final report

Project Code: A.TEC.0094

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Date published: November 2011

PUBLISHED BY
Meat and Livestock Australia Limited
Locked Bag 991
NORTH SYDNEY NSW 2059

Report on Attendance at the Radiological Society of North America Exhibition and Conference
Chicago USA November 2011

Meat & Livestock Australia acknowledges the matching funds provided by the Australian Government and contributions from the Australian Meat Processor Corporation to support the research and development detailed in this publication.

Contents

1 Overview

The Radiological Society of North America (RSNA) Conference and exhibition is held every year beginning on the weekend after the Thanksgiving holiday. It is held at the McCormack Place exhibition Centre which is a huge group of exhibition halls and meeting, lecture and presentation rooms.

This year 70,000 people attended with over 700 exhibiters.

The large players in the Radiological industry such as Phillips, Siemens, GE, AGFA all have huge displays and all of their major Single Photon Emission Computed Tomography (SPECT), X-Ray, C-Arm, Computer Tomography (CT) and Magnetic Resonance Imaging (MRI) systems are o Display.

This year there was a much larger presence of large Chinese manufacturers such as Neusoft as well as a strong Chinese Government presence to support the small fledgling manufacturing companies from China. There was an aggressive marketing pitch from the Chinese and will increase in years to come. This is probably good news for the medical Imaging arena as competition will reduce prices and drive further innovation. The problem still exists however that the quantities that can be sold into the Hospital and Private Medical practices is so large that the meat industry opportunities are dwarfed in comparison.

2 Outlook

The RSNA conference demonstrated that the technology is now available to develop a CT system that will cope with the image quality and production rates that are needed to install a CT system into a modern meat processing plant and form the foundation of an objective carcse measurement system.

This is because:-

- The trials with Scotts‟ and last year Siemens demonstrated that the capability already exists with existing equipment that was used to capture the images that will deliver most of the processors needs to generate a commercial benefit.
- New developments in image reconstruction mean that clearer images with less noise and more contrast will be achieved. This means that image analysis software will have an easier task of identifying boundaries or segmenting out the required boundaries and provide more information to deliver the benefits sought by a processor.
- New developments in dual energy CT systems are available which will give greater clarity to previously noisy data suggest that there is a development path to deliver more benefits on areas that are now not being considered. This includes such things as viscera inspection or disease detection.
- The emergence of CT systems that are slimmer in profile; wider throat diameter (1,000 mm); portable; self shielded and no longer need a specific lead line room within which they must operate, means that the expense of setting up a system or moving its location or trialling the CT system in another part of the plant is no longer a monstrous exercise.

- The core CT equipment original equipment manufacturers are involved not just in medical but in security systems as well. This results in the same hi technology benefits such as reconstruction algorithms; self shielding; portability and dual energy capable hardware being commercially available in aviation security baggage CT screening systems.
- Further along the development there are new and better detectors which will give greater contrast and density separation using photon counting detectors. This will give another quantum jump in image clarity and hence the ability to locate anatomical positions or anomalies within the slaughtered animal. This gives further encouragement to the ability to replace the meat inspector on the chain with an objective system.

3 Path Forward

The Industry funded Objective Measurement program has been under development for some time. Despite the significant benefits that CT measurement will deliver and advances in knowledge and capability, Processors have been reluctant to embrace the CT technology. This is partly because they do not believe that they can achieve the benefits and partly because there is no evidence that a CT systems outputs will deliver the information to achieve the benefits. The work undertaken by Scotts‟ with Siemens demonstrates that the results can be achieved.

The significant advances in technology; portability; shielding; size and image quality as described in this report, provide an even stronger case that the benefits can be delivered however there are still a number of milestones that will need to be overcome.

For the Australian Processors to gain the confidence to adopt the technology they need to be able to experience the systems operating in their plant and see the benefits that a CT system van deliver.

A suggested path forward to achieve a processor committing to a development in a meat processing facility would be:-

1. Follow up on all of the recommendations in this report
2. Particularly with Imaging^3 (see page 18) and follow through with testing of a number of lambs on their 100 mm bore, $500K portable and shielded CT system.
3. If successful develop a detailed research proposal for trialling the Imaging^3 system at multiple locations and products within the plant and over multiple plants and multiple species.
4. Research the Aviation baggage CT systems technology as best as possible, investigate and meet with the 3 main players of aviation checked luggage, baggage CT scanners to understand the technical capability; standard software capability; image resolution and quality and likely pricing.
5. Undertake a trial with either lamb carcases and or carcase phantoms to prove the capacity and image quality on standard baggage scanners
6. If shown to be suitable, develop a research proposal to install such a system into a processing plant identifying the costs for both hardware and software including software modifications if needed, plant modifications. Include the likely

measurements that will form the output and complete a cost benefit based solely on those outputs.

4 Software Developments

Software has continued development at a rapid pace and has advanced significantly to a level where there is potential to improve the image quality coming from existing CT Scanners.

The main developments have occurred in the following arenas:-

- Image Reconstruction Algorithms
- Automated identification of anatomical points
- Image analysis

4.1 Image Reconstruction Algorithms

Image reconstruction in CT is a mathematical process that generates images from X-ray projection data acquired at many different angles around the object. Image reconstruction has a fundamental impact on image quality and therefore on radiation dose.

In general the higher the contrast the better the image and this is generally as a result of less noise. Contrast is inversely related to scan energy. Typically, reduction in dose causes an increase in noise and image artifacts. By using lower energies then contrast between some soft tissues is enhanced but there still needs to be sufficient energy to penetrate the object. If the reconstruction algorithms can be improved such that there is greater contrast due to less noise and artifacts then the image quality will be improved at a lower dose. Some papers suggested that 50% dose reduction was achieved for the same image quality using the latest reconstruction algorithms. The Meat industry is not concerned with the dose given to a carcase and these new technologies in Image reconstruction methods will deliver clearer images at any dose level which will mean a greater ability to find meaningful information in a CT image.

Two major categories of image reconstruction exist:-

- Analytical reconstruction and
- Iterative reconstruction.

4.1.1 Analytical reconstruction

Methods based on filtered back projection (FBP) are one type of analytical reconstruction that is currently widely used on clinical CT scanners because of their computational efficiency and numerical stability. A more detailed explanation of back Projection image Reconstruction is included with the Appendix.

Many FBP-based methods have been developed for different generations of CT data-acquisition geometries, from axial parallel- and fan-beam CT in the 1970s and 1980s to current multi-slice helical CT and cone-beam CT with large area detectors.

The big disadvantage of the FBP methods is the level of noise that is left in the reconstructed image. This noise level includes streaking and other artifacts that make it difficult for subsequent software applications to extract reliable information from the image.

4.1.2 Iterative reconstruction

Iterative reconstruction has recently received much attention in CT because it has many advantages compared with conventional FBP techniques Iterative reconstruction techniques are now becoming mainstream in new CT machines. They have been developed because of the need to reduce the X-Ray dose to the patient and to consequently improve the noisy image that is generated as a result of the reduced dosage. These techniques yield lower image noise and higher spatial resolution compared with FBP. Iterative reconstruction can reduce image artifacts such as beam hardening, windmill, and metal artifacts. These techniques permit the X-Ray emission and detection process to be accurately modeled. In contrast, the filtered back projection algorithm makes no allowance for the physics of emission including attenuation and scatter of the emitted photons.

Lower dose is the holy grail for heart CT images where the heart can be seen pumping over multiple images and not risk overdosing the patient. Whilst lower exposure of patients to X-Rays is driving these new methods of image reconstruction the overall result means that more information can be obtained from an image irrespective of the dose. This is good news for the Meat industry as it means that even at the higher X-Ray doses needed to achieve the contrast and speed of image capture, improvements in image quality can be realised with the same hardware.

The one drawback of these algorithms has been the high computation load needed to do the iterations. This means that there is increased time to reconstruct the image and this has impeded its use in clinical CT imaging. Improvements in modern computer hardware and Software has accelerated the adoption of iterative reconstruction techniques. With further advances in computer processing speeds iterative reconstruction will be incorporated into all modern CT systems.

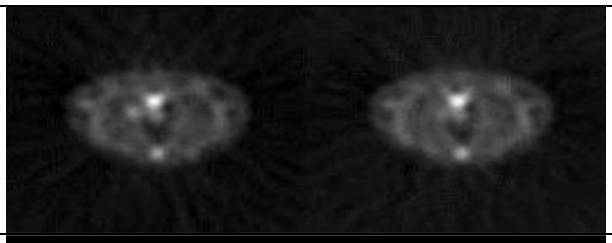
Such iterative reconstruction may result in longer reconstruction time but also in substantially less image noise from the same raw data through more complex modeling of detector response and of the statistical behavior of measurements. An adaptive shortcut which starts iterative reconstruction after a first-pass FBP reconstruction, Adaptive Statistical Iterative Reconstruction(ASIR), can help shorten the longer reconstruction time of pure iterative reconstruction while maintaining much lower image noise than if the same raw data were reconstructed with FBP alone. ASIR substantially reduces image quantum noise with no impact on spatial or contrast resolution.

The Table below summarizes the pros and cons of different Image reconstruction methods.

Method	Pros	Cons
Filtered Back Projection	Computational efficiency and numerical stability	Image quality noisy. Not suited to low dose protocols.algorithm makes no allowance for the physics of emission including attenuation and scatter of the emitted photons

Model-Based Iterative Reconstruction (MBIR)	dramatic improvements in image quality	computationally very demanding (slow)
Adaptive Statistical Iterative Reconstruction (ASIR) – is a Compromise	Computationally fast and is effective at reducing noise. It substantially reduces image quantum noise with no impact on spatial or contrast resolution	relies on the accurate modeling of the noise distribution of the acquired data

Some examples of the change in image quality can be seen below.

		Filtered Back Projection Image
		Adaptive Statistical Iterative reconstruction

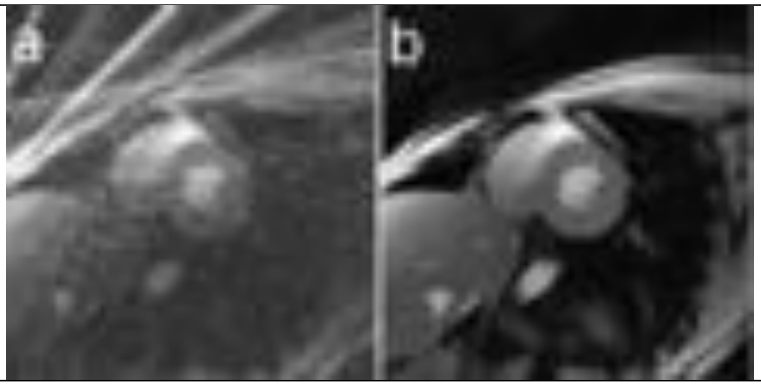
	Single Frame from a Human Hear Image (a) reconstructed using Filtered Back Projection Image and (B) Reconstructed using Adaptive Statistical Iterative reconstruction.

Image reconstruction techniques are continuing to be developed with the latest development being Prior Image Constrained Compressed Sensing or PICCS. An acronym DR PICCS has been developed which sands for Dose Regulation Prior Image Constrained Compressed Sensing. This new algorithm is designed to image low contrast structures such as soft tissue and requires one tenth of the dose compared to a Filtered Back projection image.

PICCS algorithms also have the ability to reconstruct an image where the number of segments in a scan is quite low.

In summary, image reconstruction algorithms are improving all of the time and increasing the contrast in a CT image. Higher contrast means greater capacity to differentiate between anatomical features and other clinical attributes so as to correctly analyse the image and extract the information required.

4.1.3 Recommendations

The developments in the Image Reconstruction Algorithms will have a quantum improvement for any image that has been analysed using the Filtered Back Projection method and are continuing to improve.

Mostly, CT machines produce the output Dicom files after they have been through the reconstruction process and the raw image data is not available. That makes post analysis using different algorithms most difficult. The better algorithms would apply only to new CT scans where the CT machine is capable of generating the better quality reconstructions.

The meat industry needs to understand what extra benefit can be achieved from these improved method of image reconstruction and ascertain what that means to what can now be measured eg. Marbling or overall intramuscular fat, and what that brings to the processor as a benefit.

This can only be understood by undertaking a trial with a CT machine with the improved algorithms

4.2 Automated identification of anatomical points

This Continues to be an area of development but mainly by research organisations such as the Mayo Clinic. The focus is still on responding to the needs of the Radiologist manually reviewing an image and hence the focus on less noise and enhanced contrast in CT Images.

The improvements in the image quality will promote more research in this area as it becomes easier to find a particular anatomical point, a specific organ or a change in a tissue from the normal.

Automatically finding particular anatomical points or particular items such as a liver, lymph node or a gland has application in the meat industry by augmenting the task of the Meat Inspector. The hardest part is finding the right organ or anatomical point.

The developments in this area will improve with time and whilst it will not happen quickly, the key to this type of automation is dependent on the image quality.

4.2.1 Recommendations

Keep across developments by maintaining contact with relevant researchers in the field such as Mayo Clinics Dr David Holmes.

4.3 Image analysis

The software that analyses the reconstructed volume of data from a CT scan continues to improve. It was not obvious from the discussions held with RSNA show participants that there was significant development work happening in the mainstream image analysis arena despite the improvements happening in image quality.

It seems that software is becoming more analysis specific. Large CT manufacturers have different software suites for different analyses which combines hardware settings with specific software analysis that then presents to the radiologist the best view of what is needed to be examined. Dual energy machines may for example when doing a CT of the

heart, will have embedded software routines which automatically remove the bones so that the heart can be viewed from any angle without the bones obscuring the view.

Companies such as Tomograhix are continuing to develop specific software for their clients. The software is designed to solve a specific issue rather then a generic tool for image analysis.

4.3.1 Recommendations

Maintain a dialogue with relevant industry organisations to keep a working knowledge of where the software is heading. Keep a relationship with potential software development companies and understand what will be needed to develop a Commercial system for beef or lamb.

4.4 Other Software

4.4.1 3D Slicer

This software is a free ware and has been initially developed as a teaching tool by the Harvard Medical School and the Boston University. The web site says that:-"The platform provides functionality for segmentation, registration and three-dimensional visualization of multi-modal image data, as well as advanced image analysis algorithms for diffusion tensor imaging, functional magnetic resonance imaging and image-guided therapy. Standard image file formats are supported, and the application integrates interface capabilities to biomedical research software and image informatics frameworks."

3D ***Slicer*** (Slicer) is a free, open source software package for image analysis and scientific visualization. It can be easily extended to enable development of both interactive and batch processing tools for a variety of applications. 3D Slicer is designed to be available on multiple platforms, including Windows, Linux and Mac Os X.

Discussions held with the Chief Architect of 3D Slicer, Steve Pieper, Ph.D. (His Bio can be found here. http://www.spl.harvard.edu/pages/People/pieper)

He advised that the software was primarily developed as a teaching tool but has now become much more than that. There are 1,000"s of developers around the world using the developer version to modify the software so it will deliver what they need. It is predominantly Human imaging based but he could not see no impediments being used for animal applications nor anything that would prevent others assisting in solving specific problems via their extensive mailing list of software developers.

4.4.2 Contact Details

Steve Pieper, Ph.D. Chief Architect Isomics, Inc. 55 Kirkland Street Cambridge, MA 02138	PH: 617.596.2719 (voice) 617.945.1304 (fax) **E-mail:** pieper at bwh.harvard.edu Or: pieper@isomics.com 3d Slicer Web Site: http://www.slicer.org/

4.4.3 Recommendations

Make the Meat Industry Imaging community working within the industry aware of this software. A formal review by industry as to the suitability of this software for specific

development work could have benefits which could see this become the „Standard" development platform where suitable.

4.5 Osirix

OsiriX is a very powerful freeware image processing software for Apple Computers that is dedicated to DICOM images produced by imaging equipment (MRI, CT, PET, PET-CT, SPECT-CT, Ultrasounds, ...). It is fully compliant with the DICOM standard for image communication and image file formats.

http://www.osirix-viewer.com/AboutOsiriX.html

4.5.1 Recommendation.

Make industry researchers and users aware of this resource.

5 Hardware Developments

5.1 Dual Energy CT (DECT)

This is a very exciting and emerging area for the CT systems and has become almost mainstream in the medical world but there is an increasing level of continued research occurring. DECT has the potential to provide a quantum leap in improvements in image quality of CT images allowing more delineation of anatomical points within a carcase.

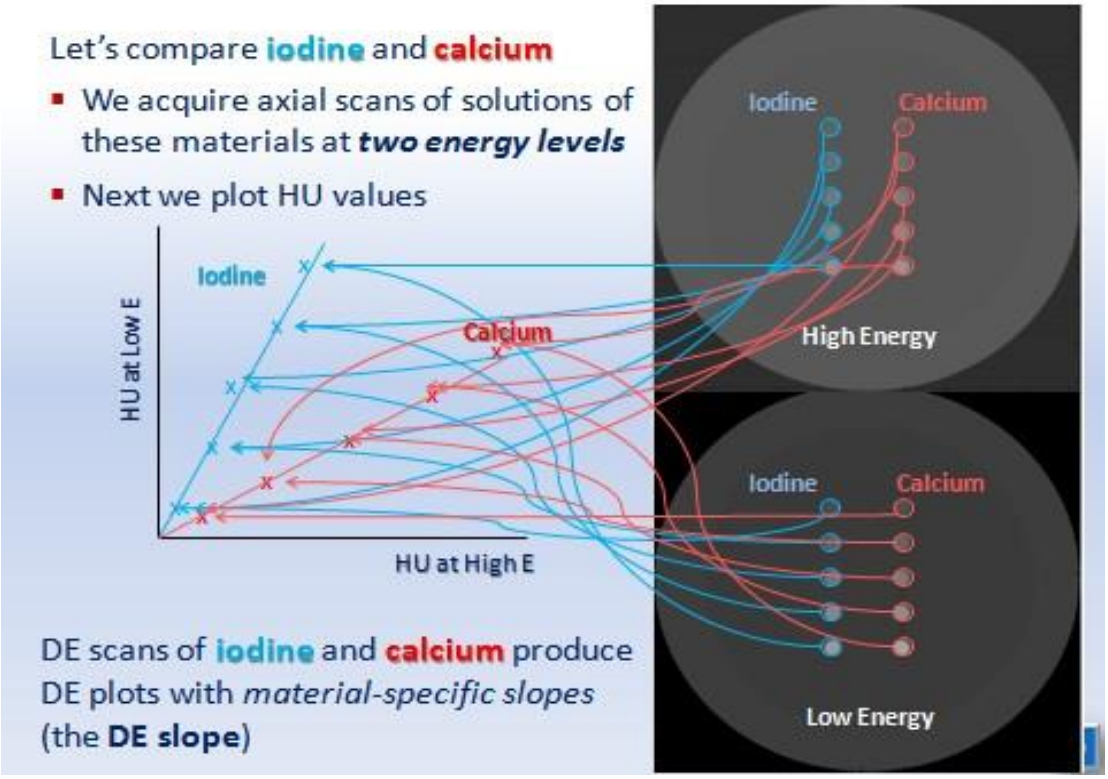
DECT uses 2 sources of X-Ray and 2 detectors where the applied X-Ray voltages are different. In medical applications, the multiple energy levels used are generally 120 kVp and 80 kVp. The two rotating X-Ray tubes and detectors are used to acquire both high and low voltage images and with two different voltages generate different attenuations of the X-Ray beam. Each image acquired is energy dependent. This allows differentiation of various tissues based on different photon absorption rates at high and low kVp settings. The two images can be added or subtracted or otherwise manipulated to extract the information.

The 80 kVp generates more noise and scatter than the 120 kVp and the 80kVp images is usually done in conjunction with an aluminium filter so as to remove the lower energy photons and „Harden the Beam" thus reducing noise.

Attenuation is also dependent upon the density of the material through which the beam passes. Using this information of the differing images, information about the material that the X-Rays have passed through can be determined.

The diagram below provides a simple illustration of how this can be done. It comes from a paper by Peter Miller MD entitled “Dual-Energy CT-Derived Iodine Mapping Technical Background and Clinical Applications” A full Copy of his paper is included in the appendices.

Diagram Showing How 2 Different Materials Densities can be derived using dual Energy CT sources



The diagram illustrates how different compounds can be delineated with the 2 different energy beams. The HU or Hounsfield Units are measured on the same Phantom at differing energy levels. The samples have been preset with differing known densities of Iodine and Calcium mixtures. This allows a material specific slope to be determined. Once this is done, threshold values can be set such that any pixel which is above the threshold slope can be designated as Iodine.

Dual-energy X-Ray imaging has been used by the medical profession extensively to assist in clarifying bones, particularly in busy areas around the shoulder. Conversely, if the bones can be correctly identified they can also be totally removed from the image. The same is for CT images except in 3 dimensions and with bone removed, an image showing tissue only can be generated.

As the diagram above suggests, most of the medical work in Dual energy CT has been done using contrast agents because of the ease with which the Low energy detects the heavy iodine contrast agent.. Contrast agents such as iodine help make blood vessels, organs and tissues more visible on CT. In the past, radiologists had to decide between higher contrast dose and reduced noise in the final images. Images taken at lower voltages have a higher resolution because of the notable increase in iodine contrast, but also have more image noise. Images taken at a higher voltage however, better differentiate soft tissue and minimises image noise.

Attenuation at moderate energy levels is primarily due to Compton scatter, but at lower energy the photoelectric effect is dominant. Certain elements within the body, such as

calcium or magnesium, have different attenuation properties and can be visualized when images are acquired at lower tube voltages. The ability to differentiate between two tissues is dependent upon the Dual Energy spectrum attenuation in the object. This has applications when trying to differentiate between meat and marbling, a diseased kidney or a healthy one and has applications in the future in the inspection of carcases before they are eviscerated.

Not only does Dual Energy CT provide better diagnostic images based on acquired data, it is also valuable in that it does not require additional dose compared to Single Energy CT. Images acquired using both techniques were compared and Dual Energy CT images provided better image quality with a decrease in noise without an increase in radiation dose than images acquired using Single Energy CT. Whilst X-Ray dose is not of importance to a carcase, it does have applicability in the amount of lead shielding needed to surround the CT machine and prevent X-ray exposure to processing staff.

Commercial manufacturers now make these systems as standard units and Siemens top of the range Somatom helical CT Scanner comes standard with 2 X-Ray sources and detectors. When not being used for different energy levels it is so configured that it can use both X-Ray sources and detectors to reduce the time taken to collect an image.

5.1.1 Recommendation:

Keep a watching brief on the developments of Dual Energy CT and ensure that any CT trial units that are purchased can have a dual energy system retrofitted.

Conduct a trial using lamb using Dual Energy CT and evaluate the results compared with single energy CT

5.2 Photon Counting

This is an exciting new arena of research and development and has the potential to significantly improve image quality and reduce the dosage necessary to achieve good quality images.

Some kinds of photo-detectors are so sensitive that they allow the detection of single photons. It is then possible to register single photon absorption events, rather than measuring an optical intensity or power. Most detectors only record the total energy of all the x-rays transmitted through the patient's body and not the individual energies of each photon. In the optical range, the energy of a photon determines its color, so that conventional CT scanners are in a sense colour blind.

And for the most part, CT scanners don't need to see individual photon energies. For the majority of uses, the black and white photo tells the physician everything they need to know. But in some cases, "colour-sensitive" X-ray detectors would be beneficial.

Most of this research is coming from technology spinoffs to commercial companies from the CERN facility in Geneva that is home to the Large Hadon Collider project. Whilst Photon Counting technology has been around for some time previous generations of photon counting detectors could count up to only 100,000 X-rays per second, which was not fast enough to produce an adequate CT image.

Five years ago, particle physicists at CERN, broke the previous barrier of photon counting by ten orders of magnitude. In need of highly sensitive detectors for their experiments hunting

subatomic particles, they increased the capabilities of photon counters to over 10 million photons per second. This increase would allow a photon counter to measure the energy of each individual photon striking the detector from a CT scan.

The Cambridge University in Christchurch is working on developments in this area and the author has previously developed a working relationship with this research team. Their paper as presented at the RSNA conference fits with what is being found in other areas of this same research.

The University of Canterbury in Christchurch is working on developing the Medipix 3 detector which has the promise of bringing colour images to CT scanning. Whilst their focus is on medical applications with a long term view to sell their technology to the larger Medical Manufacturing companies such as Siemens, GE or Phillips, they are still keen to look at other applications where the technology may be applied. They are working with the author‟s involvement and a Vacation student to begin investigating images of red meat using the Medipix detector.

Whist in its infancy of research and the size of the detectors is still very small; it has the promise of lowering the dose and dramatically improving the quality of the image. This is an exciting step for the red meat industry since it will potentially provide the capability to measure marbling more accurately, find cut boundaries between meat and selvedge easily and inspect and collect images of the internal organs and glands of a carcase before they are removed this saving the need to be inspected by a qualified meat inspector. This may eventually be done automatically on a computer and reported by exception

5.2.1 Recommendation

Establish a relationship with the University of Canterbury and the Medipix team and understand where the technology has applications in the overall strategy for objective measurement using CT.

Consider funding some further research specifically into the measurement of meat using the photon counting and detector technology with a long term view of constructing a CT machine.

Consider acquiring the rights to the Medipix technology for the use in Meat processing applications.

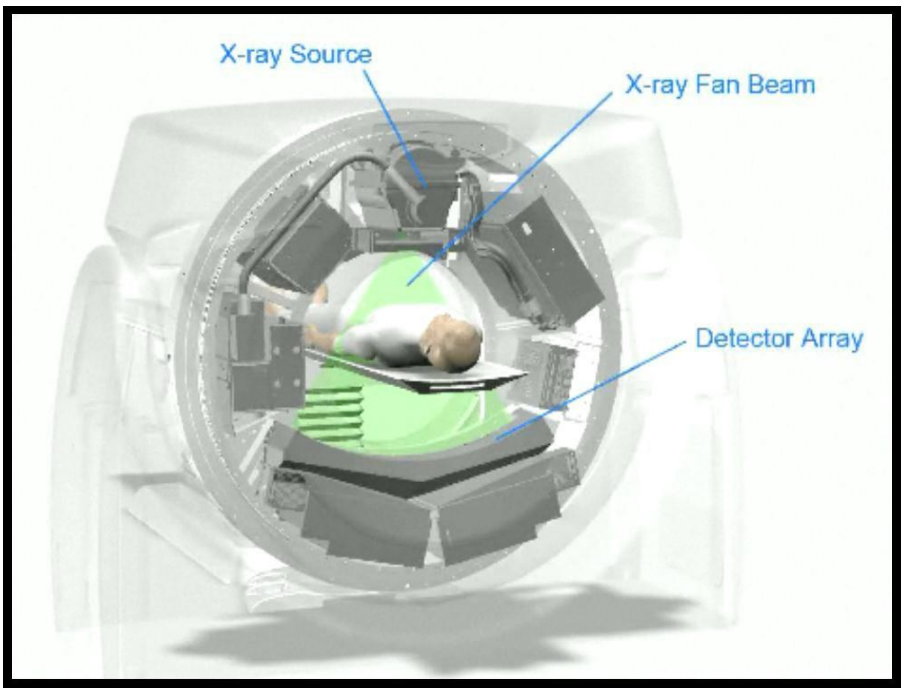
6 Specific Companies

The following discusses the relevant companies that were spoken to and who were thought to be capable of providing some service or product the Australian red meat industry.

6.1 Analogic Inc.

Analogic are manufacturers of the rotating component core for CT systems. They supply to OEM Ct manufacturers and have in the past supplied all of the major CT Manufacturer.

Analogic have a unique system of bringing power for the X-Ray source and other devices such as the detector onto the system. Most manufacturers of rotating machinery use slip rings with carbon brushes to transfer the power to onboard the rotating frame.



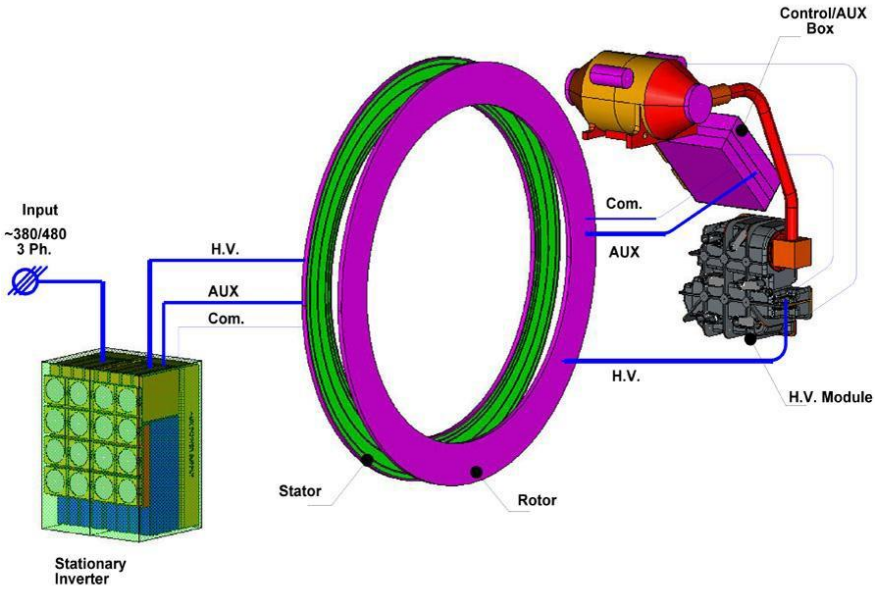
Analogic use a propriety system called Power-Link. It uses the principal of an induction disc that transfers power without any contacts. It also allows control, and data transfer. According to the marketing blurb it

“Provides practical advantages that include:

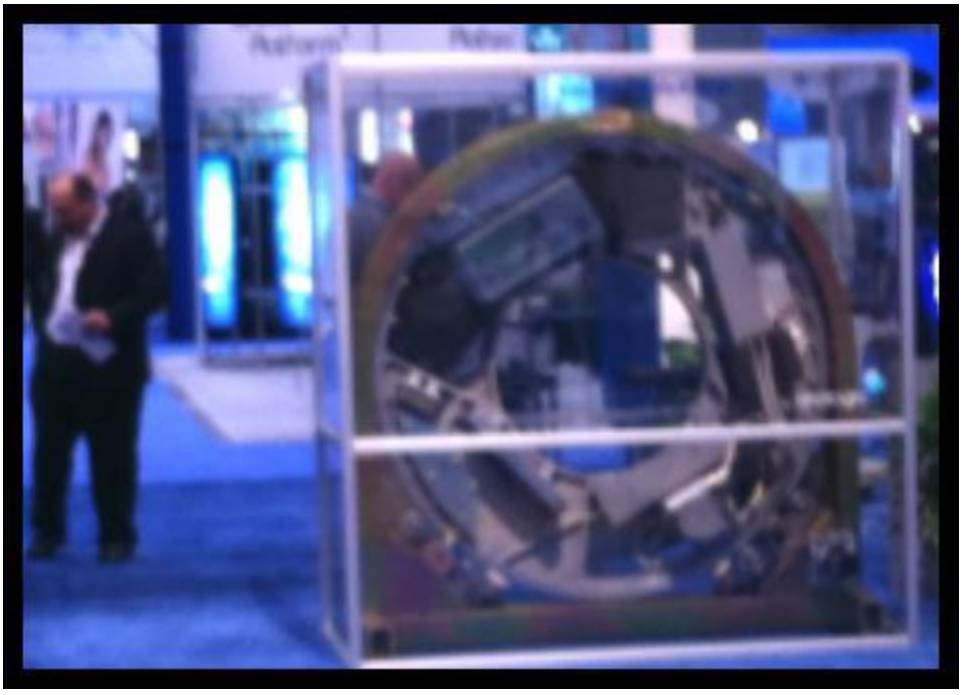
- Improved reliability
- Reduced maintenance
- Significant gantry space savings
- Enables dose reduction; dose modulation for cardiac applications; and kV modulation for dual energy enhanced imaging applications.

The “Non Contact” means there is low electrical noise generated which assist in a clearer image.

The Analogic system is shown schematically below



Analogic had a complete rotating cut-down system on display. Unfortunately no clearer photo than the one below was able to be taken. The simplicity of their system was impressive and it has obviously taken much iteration to get to the stage of development that they are at now.



Analogic purchase from another OEM the X-Ray generator but design and make the detectors themselves. They design and build the rotating frame and solid base mounting. They have developed their own reconstruction software that takes the information from the Fan Beam detector and converts this into the „Dicom" files that can be read by any analysis software package.

They typically do not build the tables and devices for manipulating the patient but allow the OEM to configure the system to meet all of the Regulatory requirements on safety and electronic interlocks to protect the patient.

When meeting with Analogic the following people were spoken to.

David Leong, Analogic Corporate Strategy and Development Manager

And

Bill Tabola, (David Leong"s Boss) Director, Product Marketing Medical Imaging.

Both of these gentlemen suggested I also needed to talk with Eric Zanin, (Bill Tabola"s Boss) Vice President Business Development Medical imaging and Security Systems.
Unfortunately, despite trying on multiple occasions, I was unable to meet with Eric Zanin.

In discussions with Bill Tabola he said:-

- Analogic would consider developing specific machines to suit a client and a decision to do so would be done on a case by case basis.
- They cannot seel an off the shelf machine since all of their machines are built o a specification from one of the larger companies such as GE or Phillips who own the IP in their machine.
- The IP is involved with the particular configuration of detector and X-Ray tube etc.
- They would be happy to work with us to develop a specification which they world then be able to price.
- Special machines with wide throats can be developed if needed. This changes many things since as the diameter increases, the energy required increases based on a distance squared law. i.e. move twice as far away and you will need 4 times the energy to achieve the same photon density

Bill also believed that we needed to talk with Eric Zanin regarding the baggage CT systems since he thought they would be more closely aligned to what our needs were. The aviation baggage CT scanning machines were also self shielding and hence no special lead lined room was needed to protect the people in the local area.

6.1.1 Contact Details

Bill Tabola, Director, Product Marketing Medical Imaging Analogic Corporation 8 Centennial Drive Peabody, MA 01960	Tel: 978 3264237 M 617 943 1447 btabola@analogic.com www.analogic.com
Eric Zanin Vice President, Business Development Medical Imaging and Security Systems Analogic Corporation 8 Centennial Drive Peabody, MA 01960	Tel: 978 326 4182 M 978587 1919 ezanin@analogic.com www.analogic.com

6.1.2 Recommendation:

Communicate with the 3 names above and communicate our predicted needs regarding a CT system in a Beef and lamb processing plant. Make plans to visit them in Massachusetts when next in the US particularly Eric Zanin regarding baggage CT scanners.

6.2 Imaging^3 Inc.– Portable CT Machine manufacturer

This Californian Based Company was founded in 1993. It started life as a C-Arm reconditioning service and remanufacturing business before moving to develop their own CT system. A novel, simple Helical CT system that used a Varian Flat Panel Detector and not a Fan Beam detector as used by other medical CT Systems was displayed. This means it is a Helical Cone beam system. There are some reasonable videos that provide more information on this company and its philosophies at this web site.

http://www.imaging3.com/investors/imaging3tour.html

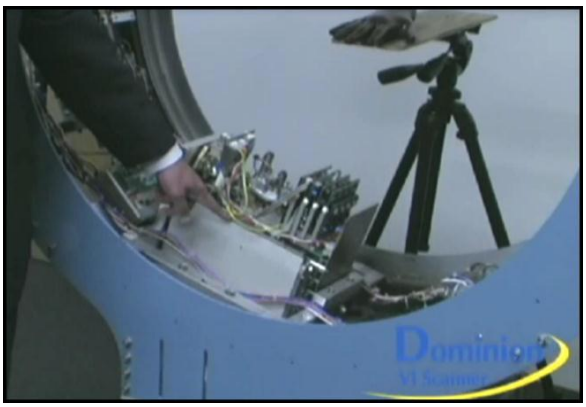
The other Novel features are that is has over 1016 mm throat diameter making it over 100 mm larger than most Medical CT systems.

The other novel feature is that it does the 3-Dimensional reconstruction on the fly and it is immediately delivered to a monitor beside the system. The concept is that a surgeon can see what is going on in a number of specific medical procedures and indicates is that the image reconstruction algorithm is particularly fast.

- The system rotates at 1 cycle per second and can scan at a forward speed of 150 mm/ rotation (this can be changed)
- The system is fully shielded and does not need a special lead line room to protect the area from radiation exposure.
- It comes with or without a portable table which has its own independent controls. This means it can easily be dispensed with and replace with a conveyor belt.
- A ball park price is $500,000 US .
- I met the Chairman/ CEO Mr Dean Jones and Mike Nessen, VP business Development.

In the discussions I noted that I had some concerns with the flat panel detector and the image quality. The offer was given to do a trial on a lamb carcase at some convenient time to ourselves and at no charge for the use of the system.

Flat Panel Detector



X-Ray Source

Note Slim edge Profile

The Manufacturer sates that the system:-

- Only product with 3D Real-Time Imaging
- Portable, fits through a standard door
- Plugs into regular wall power

- Continuous 3D acquisitions every second
- Pending FDA Approval
- 2008 North American Medical Imaging Innovative Product Award, Frost & Sullivan

It has the following features

- Performs 3D Real-Time Imaging
- Performs CT Imaging
- Performs 2D Real-Time Imaging
- Up to 52% Lower Radiation (c-arms)
- Up to 1,000 Times Lower Radiation (hi-res CT)
- Utilizes High Speed Photo Fluoroscopy
- Utilizes “Off the Shelf” Technology

6.2.1 Contact details

Dean Jones – Chairman /CEO Imaging^3 Inc. 3200 W.Valhalla Drive Burbank California 91505	800.900.9729 818.260.0930 Fax 818.260.0445 Online: www imaging3.com dean@imaging3.com

6.2.2 Recommendations

The Imaging^{3}system was one of the most exciting developments identified, primarily because of the speed of image acquisition; lack of a need for a lead room and the portability of their CT machine.

A number of recommendations are considered worth progressing with this company:-

1. Continue to entertain an email dialogue with this manufacturer and confirm all specifications and production rates. Re-visit the idea with the Company Imaging^3 of scanning a lamb carcase, develop specification criteria beforehand and if the manufacturer is still willing, plan to undertake these trials when next in the Los Angeles area.

   Consider the idea of using a purpose built Phantom of a lamb carcase as well and use this to confirm the attributes reflect a lamb carcse and can be used in the future. (See section on Phantoms)

2. Develop a detailed proposal to purchase an Imaging3 system for testing in a number of Beef and lamb processing plants. The portability and lack of a requirement for shielding means that trials could be conducted on:-

   - Carcases
   - Bone belts for boning efficiency
   - Primal Cuts on a product belt
   - Trim cartoons.

- Viscera

It is the authors belief that processor will be unlikely to get behind the technology until they see it working in the Meat Processing environment and can see the results of what the information can deliver.

A trial period of 3 months or longer in each processing plant with the resources to take the data and turn it into useful information would be needed.

6.3 Neusoft (China)

http://www.neusoft.com/solutions/1358/

Neusoft is a large multi product business in hardware and software based in Beijing. According to a contact in Australia who works for Neusoft, they have 3 core divisions,

- It Solutions
- Medical Equipment
- IT training.

They produce a range of single and multi slice systems (as well as X-Ray and MRI and PET systems) and whilst their brochures are big on pictures they are light on with the technical information. Having said that I spoke with Keith Milden Berger of Neusoft, an electrical engineer who really knew his stuff.

He was particularly interested in the MLA/AMPC project and advised that Neusoft could be keen on looking at projects such as this. They are trying to break into the medical market and are struggling against the long established firms of Phillips, Siemens and GE.

Keith has asked for some more information on our project and some indication of what would the specifications of our machine look like. I undertook to give these to him after clearing it with MLA/AMPC.

Keith also told me that they have done specialist collaboration work before on specific projects and he saw this as being no different. He saw no reason why we could not purchase just the “bits” of equipment we needed and to modify the interlocks and tables etc to suit our needs.

6.3.1 Recommendation

Neusoft are probably a long shot to collaborate with because of their size but I believe they are worthy of continuing with them to establish some more details of their CT equipment particularly their technical specifications. Graham Chen of Neusoft Australia has agreed to make contact with the head of their medical division initially on our behalf and to arrange to introduce me to him.

I believe we need to continue the dialogue with Neusoft with possible meeting with their technical people in Beijing to asses their capability and suitability as a collaborator.

Keith Mildenberger Product Manager Neusoft Medical Systems USA Inc. 12941 N freeway, Suite 633	TEL: 281 453 1205 Toll Free: 866 520 2626 Fax: 281 966 6923 Cell: 615 686 7038

Houston, TX 77060	Email: Keith mildenberger@us.neusoft.com http://medical.neusoft.com/en/
Australian Contact Dr Graham Chen	g.chen@ieee.org Mobile: +61 405 591 168

6.4 Tomagraphix IP Ltd.

This is a Toronto Canada based company that specialises in improving what is seen in a CT or PET image. They have many years of experience in the medical imaging world particularly with CT and PET images and have used their extensive experience to develop some very clever advanced medical image analysis software. They have a propriety range of software marketed under the Quantiva Series. This software offers solutions to a number of imaging problems.

- high performance 3 dimensional image display
- Image improvements with filtering post reconstruction to increase image contrast and reduce noise.
- Registration matching and deformable and elastic image fusion and quantitative image analysis on for multiple images. One example is matching a CT image with a PET image which may have been captured at differing times or on a patient with image movement due to breathing. Matching the CT and PET images is a complex process but it allows a radiologist to be able to see either a combined image or 2 images of exactly the same location in the body.

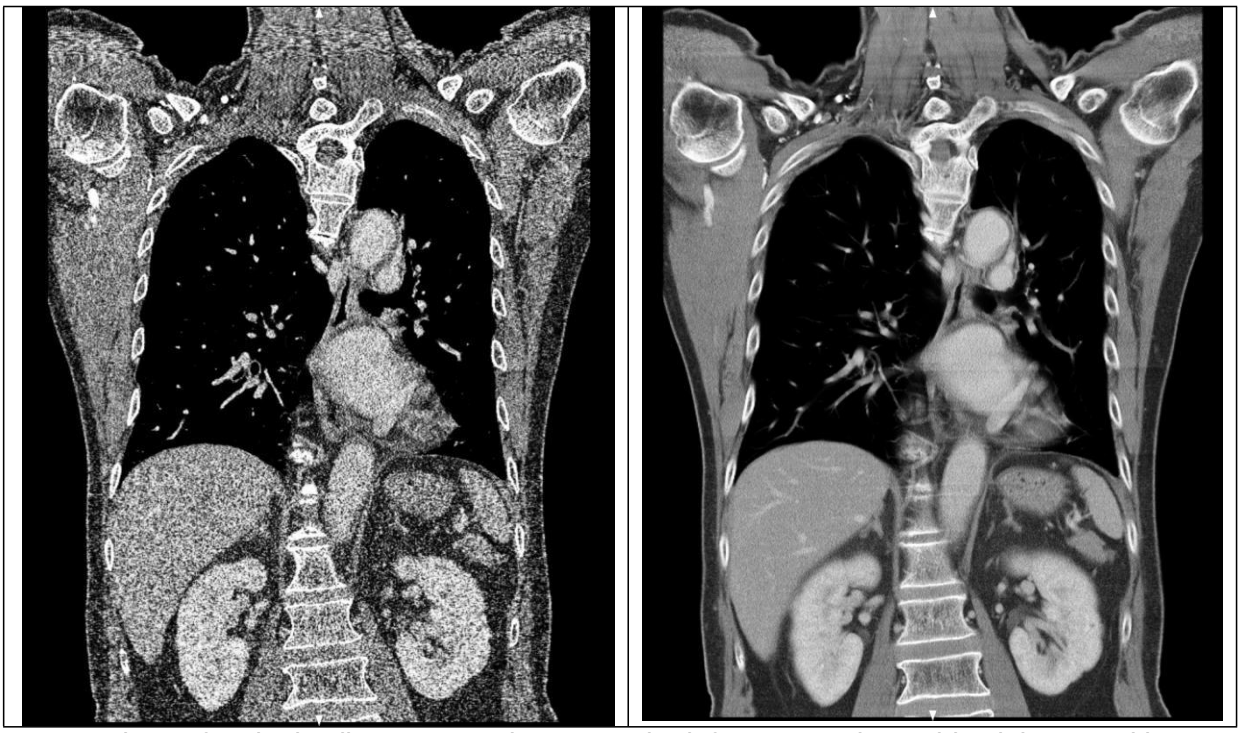
Tomographix also undertakes custom development for a range pf major medical equipment manufacturers.

This company was a great source of knowledge generally regarding the Imaging technology and where it was heading. Their website is worthy of a visit since they have animations illustrating some of their softwares capability. Applications such as:-

1. Improving an image by reducing the noise and improving the contrast so that a cut line could be identified or fine marbling discriminated or an fat meat interface boundary identified
2. reviewing a carcase for diseases of the viscera by a Meat Inspector prior to the viscera being removed

are two applications where this technology would have a use today in a modern meat processing facility.

The images below illustrate the level of sophistication of their software that enables significant improvements in image quality.



Comparison of a single slice 2D MPR image on the left compared to a thin slab 3D Multi Planar Reconstruction on the right with filtering showing the significant improvement in signal/noise ratio revealing more anatomical detail

6.4.1 Contact Details

Tomographix IP Ltd. Suite 1801, 1 Yonge Street, Toronto, Ontario M5E 1W7, Canada	Tel. 1 888 810 2225 ext 1 Fax. 1 866 556 7798 E-mail. quantiva@tomographix.com, WEB:http://www.tomographix.com/

6.4.2 Recommendation

Tomographix will offer benefits in the customising of software to suit the needs of the Meat industry. In the short to near term their skill-set will be needed to conduct the „Re-registration" of the carcase if it is imaged in the horizontal plane such as through a baggage scanner. When it is then hoisted onto the rail, the carcase will not be exactly the same shape and some adjustment to the CT image will be needed.

It is recommended that a dialogue be kept ongoing with this company to:-

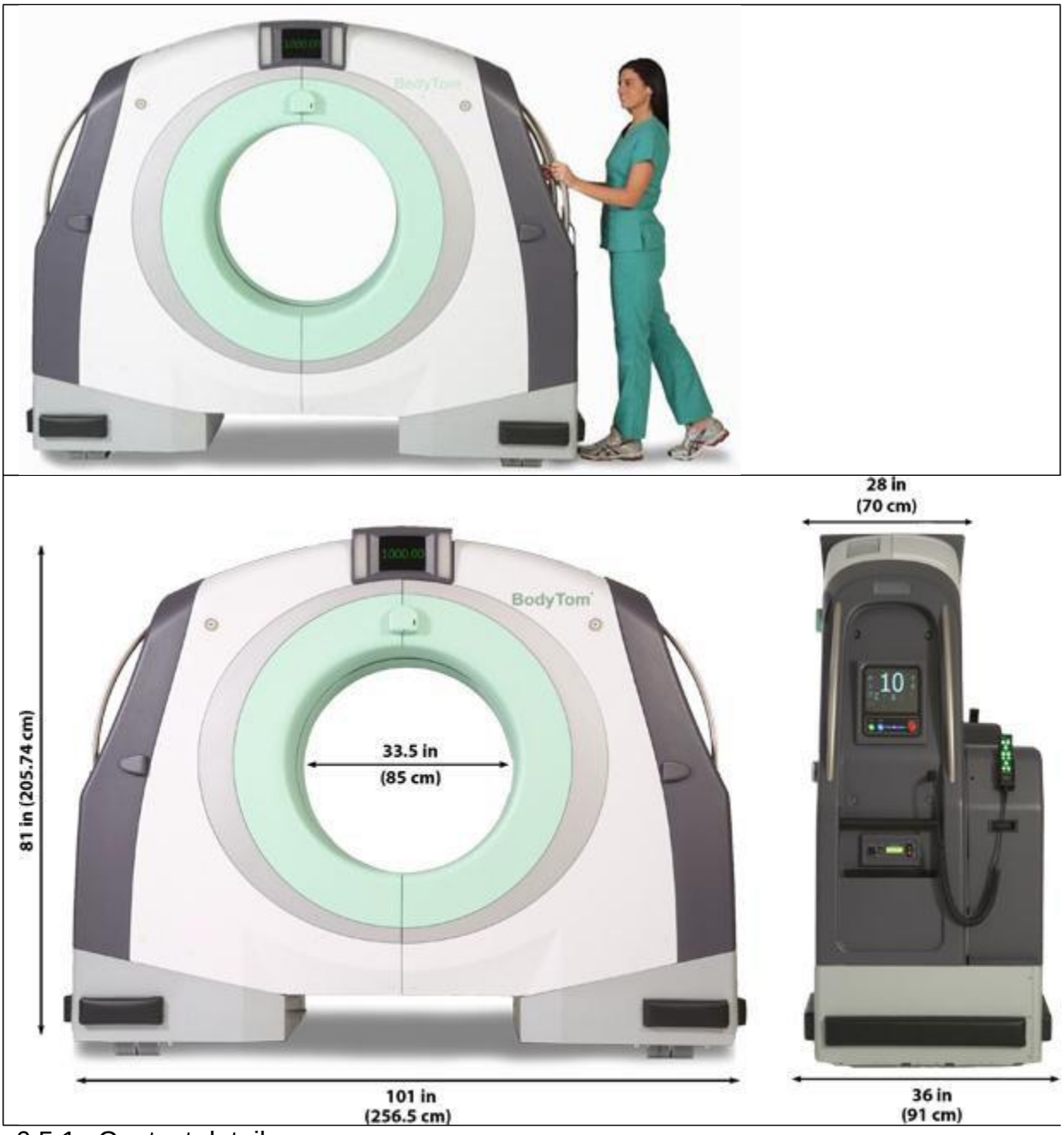
- Keep abreast of developments in the CT Imaging world in general
- Keep them informed of where the CT Objective measurement project is at with a view to using their services if needed when the time is appropriate.

6.5 Neorologica

This company has been at all of the other RSNA shows attended and was attending again with a very large stand. They are competing with the main stream CT Manufacturers and have developed a marketing edge over the larger companies. All of their range of CT systems are portable and can be used without the need for lead shielding. This means they can be wheeled about a hospital or surgery and taken to the patient without the need for special protection from X-Rays for those in the vicinity.

They have also developed smaller systems that are designed specifically for Arm and or Leg, and Head. The „inSPira HD" model is a battery operated system used for SPECT Imaging.

Their largest machine is the Bodytom and has a throat width of 850 mm. All data communication is done wirelessly and this with the portability makes this a very flexible research system. It is not as good however in this regard as the Imaging 3 system.



6.5.1 Contact details

Address: NeuroLogica Corporation 14 Electronics Ave. Danvers, MA 01923 USA http://www.neurologica.com	**E-mail**: info@neurologica.com **Telephone:** +1.978.564.8500 **Toll-Free:**1.877.564.8520 **Fax:** 978.560.0602

6.5.2 Recommendation

Maintain a watching brief over their developments via website review or tradeshows when attending for other reasons.

6.6 Swissray International Inc.

This Switzerland based company was approached because of their impressive C-ARM X-Ray system that that they had on display. The Swissray website which predominantly features 2D X-Ray systems certainly does not reflect what they presented at the RSNA. The C-Arm concept is one of the options still under consideration for a production CT system for both beef and Lamb. It has the advantages of low cost because there is no large rotating gantry but image quality still needs more investigation.

A long discussion was held with Joel Anthony, Swissray‟s National Support manager. He advised that their C-Arm X-Ray system could be re- configured into a CT system and the software modified accordingly. He advised that Swissray are amenable to doing development work such as a carcase CT system. He was enthusiastic about the project but will need to convince his superiors.

6.6.1 Contact Details

Joel Anthony National Support Engineer Swissray International Inc. One Tower Blvd. East Brunswick, NJ 08816	Direct: 908 3726437 Tel: 8009035543 Fax: 9083531237 Joel.anthony@swissray.com www.swissray.com

6.6.2 Recommendations

Write a formal submission to Joel detailing the Industry‟s needs regarding a CT system and continue a dialogue to asses further their capability and their level of interest.

7 General Electric (GE) and baggage Scanners

I had the opportunity to talk with Jed Pack (PhD). He works for GE Global and is responsible for writing among other things, their image reconstruction algorithms.

In out discussions he also suggested that I needed to talk with the baggage scanner companies. GE used to have a baggage scanner division but it was sold off to a new Company called Morpho Systems. (http://www.morpho.com/detection)

Jed advised that he used to share an office with the head of technology of Morpho Systems and was happy to put me in contact with him. In the discussions that followed Jed revealed that the Morpho Systems baggage scanner is running the latest technology in reconstruction algorithms. He knew this because he wrote the software that is in that system.

Morpho CTX 5800 – CT Explosives Detection System for Aircraft Baggage.

7.1.1 Contact Details

Morpho has an agent here in Australia at:-

Lane Cove, Australia

Tel: +61 2 9424 3500

Fax: +61 2 9424 3540

sales.mdii@morpho.com

7.1.2 Recommednation

Continue to establish the contact via Jed Pack with Morpho Systems head of research with a view to:

- Outlining the need of the red meat industry as it pertains to CT
- Understand the technical characteristics and capabilities of the systems from Morpho
- Work towards a visit to their technical team once the above are all positive.
- Gain an understanding of their readiness to undertake trial on carcases and to collaborate on a development project

7.2 Phillips and Reconstruction Algorithms

I also had an interesting conversation to Zabic Stanislav of Phillips. He is also engaged on the development of new and improving reconstruction algorithms. At a technical presentation he asked many questions of all of the speakers and is obviously across the reconstruction process.

7.2.1 Recommendtaion

Maintain good communication terms with Zabic with a view to keeping the knowledge transfer ongoing

8 Phantoms

One of the problems that has plagued Australian CT researchers in the past is that of being able to compare one objective imaging system with the other. There is always a doubt that perhaps the animals that were imaged with CT were different from the first set? There is definitely the problem of trying to keep Meat/ Carcases fresh while trials extend over several days despite the access on some occasions to refrigerated rooms.

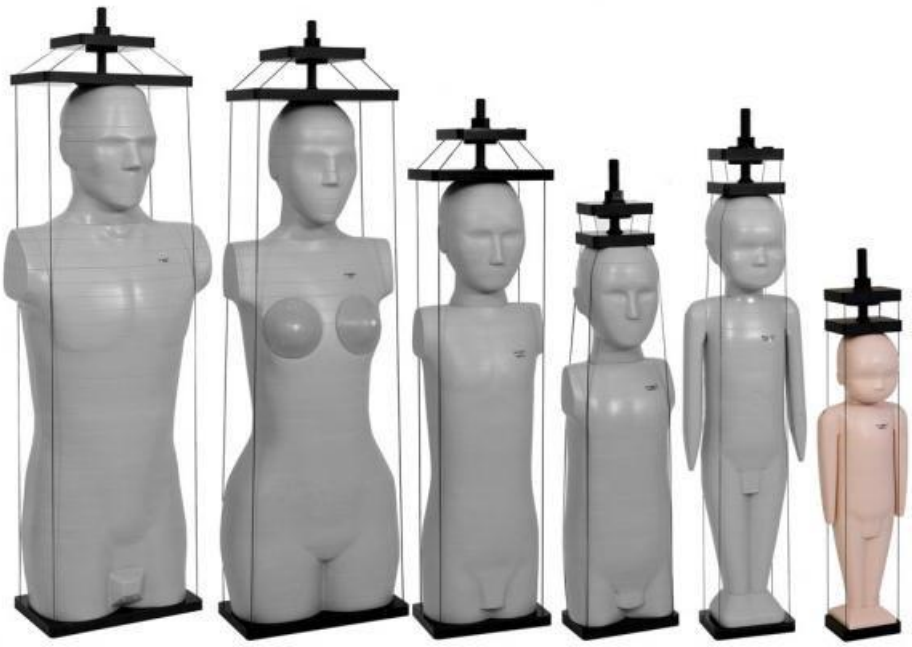
One way that may circumvent these problems is to have an Imaging Phantom or “Phantom” Carcase manufactured. Phantoms are specially designed objects constructed of materials reflective of the same characteristics as human tissue, that are scanned or imaged by the CT system to evaluate, analyze, and tune the performance of the device. For the Meat industry it can be used to compare the performance of one machine against another or to compare the improvements or not at various parameter settings of a machine.

Phantoms are used extensively in medical CT to provide a lifelike representation of a human body. Various additions are included in the Phantom so that different substances may be inserted and captured in the image, such as Iodine or calcium. These can be adjusted at various densities so that an objective measure of the substances density is known and can be compared with the Hounsfield values of the CT result.

One company that was spoken with at length at the RSNA was CIRS, Tissue simulation and Phantom Technology.

8.1.1 CIRS Inc.

CIRS stands for Computerised Imaging Reference Systems. INC. This company makes a wide range of Phantoms for the Medical Industry. Their system for Phantoms that look most human like is unique in that each Phantom is made up of specific segments or slices that are then joined together to make the lifelike representation as shown in the image below.



The President of CIRS, Mark Devlin advised that it would indeed be possible to develop a phantom in the shape of a lamb and add whatever attributes we wanted. He advised that adding in several Slices or section at various levels of intra muscular fat would be possible as well as simulating the AUS-MEAT Marbling chips should it be decided to develop a Beef Side phantom.

Different densities of bone can be added as well to simulate changes with age as a result of ossification if that was considered important.

One of the biggest advantages of having a Phantom beef and lamb carcase would be in equipment evaluation. Manufacturers could be sent the phantom and undertake the tests with in the initial proving stage, with no need for sourcing of whole carcases or sides. The results can be analysed between differing, manufacturers and their results on the Phantom Carcase compared directly.

Phantoms can also be used to test the capability of a system on a new opportunity. An example would be trying to determine if a particular machine can determine the disease status of a lymph node for example. Such a node (with and without disease) could be included in the appropriate segment in the Phantom and the system tested and the results analysed over a number of different machine settings or software versions.

8.1.2 Contact Details

Mark Devlin President CIRS Tissue Simulation and Phantom Technology 2428 Alemeda Ave. Suite 316 Norfolk VA 23513	(800)617-1177 (757)8552756 Fax: (757)8552765 mark@cirsinc.com www.cirsinc.com

8.1.3 Recommendation

The Meat industry needs a “Lamb phantom” as a minimum (and preferable a Section of a full Beef Side Phantom) to allow for capturing CT images at different systems and machinery but with the same reference. Proceed to investigate further the phantom options and suppliers and submit a proposal to MLA.AMPC for the purchase of 1 Simulated Lamb Phantom as an initial trial Phantom.

9 Appendix

9.1 Technical Paper by Dr Peter Miller MD

Paper Entitled “Dual-Energy CT-Derived Iodine Mapping Technical Background and Clinical Applications”

9.2 Details on Filtered Back Projection

The standard method for reconstructing CT images and reducing noise has been filtered back projection (FBP). This method has the advantage of being less mathematically demanding than iterative methods and image reconstruction using FBP is very fast particularly with modern PC computers. This is the oldest method of Image reconstruction and has been in use for a long period. The following website provides a good overview of how it works and its limitations. Excerpts have been taken from this website (http://www.dspguide.com/ch25/5.htm) to explain the method of operation.

"Filtered Back-projection technique is the modification of older techniques called backprojection or simple backprojection**.** The **f**igure below shows that simple backprojection is a common sense approach, but very unsophisticated. An individual sample is backprojected by setting all the image pixels along the ray pointing to the sample to the same value. In less technical terms, a backprojection is formed by '*smearing*" each view back through the image in the direction it was originally acquired. The final backprojected image is then taken as the sum of all the backprojected views

While backprojection is conceptually simple, it does not correctly solve the problem. As shown in (b), a backprojected image is very blurry. A single point in the true image is reconstructed as a circular region that decreases in intensity away from the centre. In more formal terms, the point spread function of backprojection is circularly symmetric, and decreases as the reciprocal of its radius

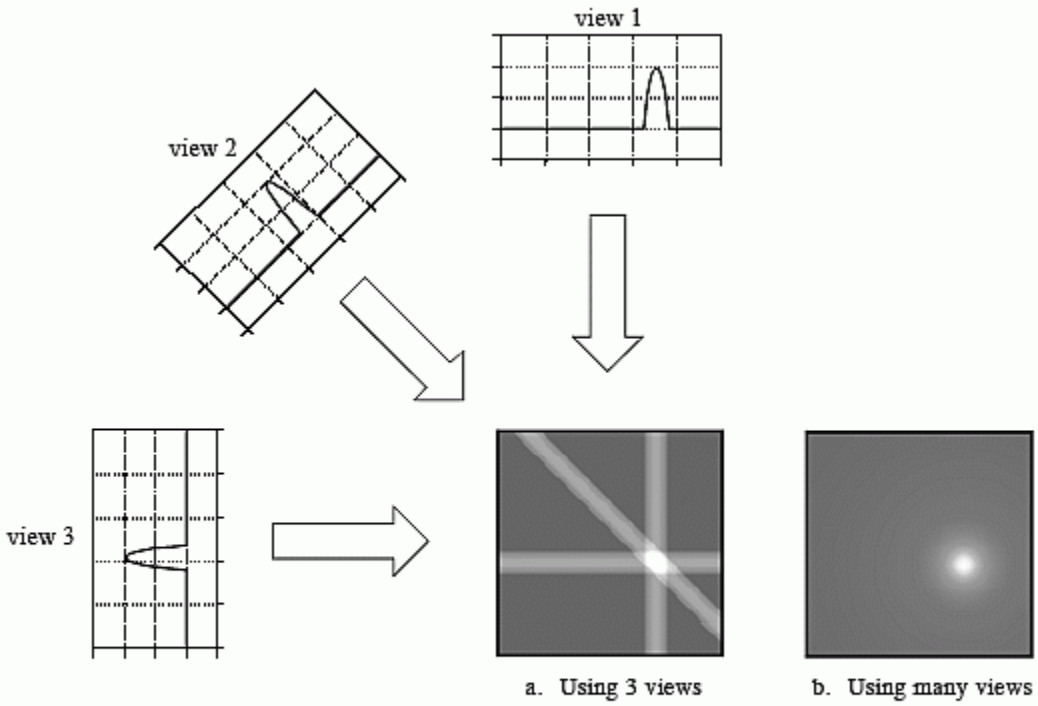


FIGURE 25-16
Backprojection. Backprojection reconstructs an image by taking each view and *smearing* it along the path it was originally acquired. The resulting image is a blurry version of the correct image.

Filtered backprojection is a technique to correct the blurring encountered in simple backprojection. As illustrated in Fig. 25-17, each view is *filtered* before the backprojection to counteract the blurring PSF. That is, each of the one-dimensional views is convolved with a one-dimensional filter kernel to create a set of *filtered views*. These filtered views are then backprojected to provide the reconstructed image, a close approximation to the "correct" image. In fact, the image produced by filtered backprojection is *identical* to the "correct" image when there are an infinite number of views and an infinite number of points per view.

In the diagram below the profiles have been changed by the filter. The image in this example is a uniform white circle surrounded by a black background (a pillbox). Each of the acquired views has a flat background with a rounded region representing the white circle. Filtering changes the views in two significant ways. First, the top of the pulse is made flat, resulting in the final backprojection creating a *uniform* signal level within the circle. Second, negative spikes have been introduced at the sides of the pulse. When backprojected, these negative regions counteract the blur

The filter kernel used in this technique will be discussed shortly. For now, notice how the profiles have been changed by the filter. The

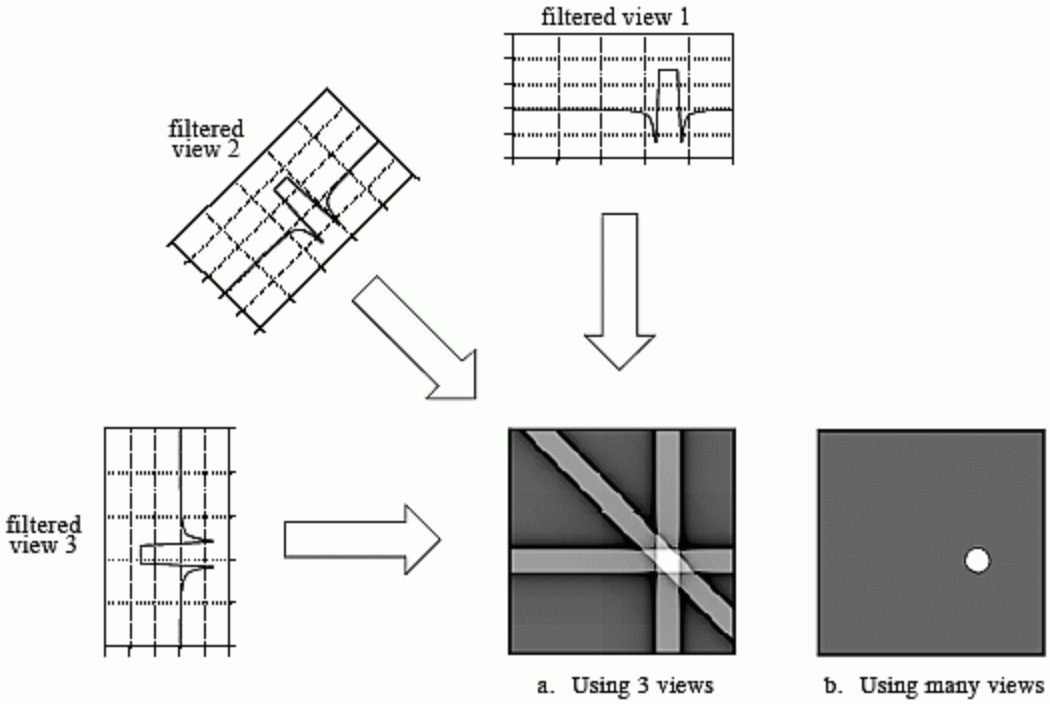


FIGURE 25-17
Filtered backprojection. Filtered backprojection reconstructs an image by filtering each view before backprojection. This removes the blurring seen in simple backprojection, and results in a mathematically exact reconstruction of the image. Filtered backprojection is the most commonly used algorithm for computed tomography systems.

From the above it can also be seen how this method can be subject to many artefacts and noise non clear images as a result of noise and scatter. The more recent methods of image reconstruction do so in a way that reduces noise and enhances contrast.

9.3 Security Conferences

The medical industry is the leaders in the technical development of CT for medical purposes. The medical industry has concerns regarding radiation dose to patients and the throughput volume of patients in a modern radiological clinic is not great. None of this aligns with the goals of implementing CT systems as the prime objective measurement tool for a modern meat processor.

The Aviation (perhaps more generally „Transport") Industry has more in common. Modern aircraft baggage scanners are high volume; self shielding from radiation; reasonably portable; high duty cycle (24/7) and are a better fit in a production sense than the medical industry.

Relationships are yet to be established within this industry and it is the one area that has not been investigated as to the applicability of the technology. There are 3 key players that are know to be the leaders in the CT Baggage scanner market and these are

- Analogic
- Rapiscan
- Safran /Morpho

These companies are generally exhibiting their products at the major Aviation Security conferences around the world. Rapiscan and Saffran/Morpho list which conferences that they will be attending but unfortunately Analogic does not.

The list below gives some indication of the Security conferences being held and which companies have indicated that they will be exhibiting

Conference/ Exhibition	Rapiscan	Safran Morpho	Analogic
National Security technology Expo 6-8 February San Diego Convention Centre San Diego, CA http://www.nstexpo.com/			?
Airport Security Asia 2012 27 - 28 February, 2012, Prince Hotel & Residence, Kuala Lumpur, Malaysia http://www.airportsecurityasia.com/Event.aspx?id=567058			?
IATA World Cargo Symposium 2012 13 - 15 March 2012 Kuala Lumpur - Malaysia Shangri-La Hotel http://www.iata.org/events/wcs/Pages/index.aspx	✓	✓	?
Air Cargo PREMIER annual trade show and CONFERENCE March 18 - 20, 2012 Doral Resort and Spa. Miami, FL. http://www.aircargoconference.com/	✓		?

International Security National Resilience 19-21 March 2012 Abu Dhabi National Exhibition Centre U.A.E http://www.isnrabudhabi.com/Portal/home.aspx	✓	✓	?
Aviation Security Summit 21-22 March Realm Hotel Canberra http://www.informa.com.au/conferences/transport/aviation/aviation-security-summit		✓	?
ISC West 28-30 March 2012 Las Vegas USA http://www.iscwest.com/		✓	?
Passenger Terminal EXPO 2012 18-20 April 2012 Messe Wien Exhibition and Conference Center Vienna, Austria http://www.passengerterminal-expo.com/index.php?n=hom		✓	?
IFSEC International 14 - 17 May 2012 Birmingham, UK www.ifsec.co.		✓	?
TRANSPORT SECURITY EXPO 14-15 November 2012 Olympia London http://www.transec.com/		✓	?

A more extensive list can be found here.

http://www.securityinfonet.com/Security_Conferences_and_Seminars.htm

9.4 Correspondence with Specific Companies

The following are copies of emails correspondence with various companies since the RSNA Exhibition and Conference.

9.4.1 Analogic Inc.

Thanks Bill,

I appreciate you doing that for me.

One of the next steps for us will be to put together a specification. On Baggage scanners it is somewhat more difficult since we have little idea of what they are capable of in relation to organic materials. I know some come with a dual energy capability and we have little idea how that may help us. My instincts tells me it will but I need to understand more. We have done many CT trials on both beef and lamb and know what we can get from a medical CT scanner but I presume the key dimensions with a baggage scanner are very different.

All of our trials have been undertaken using a standard machine and then review the resulting image and review if it is sufficient for our needs. We have tried to simulate our production rate needs but medical machines generally cannot meet our throughput needs.

Our throughput speed needs always bring us grief. With lamb we have a target of 5-6 seconds per lamb and a lamb is approximately 1.8 metres long depending on weight. For a beef side, (a carcase cut longitudinally) the cycle rate is one every 10 seconds and a beef carcase is around 3.2 metres long, also dependant on age and weight.

The image analysis pert of the process is also another issue. I presume the out put from the baggage scanners is still a Dicom file and we can run standard software such as the Mayo Clinics Analyse, over the images?

I know you will need more details and I will endeavour to develop a more comprehensive specification with some size and weight ranges for you.

Regards

Greg

From: Tabola, Bill [mailto:BTabola@analogic.com]
Sent: Tuesday, 24 January 2012 8:32 AM
To: Greg Palmer
Subject: RE: CT Systems for the Australian Meat Industry

Greg,

Thanks for the follow up. I forwarded your email to some of our folks on the security side of our business. Let me follow up with them and get a reply to you. Do you have any specifications we can review? Things like resolution, speed and size requirements and environmental conditions would be helpful. Thanks.

Regards,

Bill Tabola

Analogic

From: Greg Palmer [mailto:agpalmer@matrixprof.com.au]
Sent: Monday, January 23, 2012 4:04 PM
To: Tabola, Bill
Subject: RE: CT Systems for the Australian Meat Industry

Hi Bill,

I was wondering if you had had a chance to progress discussions regarding our meat industry project. We are planning to talk with the key players in the Meat Industry soon and I was hoping I could let them know something regarding any opportunities with Analogic.

Warm regards

Greg

From: Greg Palmer [mailto:agpalmer@matrixprof.com.au]
Sent: Thursday, 12 January 2012 11:56 PM
To: 'dleong@analogic.com'; 'btabola@analogic.com'
Cc: 'ezanin@analogic.com'
Subject: CT Systems for the Australian Meat Industry

Howdy David and Bill,

I met you in Chicago at the RSNA Conference and Exhibition. You both very kindly discussed with me the rather unusual application that we have for a CT system

As you may remember, I am undertaking a project with the Australian red Meat industry (Beef, Lamb and Goats)

As mentioned, our industry is struggling to find the labour resources to be able to have sufficient people to operate their processing plant at the throughput that maintains and economical business. The lure of the rather better paid and much better conditions in the mining industry is attracting workers at a faster rate that they can be replaced. Even though we have special Visas for people to have short term work contracts form other countries, our processing plants still struggle to find the number to operate efficiently.

The industry Bodies of Meat and Livestock Australia (MLA) and the Australian Meat Processor Company (AMPC) have had an innovation strategy in place for over a decade to automate some of the manual repetitive tasks that exist within a processing plant. Many of these have been completed with great success and now some of the more difficult tasks have been undertake with the

assistance of X-Ray imaging to identify key skeletal points in the carcse to facilitate accurate processing.

At this stage there are 4 processing plant in Australia and New Zealand that are operating using these X-Ray systems that provide information to robotic carcase cutting systems.

The next level of task to be automated requires more detailed 3-Dimensional information and our industry has taken the view that CT will provide the best solution to provide the objective 3-Dimensional information.

Once installed a CT system will not only provide information on the key skeletal points for robotic cutting but other benefits are derived as well.

These benefits include:-

Payment systems based on how big the cut of meat is and which cut it is- a more “Meat Value” approach rather than the averaging approach taken now based on weight and Marble score.

Marble score or grade before the carcase is chilled timing benefits as well as savings in Refrigeration costs as a result of only chilling those carcases that are going to meet the high marble grade

Decisions on how to cut the carcase up based on the optimum fit of the weight of the cut and to which market will deliver the optimum value

These benefits together are quite substantial and justify significant investment and the same needs generally apply to both beef and lamb.

MLA and AMPC have funded a number of projects in the past to evaluate the existing medical and industrial Ct systems and to understand the specification requirements of a CT machine that would suit a beef system and a lamb system.

These trials have delivered most of this information and MLA and AMPC would now like to form an arrangement with an OEM CT manufacturer such as Analogic to continue working with so that we can install a CT system into one of our major operating meat processing plants. We do have a number of company’s that have significant meat processing developmental experience who we would suggest to partner with to do the specialist ,meat specific items such as feed in conveyors etc.

I was very impressed with simplicity of the design of the core of your CT machine which I understand other companies purchase and then modify to their own specifications and branding. I also understand that behind that simplicity is many 1000’s of man hours and countless dollars have been expended to present such a well designed and stylish machine.

In our discussion you also mentioned that you thought that your security baggage scanner division may have some technology that may suit our needs even better. The long operating times of modern aviation baggage security systems certainly reflects our needs more closely than does the ‘stop/start’ medical systems with very low duty cycles.

You both suggested that I needed to speak with Eric Zanin, something I tried to do on a number of occasions at the RSNA but was not to happen. Hence I have taken the liberty of copying Eric on this email.

As it turns out, we were planning on investigating the baggage scanning technology next as part of our search for the most appropriate partner to collaborate with in the future.

We would be very pleased to meet with the relevant people in your baggage scanner division and especially to gain an understanding of the technology and how it fits with our needs. Our knowledge and understanding of the Baggage Scanner technology is very low and hence we do not have a good grasp of how it may work together as a unit.

Looking forward to continuing the relationship.

Warm regards Greg

9.4.2 Neusoft Inc.

Hi Keith,

Great to hear back from you. As time draws near for harder specifications I will need to get you some firmer values based on a sample of Carcases and these are based on my estimates at the moment.

My Answers in below.

Some introductory references that may help as well

http://wagyu.org.au/grade/HAM%207th%20CAS.pdf

http://www.ausmeat.com.au/media/1711/Chiller%2010%20Low.pdf

http://www.australian-meat.com/chiller-assessment-beef

I will see if I can dig up some more

Greg

From: Mildenberger, Keith [mailto:keith.mildenberger@us.neusoft.com]
Sent: Saturday, 14 January 2012 6:14 AM
To: Greg Palmer
Subject: RE: CT systems for the Australian Meat Industry

Hello Again Greg,

Was revisiting our discussions in the booth and was working through some of the particulars.

Could you give me average dimensions and weights for the carcasses (lamb, goat, beef)? That would allow me to do some figures about what would be required from a workflow and x-ray point of view. As we talked in Chicago, these would ideally be on some sort of a conveyor system that would move them through the CT non-stop.

Ignore goats since they are not a large % of production. Lamb Weight is approximately 16- 25 Kgs. Length around 1.3 metres, width up to approximately 450 mm at max.

Beef is a bit more difficult because of the weight and size and age range. Length around 3.5 metres per side, maximum width around 900 mm but may be larger- I will need to measure a range. An 18 month old carcse after 70 days grain feeding is around 600 mm wide so older carcases and bulls will be substantially larger.

You mentioned other x-ray processes used to identify key skeletal points. What type of x-ray power are you using (kVp and mAs) for this? Do you use some sort of a digital panel for imaging; how is the x-ray information captured? Any pictures you have of the captured image that you could send me would help me better understand.

Do you have any pictures that could help me understand “key skeletal points”?

I will see if I can dig out some videos or diagrams. By way of an example that we do now with X-Ray, In the lamb diagram attached, we want to cut the carcse into 3 sections, Forequarter, Middle (Loin and Rack) and Leg.

Most lambs have 1 ribs so if we are after an 8 ribbed rack (+loin- these are separated later) we want to if we can cut between the 5th and 6th rib. We need to measure the angle of the ribs as they all change somewhat and adjust the ct to suit and cut between the ribs. If we get it wrong it will leave a portion of the rib poking out which will need to be removed as it will look unsightly and worse still we now probably have a 7 ribbed rack when the customer wanted 8. It also gets more complicated when the lamb has 14 or 12 ribs. So the software has to be able to identify and then count the ribs. It gets difficult around the shoulder blade and collar bone area and sometimes the X-Ray does not always get it right.

A similar thing happens with the leg/ Loin+Rack interface. We want to cut so that we just miss the top of the Ilium bone so that we leave the most amount of meat on the loin- (the most $ valued cut) and do not cut so low that we cut or shatter the Ilium and send pieces of bone fragments through the loin cut. We are doing this segmenting process now in 4 processing plants in Australia and New Zealand using X-Ray. This is happening at normal processing speed which in a large plant is 10-12 a minute

I think the analysis of the marble scoring would be easy to do. This could be done by evaluating the average density of the carcass at key points. You could develop a standard that correlated Hounsfield Units (HU) to marble score over a given region of the carcass. As fat and muscle have a reasonable spread between them in HU, then the average density (HU) over a given area should indicate the fat to muscle ratio pretty accurately. It would be more objective measure I would imagine. I would think that with some clever coding from our IT folks, the regions of interests (ROI) for the key measuring points could be ascertained automatically on the carcass. Obviously the measurement and average HU operation would be performed as well.

The marbling work needs some careful thought. In the US and Australia the marbling is measured by a grader who looks at a cross section of the Rib-Eye at a specified position between 2 ribs, (9th and 10th I think but it varies depending on which market the meat is being sent to).

To replicate what the grader does we would need to take a single slice, segment out all of the Subcutaneous fate and the intra muscular fat, find the outline of the rib-eye and measure the % of marbling inside this rib-eye area.

This is the way it has traditionally been done for years. A better way is as you suggest since it gives and overall evaluation of the amount of Intramuscular fat in the Rib-eye muscle and not just at one point but this is a change of how things have been done and may have resistance. We may need to do both until we can prove that the way you suggest is of a superior standard.

The grade sees only I slice and 2 mm below that slice can yield a score difference because of the vagaries of a biological product.

There is also some work being done on lamb to measure the intramuscular fat as well as there is some correlation to the eating experience so this is applicable to both beef and lamb.

The DICOM header could be used to track the given carcass. There are a number of different ways to tag the carcass (barcode for example) and tie that back to the imaging header for the specific carcass. That way, once the carcass hits the conveyor, all information about it is sent to the CT system via the DICOM worklist. The ROIs could be captured in the header (once it is scanned) and any number of automated grading, billing, shipping operations could be driven from there. The other advantage would be that one system could be setup to do different types of meat. The information about the carcass in question (goat, lamb etc.) would be part of the DICOM header and would automatically change the setup of the scanner regarding x-ray techniques, ROI etc.

Our Meat processing plants have very sophisticated methods of carcase tracking now. These have been implemented over the years to keep up with health and hygiene issues as well as foods safety especially after the BSE scare a few years ago. We now know from which property it was born and where it has been before it goes into a box to go on a transport truck. Many plants now have electronic ID systems that are used to automatically record a carcse identification number. We will, as you suggest need to link the carcase number (or processed sequence number) to the Dicom image since the sequence number is the link back to the other information about the carcase.

Could you better explain to me how the marble scoring is done. I understand it is basically muscle to fat but, don't understand what determines where on the carcass this analysis is done. Understanding this would allow us to better generate an algorithm to automate it.

The Marble score is calculated as a % of Intramuscular fat to the amount of Meat in the Rib-eye muscle –(Longisimus dorsi muscle). The grader slices through the carcse between the 9^{th} & 10^{th} rib- or elsewhere depending on the specification, and then lets the muscle be exposed to the oxygen in the air for a period of time 30 minus plus I think.

In this time the muscle gains oxygen and gets much redder in appearance. This gives a consistent contrast to the fat. The grader compares what he sees to a number of standard cards that have been classified as a certain "grade". The grades are basically in increasing fat %'s.

Please correct any inaccurate assumptions or memories from above. Any information you can send me that will help me better understand the current process would be appreciated. I'm a visual person so any and all pictures are welcome.

Talk with you soon,

Keith

From: Greg Palmer [mailto:agpalmer@matrixprof.com.au]
Sent: Thursday, January 12, 2012 5:07 AM
To: Mildenberger, Keith
Subject: CT systems for the Australian Meat Industry

Hi Keith, Howdy from Down-under,

I met you in Chicago at the RSNA Conference and Exhibition. You both very kindly discussed with me the rather unusual application that we have for a CT system

As you may remember, I am undertaking a project with the Australian red Meat industry (Beef, Lamb and Goats)

As mentioned, our industry is struggling to find the labour resources to be able to have sufficient people to operate their processing plant at the throughput that maintains and economical business. The lure of the rather better paid and much better conditions in the mining industry is attracting workers at a faster rate that they can be replaced. Even though we have special Visas for people to have short term work contracts form other countries, our processing plants still struggle to find the number to operate efficiently.

The industry Bodies of Meat and Livestock Australia (MLA) and the Australian Meat Processor Company (AMPC) have had an innovation strategy in place for over a decade to automate some of the manual repetitive tasks that exist within a processing plant. Many of these have been completed with great success and now some of the more difficult tasks have been undertake with the assistance of X-Ray imaging to identify key skeletal points in the carcse to facilitate accurate processing.

At this stage there are 4 processing plant in Australia and New Zealand that are operating using these X-Ray systems that provide information to robotic carcase cutting systems.

The next level of task to be automated requires more detailed 3-Dimensional information and our industry has taken the view that CT will provide the best solution to provide the objective 3-Dimensional information.

Once installed a CT system will not only provide information on the key skeletal points for robotic cutting but other benefits are derived as well.

These benefits include:-

Payment systems based on how big the cut of meat is and which cut it is- a more “Meat Value” approach rather than the averaging approach taken now based on weight and Marble score.

Marble score or grade before the carcase is chilled timing benefits as well as savings in Refrigeration costs as a result of only chilling those carcases that are going to meet the high marble grade

Decisions on how to cut the carcase up based on the optimum fit of the weight of the cut and to which market will deliver the optimum value

These benefits together are quite substantial and justify significant investment and the same needs generally apply to both beef and lamb.

MLA and AMPC have funded a number of projects in the past to evaluate the existing medical and industrial CT systems and to understand the specification requirements of a CT machine that would suit a beef system and a lamb system.

These trials have delivered most of this information and MLA and AMPC would now like to form an arrangement with an OEM CT manufacturer such as Neusoft to continue working with so that we can install a CT system into one of our major operating meat processing plants. We do have a number of company's that have significant meat processing developmental experience who we would suggest to partner with to do the specialist ,meat specific items such as feed in conveyors etc.

I was very impressed with simplicity of the design of the core of your CT machine. I also understand that behind that simplicity is many 1000's of man hours and countless dollars have been expended to present such a well designed and stylish machine.

We would be very pleased to meet with the relevant people in your technology area to gain an understanding of the technology and how it fits with our needs. Our knowledge and understanding of CT technology is low compared with yourself and hence we do not have a good grasp of how it may be modified to suit or specific needs

I did promise to give you the information regarding our best guess at a lamb machine specification which I will dig out for you.

I also promised to get you the details of the 'Photon Counting' detectors that are being developed in Christchurch within the University of Canterbury,

Their details are :-

http://wiki.canterbury.ac.nz/display/MARSCT/Publications

http://iopscience.iop.org/1748-0221/6/01/C01059/pdf/1748-0221_6_01_C01059.pdf

http://www.ncbi.nlm.nih.gov/pubmed/19239056

I hope these help. If not let me know, I know I have some more references somewhere. I will have to dig them out.

.Looking forward to continuing the relationship.

Warm regards

Greg

9.4.3 Imaging[3]

Hi Greg,

Great to hear from you. Your project is one that Dean has taken a personal interest in where normally it would have been delegated to me. The bottom line to that is there is a great deal of interest on our part in your project. I think "fascinated" would also be an appropriate descriptor

along with interested. That said, you obviously haven't heard from Dean – counter-intuitive as that may be based on what I just wrote. I know, without even talking to Dean, that this is due to some important issues with our FDA approval process that Dean has been dealing with.

So, to keep this on a front burner, I will bring it up this afternoon either in our Board meeting which I'm invited to or one-on-one with Dean if we don't meet which is a possibility this week.

I'll leave it there because the probability is high he'll respond to this e-mail this morning but in the event he gets tied up I just wanted to let you know that I'll follow up on our end to ensure we're doing whatever we can here in Burbank.

Thanks again,

Mike

PS: If this is ever needed my cell number is 818-321-0461 and feel free to call me at any time. By design this number isn't on my business card and I cannot recall if I gave it to you.

From: Greg Palmer [mailto:agpalmer@matrixprof.com.au]
Sent: Tuesday, January 17, 2012 12:32 AM
To: dean@imaging3.com
Cc: mike@imaging3.com
Subject: Howdy from Down Under- Beef and Lamb CT systems

Howdy Dean and Mike,

It was very nice to meet with you at the recent RSNA Show in Chicago. You both very kindly discussed with me the rather unusual application that we have for a CT system

As you may remember, I am undertaking a project with the Australian red meat industry (Beef, Lamb and Goats)

As mentioned, our industry is struggling to find the labour resources to be able to have sufficient people to operate their processing plant at the throughput that maintains and economical business. The lure of the rather better paid and much better conditions in the mining industry is attracting workers at a faster rate that they can be replaced. Even though we have special Visas for people to have short term work contracts form other countries, our processing plants still struggle to find the number to operate efficiently.

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MLA and AMPC have funded a number of projects in the past to evaluate the existing medical and industrial Ct systems and to understand the specification requirements of a CT machine that would suit a beef system and a lamb system.

These trials have delivered most of this information and MLA and AMPC would now like to form an arrangement with an OEM CT manufacturer such as Imaging3 Inc.

to continue working with so that we can install a CT system into one of our major operating meat processing plants. We do have a number of company’s that have significant meat processing developmental experience who we would suggest to partner with to do the specialist ,meat specific items such as feed in conveyors etc.

I was very impressed with simplicity of the design of your CT machine. I was particularly impressed that there was no need for a lead lined room to surround the unit.

As mentioned I do, based on poor results from past experience, have some reservations regarding the ability to achieve a clear high contrast image using the Cone beam style of image acquisition. I would love to be proved wrong!!

We discussed the possibility of doing a trial on a lamb carcase and if that still is an option I would very much like to explore this further.

I would be interested to hear your thoughts on how we might proceed and what thoughts you may have had since we met in Chicago.

Warm regards

Greg

10 Glossary

10.1 Compton Scatter

Compton scattering occurs when the incident x-ray photon is deflected from its original path by an interaction with an electron. The electron is ejected from its orbital position and the x-ray photon loses energy because of the interaction but continues to travel through the material along an altered path. Energy and momentum are conserved in this process. The energy shift depends on the angle of scattering and not on the nature of the scattering medium. Since the scattered x-ray photon has less energy, it has a longer wavelength and less penetrating than the incident photon.

10.2 Photoelectric effect

The photoelectric effect states that when a substance is bombarded by photons (light), electrons will be released by that substance, creating electricity. This is the reason that we have solar cells. This can only happen if there is enough light (energy) to break free an electron from the atoms.

10.3 Attenuation

X-rays are attenuated as they pass through matter. That is, the intensity of an X-ray beam decreases the farther it penetrates into matter. Basically, each interaction of an X-ray photon with an atom of the material removes an X-ray from the beam, decreasing its intensity. It is the gradual loss in intensity through a medium. The gray levels in a CT slice image correspond to X-ray attenuation, which reflects the proportion of X-rays scattered or absorbed as they pass through each voxel. X-ray attenuation is primarily a function of X-ray energy and the density and composition of the material being imaged