speed in the long term will not be an issue. Independent of this project MLA

will commences negotiations with medical CT suppliers to understand the likelihood of joint collaboration and funding. Matrix professionals is working with MLA to understand the potential of medical CT suppliers engaging with this program

Risk 6 mitigation strategy has commence by MLA undertaking preliminary discussions with the Mayo Clinic in America for 'body part' analysis (attributes in Cat A and B) and Defines in Germany for analysis of images to detect Cat C attributes. In addition to these companies MLA will need to source a local 'systems integration' software company.

Risk 7 mitigation strategy has not commenced.

Risk 8 mitigation strategy has commenced with respect to understanding the pros and cons of different locations within the processing chain as well as working with one company (Cargill) to determine where an R&D machine could be located in the interim.

Risk 9 mitigation strategy is underway with MLA ensuring all requisite parties are involved and information on a need to know basis.

Risk 10 mitigation strategy has been underway since inception by the formation of the four processor CEOs as MLA's unofficial steering committee. The CEOs are from NCMC, Cargill, CRF and WAMMCO. The CEOs are meeting again in late April. For this meeting MLA will present an update of the above detail and in addition would like to should videos of sheep and beef cuts being 'analysed' by CT software and providing attribute measurements. Development of these videos will be undertaken in the project.

<u>Project Description</u>

This project will consist of the following:-

- Provide project management services on a monthly basis to broadly achieve the following:-

1. Working with suppliers every month to attempt to solve the still unknown risks associated with going forward and undergoing a CT Trial of a beef side and a lamb carcase to test the unknown issues still remaining
2. Sourcing commercial companies or academic or research institutions capable of providing the expertise or the knowledge to conduct these tests
3. Assisting as needed, to assist a trial or testing to happen quickly.

The objectives of the projects are:

1) Identify organisations that are capable of providing the knowledge or equipment to test a substantial part of a lamb and beef carcase to prove the unknowns around the CT project.

2) Develop the information necessary to present to the nominated 4 meat processing CEO's in Late April.

3) Progress the CT project in general with a view to funding a full scale CT system as soon as all risks are fully understood and are considered acceptable to a meat processor.

10 A.SCT.0058 CT OCM Project - Risk 2, 3, 4 and 9 further mitigation

10.1 Purpose and description

MLA has been investigating the potential for CT scanning technology to be used in the meat processing industry to deliver objective measurement of carcase traits. Work over the past two years has demonstrated CT technology in human medical field has enormous potential. Using four CEOs as guides (NCMC, Cargill, CRF and WAMMCO) Industry has confirmed there would be real economic benefits if technology can be adapted to the meat processing environment to provide a range of benefits. These potential benefits are varied but include reduction in labour costs through automation, quality assessment earlier in the production process to save costs, more accurate measurements to improve management decisions that reduce cost or add value to the finished product.

RISKS

The risks/unknowns identified in applying CT to the meat industry are:

11. Value Proposition
    a. How big is the opportunity? Is it worth chasing? What are the minimum attributes that justify the investment?
12. Meat Science
    a. Do animals 'behave' in a repeatable way under a CT scanner
13. CT ability to differentiate meat parameters
    a. Can CT system measure all of the required parameters
14. CT Platform
    a. Medical, Industrial, Cone Beam, Spiral, Scintillator
15. Speed
    a. Medical scanners at the time of opportunity conceptualising could not process a human body any faster than 2 minutes with the required resolution. This project needs to aim at a 6 second scan for sheep and 20 second scan for beef.
16. Software

    a. Can the system be automated? What level of skills and support is required at processing level?
17. Data Handling
    a. How much data? How is it handled? Who owns it?
18. Process integration
    a. Where will it integrate? How will it integrate? Stainless Steel and lead considerations? Who will do this integration work?
19. Adequate technologist, suppliers, system integrators and support companies
    a. What companies do we need at the table? How will they relate and interact with each other?
20. Will the industry accept if risks 1-6 are mitigated.

Risk 1 was mitigated 18 months ago via Phil Green working exclusively with the four processing CEOs to determine the CBA for each of their companies. This data was then used by all four CEOs to provide support to MLA to continue investigation into this area and opportunity. The value proposition model developed will be continually updated for each of the four companies as MLA understands more and more about how this technology works and will integrate into the supply chain.

Risk 2 has been substantially mitigated by MLA research conducted by a student during Dec 08 – Feb 09 involving a series of tests to confirm whether meat behaves in such a repeatable fashion that a CT system could automatically differentiate between fat, muscle, bone, marbling and find seams in order to deliver the benefits available to the red meat supply chain that were identified in an earlier MLA project investigation with processors. Due to the short nature of access to the student there are some addition results that MLA would like to further evaluation pertaining to allowing for chemical fat/lean analysis to be factored into the raw data to see how this (if at all) impacts on the already positive results.

Risk 3 has been increasingly mitigated by the same study described in Risk 1 (above). During this project Kate Killen was able to demonstrate that a medical CT scanner could differentiate between:

Category A

- Fat
- Meat
- Bone
- Intramuscular Fat (marbelling)
- Silverskin (i.e. membrane between muscles)

This in turn enabled the project team to confirm that the following can be computed by the above attributes being found:

Category A

- Lean meat yield
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- Saleable meat yield

- Cut size and weight
- Ossification
- Dentition

The remaining attributes to be confirmed include:

Category B

- Eating quality
- Tenderness
- Colour

Category C

- Cysts
- Abscesses
- Disease
- Contamination

Category D (unknown)

More recently rapid advancements in medical CT imaging are enabling image quality as small as a nanometer. NanoCT is able to differentiate muscle and cell structures down to the sarcomere. International research indicates it could be possible to differentiate quality attributes like taste, meat colour and composition of fat from a single CT scan. The Australian National University (ANU) based in Canberra has developed a NanoCT lab that is capable of conducting research scans to this level of detail. Part of this project will be to explore the wider opportunities for NanoCT in the meat industry with respect to additional measurement parameters not before considered.

Risk 4 mitigation strategy has commenced by having two simultaneous projects underway. The first was with IMTEC using industrial cone beam CT scanners and the second was Kate's project using a medical spiral scanner. The results are inconclusive at the moment in the sense that the medical scanner appears to differentiate the meat attributes on the image and the analysed data, whereas the industrial scanner appears to differentiate the attributes in the visual image but not the extrapolated data.

ANU (see above under Risk 2) additionally is using Scintillator materials in conjunction with high quality cameras to capture and reconstruct the CT data. This is of particular interest to MLA as this type of system has been identified as a possible cheaper alternative for a commercial meat processing system than the standard medical CT detectors.

A risk 5 mitigation strategy has been one of focusing on industrial scanners. However recently Siemens has developed a '666' machine that can scan a 6 foot 6 inch human being in less than 6 seconds. This recent development has provided the project team with confidence that speed in the long term will not be an issue. Independent of this project MLA will commences negotiations with medical CT suppliers to understand the likelihood of joint collaboration and funding.

Risk 6 mitigation strategy has commence by MLA undertaking preliminary discussions with the Mayo Clinic in America for 'body part' analysis (attributes in Cat A and B) and Defines in Germany for analysis of images to detect Cat C attributes. In addition to these companies MLA will need to source a local 'systems integration' software company.

Risk 7 mitigation strategy has not commenced.

Risk 8 mitigation strategies has commenced with respect to understanding the pros and cons of different locations within the processing chain as well as working with one company (Cargill) to determine where an R&D machine could be located in the interim.

A risk 9 mitigation strategy is underway with MLA ensuring all requisite parties are involved and information on a need to know basis.

Risk 10 mitigation strategy has been underway since inception by the formation of the four processor CEOs as MLA's unofficial steering committee. The CEOs are from NCMC, Cargill, CRF and WAMMCO. The CEOs are meeting again in late April. For this meeting MLA will present an update of the above detail and in addition would like to should videos of sheep and beef cuts being 'analysed' by CT software and providing attribute measurements. Development of these videos will be undertaken in the project.

The objectives of this project are to:

1. Produce a final set of data from the MLA CT scanning trials at UNE
    a. Calibrate the CT scanned meat sample results against their chemical fat tests
    b. Determine how well CT differentiated marbling fat from other types of fat and from muscle tissues within the samples of striploin at the same temperatures.
    c. Indicate the impact this could have on commercial CT development. Write up report with as much detail about how the findings will impact on commercial operation and subsequent image analysis limitations and requirements.
    d. Use gleanings from this research to scope trials on ANU's high resolution CT scanner.
    e. Prepare findings for the upcoming CEO workshop that address as much as possible the concerns raised by industry in delivering a commercial system
2. Conduct scanning trials at ANU on beef and lamb to:
    a. Determine the types of definition that could be achieved and how this relates to the cost benefit items identified in the previous processor cost benefit project
    b. Attempt to quantify the differences in CT density values resulting from marbling differences and those resulting from connective tissue differences
        i. Lab testing will be required to create a gold standard for comparison of IMF% and amount of connective tissue.

    c. Determine the ability of the ANU scintillator type system to be used in testing to reduce the risk of scintillator materials in a large commercial beef application.
3. Assess the potential for future collaboration with ANU in development of a prototype meat industry CT:
    a. Determine the potential of the lab to conduct further CT scanning trials that could reduce cost and risk
    b. Understand the engineering and mathematical capabilities of the team or outside contacts they have as a potential development resources to reduce MLA's reliance on commercial third party companies in the prototype of development.
    c. Explore the option of a student position in conjunction with ANU to assist MLA's project development activities
4. Compare Industry CT versus Medical CT 'resolution' ability:
    a. Use of a Mosman, Sydney based dental scanner with Kate Killen as the analyser. These samples will be compared to UNE medical scanner scans.

This project will progress the overall understanding of CT in relation to meat and to the development of the CT opportunity, however, it also has a short term importance in delivering specific understandings for the upcoming CEO's workshop on how to best move forward with the development of a CT solution for the meat industry.

To achieve this the following approach is planned:-

- Greenleaf to obtain chemical composition results and CT scanning results from UNE , adjust CT values for the different samples based on chemical results. Conduct analysis across the data set and present results with commentary and presentation on what this means for carcase measurement, muscle segregation etc.
- Write up a proposed test plant for trials at ANU and review with the MLA project team.
- Organise meat samples and conduct trials on site at ANU and IMTEC Mosman along with Kate Killen (contract separately by MLA). Organise meat science testing to be done in conjunction on the same samples for correlation purposes.
    - Meat laboratory tests include fat composition, water holding capacity, pH, etc. AUS-MEAT meat & fat colour and marbling content
- A presentation will also be given at the CT planning workshop held at MLA in April 2009.

Costs charged by ANU for use of their facility have not yet been included. Meat science testing to be done at CSIRO has been estimated but quotes are yet to be obtained.