Final report

Cone Beam X-ray Livestock Imaging

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Abstract

Note: After preliminary primal scanning at the provider research facility in Chicago USA, and subsequent to system detailed design work, the project was terminated due to Covid-19 related impacts to the US based business and their milestone delivery capabilities.

This project will enhance the recently developed 4DDI equine robotic CT scanner to be suitable for scanning carcase yield, eating quality, and health attributes, on Australian beef livestock in feedlots. The scanner will be trialled at an Australian beef feedlot. 4DDI will report on the success of the scans, and whether they can be paired with 2D DEXA and CT LMY and EQ OM results for beef sides.

The completed work confirmed many aspects of the technical and commercial feasibility; however, premature termination has limited the project value, and consequently further work including a site demonstration is still required.

Executive summary

Background

This project will enhance the recently developed 4DDI equine CT scanner to be suitable for scanning Australian beef at a feedlot. The scanner will be trialled at an Australian feedlot. A suitable carbon fibre restraining device will be developed. 4DDI will report on the success of the scans, and whether they can be paired with 2D DEXA and CT LMY and EQ OM results..

4DDI has developed an equine CT scanner, capable of CT scanning a horse's entire body to be while standing, or even in motion, using four robots capable of operating several panels, high-speed cameras, 3D surface scanners, and emitters in coordinated manoeuvres. Equimagine can capture more than 900 images in a 90-second session.

Equimagine can be programmed to capture a detailed digital scan from every angle of an area of interest.

MLA believes that this technology will may offer cost effective marbling measurements, and potential health attributes during induction, for instance, to predict marbling outcomes and facilitate optimum days on feed sortation.

Figure 1: 4DDI's horse cone bean imaging prototype

Objectives

The project had the objectives of:

- Equipping the 4DDI Veterinary CT scanner to scan Australian beef sides and lamb carcases
- Manufacture, integrate and quality test in US factory, then transfer system to Australia;
- Undergo a meat science performance evaluation at a research facility
- Scan a number of beef sides at an Australian beef feedlot facility
- Final report submitted to MLA, with a public version also submitted if required.
- Commercialisation plan

Methodology

- Demonstration of system capabilities scanning various beef and lamb primals
- Site visits to potential Australian clients: plants, feedlots, research service providers;
- Demonstration of system capabilities to Australian industry steering group, including addressing scanning throughput, addressing carcase movement during scanning, and preliminary meat science MSA calibration

Results/key findings

Preliminary scanning of primals occurred in US, and demonstrated encouraging results.

The design of a system, with technical validation, was carried out, and system specification and commercial proposal submitted.

Work was terminated prior to an Australian demonstration.

Benefits to industry

A flexible CT x-ray livestock imaging system, with capability to integrate into a feedlot induction or hospital area, and be able to grade livestock for eating quality and health attributes and allow for sortation and process days-on-feed optimisation value gains.

Future research and recommendations

The system concept is still considered technically and commercially interesting. MLA would seek to continue this evaluation.

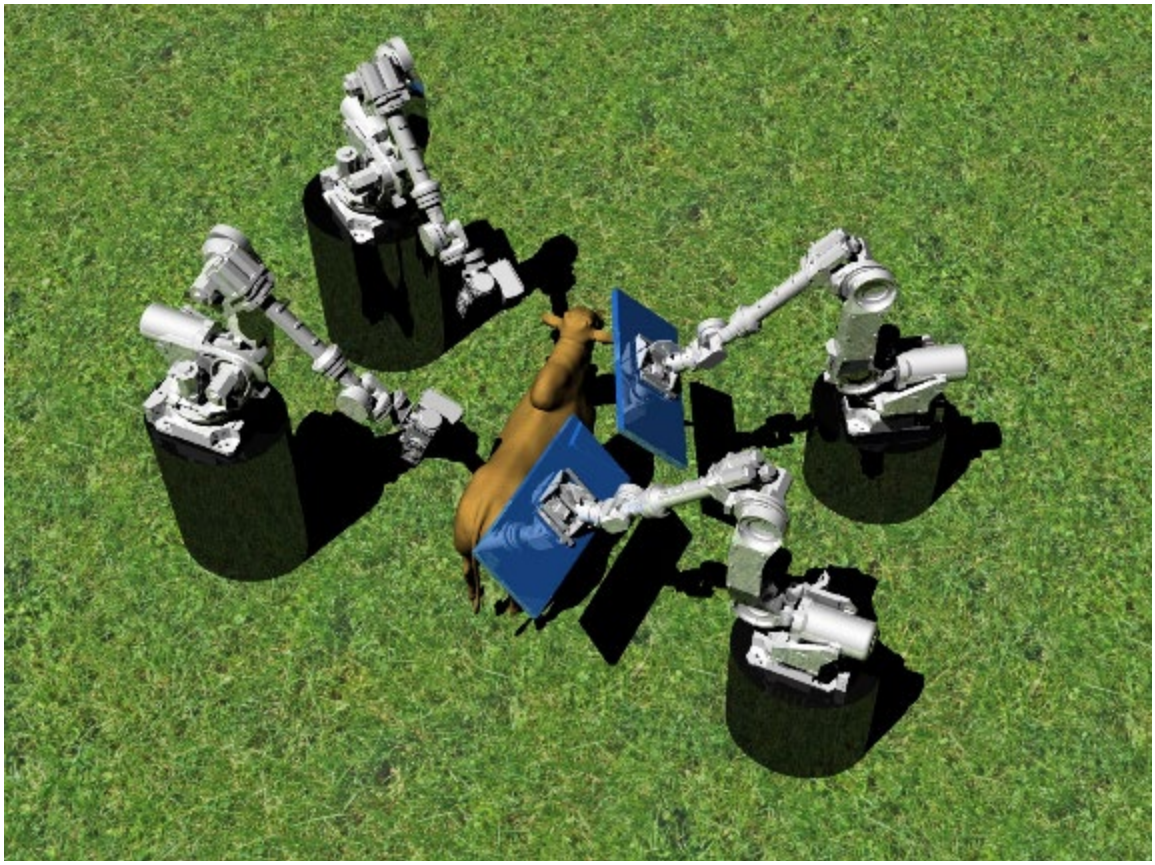

Figure 2: Initial concept of scanning a live animal

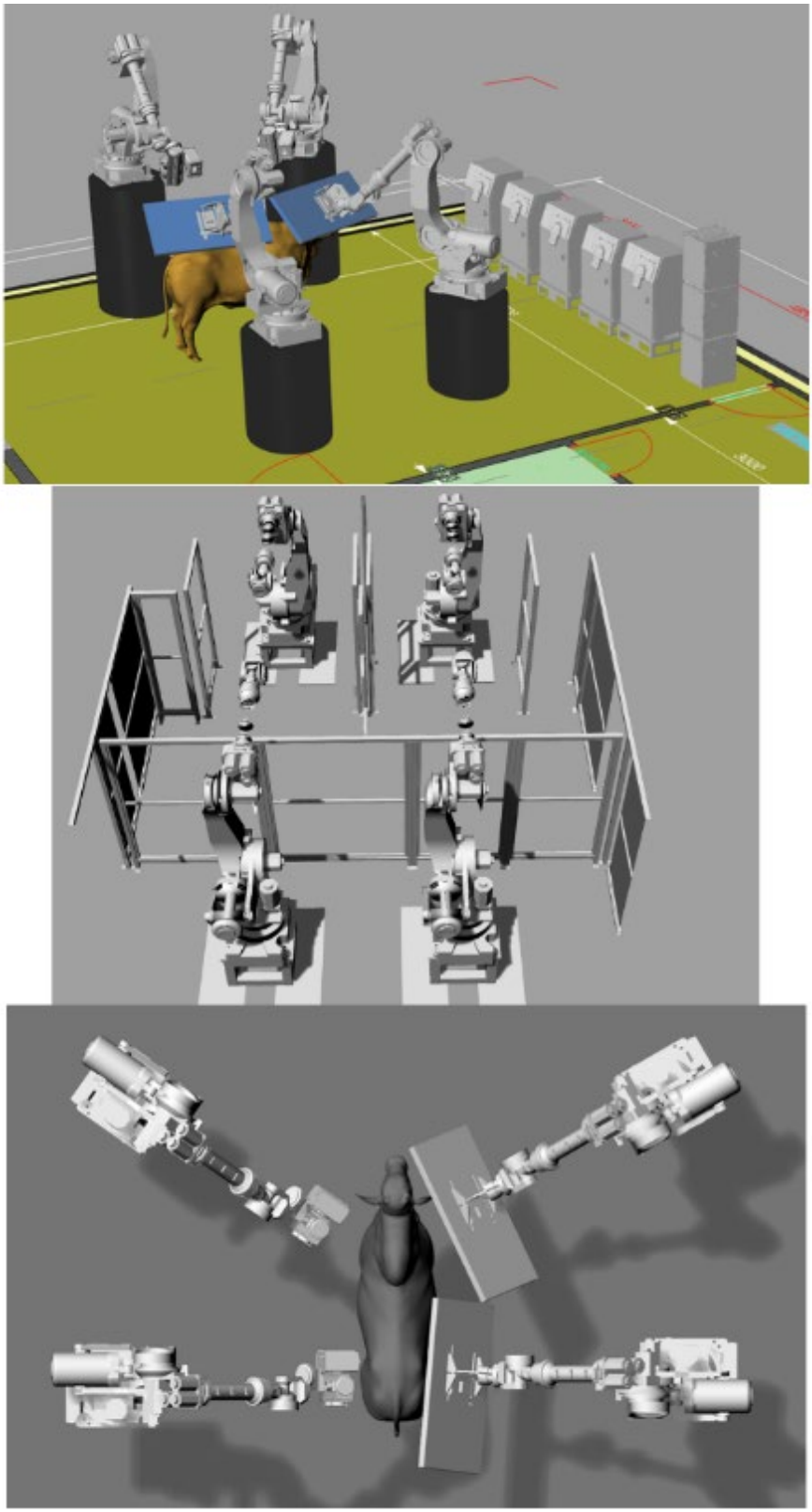

Figure 3: Further concepts of scanning live animals

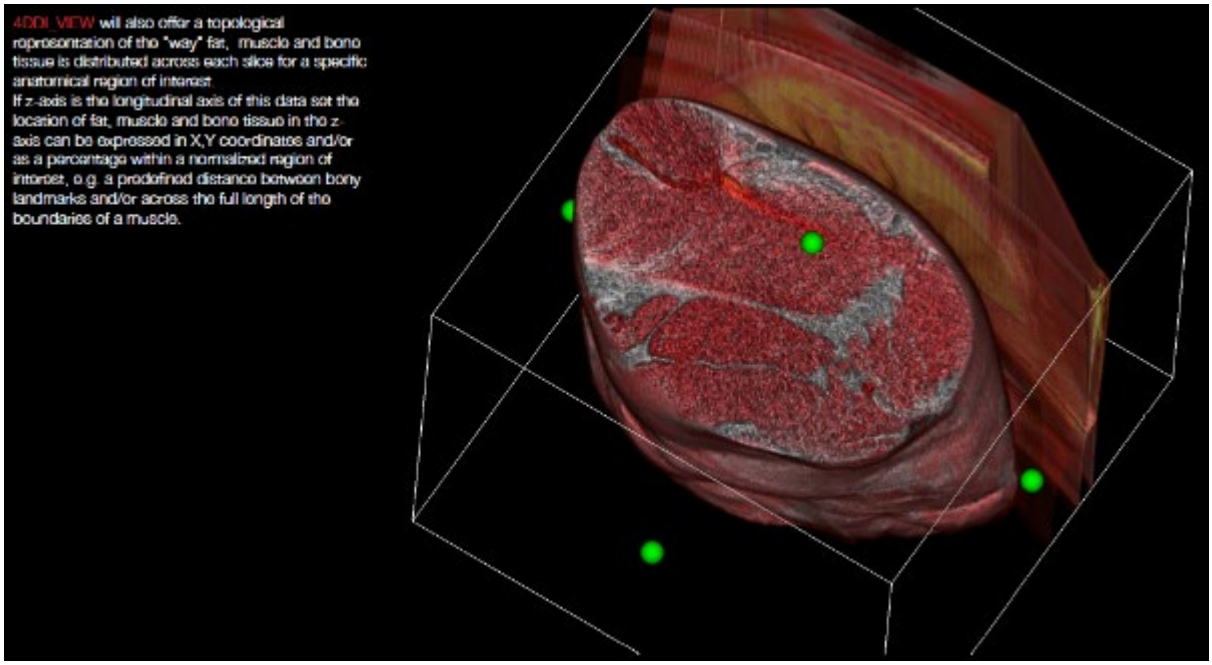

Figure 4: Example of cone beam tomographic reconstruction of rib area muscle.

Imaging quality is considered adequate for marbling assessment, however issues such as speed of scanning, operation in aggressive agricultural environment of heat dust and humidity, and economic value proposition, are still required.

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1.1 Basic System and Evaluation

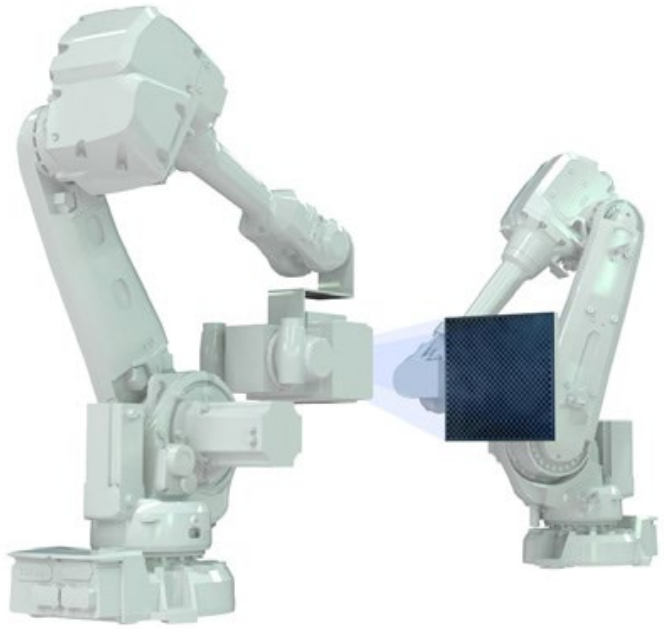


Figure 5: Basic configuration of robotic cone beam imaging with cone beam x-ray emitter and flat panel detector.

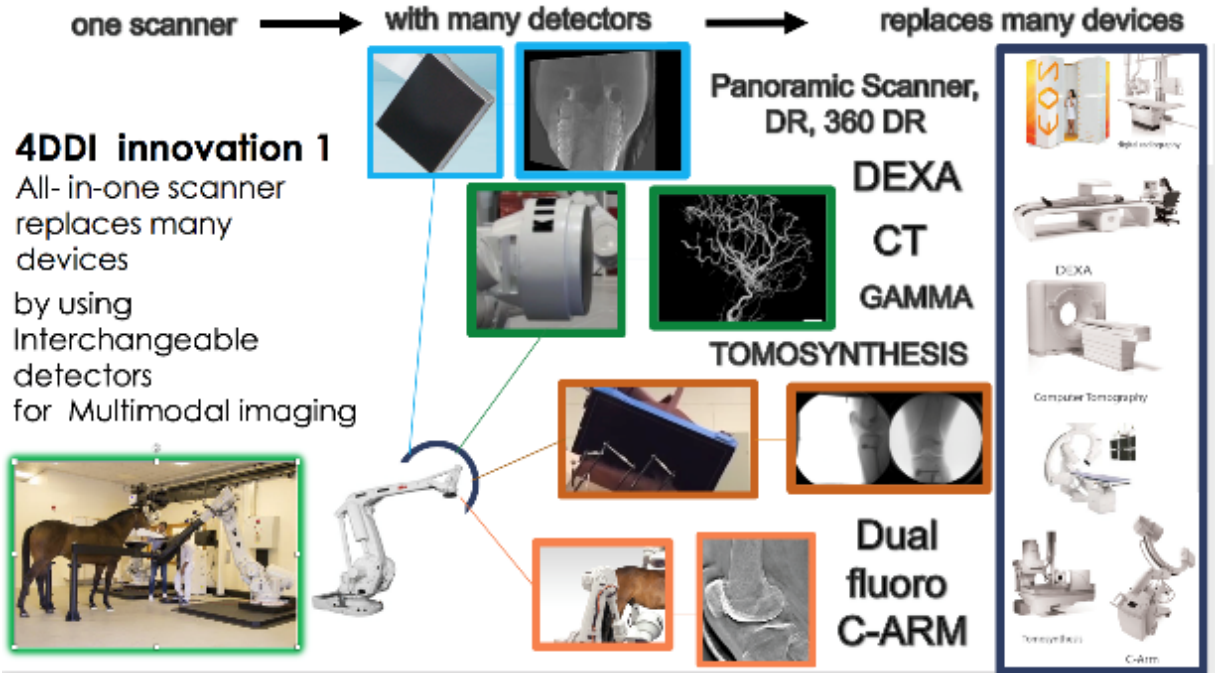


Figure 6: Summary of proposed system flexibility with a variety of customised end-of-arm sensing

The 4DDI technology takes advantage of optionally mounting different detectors and emitters on the various robotic arms to produce and effectively replace all the scanning devices shown above.

2. Objectives

- Re-design the 4DDI Equine CT scanner to scan live cattle in an Australian feedlot
- Employ a suitable carbon fibre restraining device
- Manufacture, integrate and quality test in New York factory
- Scan live cattle in an Australian feedlot
- Final report submitted to MLA, with a public version also submitted if required.
- Commercialisation plan

3. Methodology

3.1 Preliminary evaluation and design concepts

Milestone 1: Report detailing outcomes of measuring the following attributes

- A box/carton of approx. 90CL trim
- A box/carton of approx. 60CL trim
- A butt cut such as a **Rostbif**
- A chine bone in **Rib Roast** (with some level of marbling)
- A **striploin**, with chine bone and other bones still attached (with some level of marbling).
- Chuck, bone in

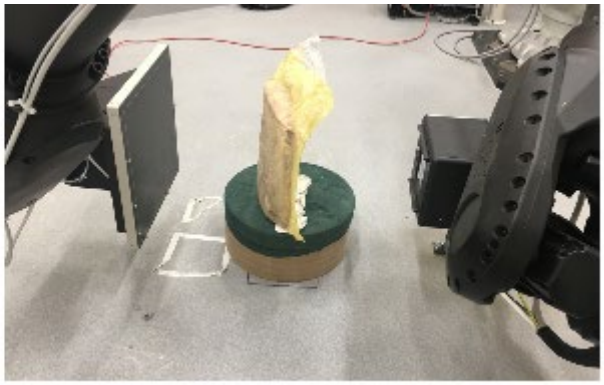
Go/NoGo decision:

Milestone 2: System design with special attributes for installation in 1 x Australian feedlot. Suitable carbon fibre restraining device to be developed. 4DDI to investigate the site to determine suitability. Installation location to be agreed with 4DDI, site and MLA. Report submitted to MLA to include:

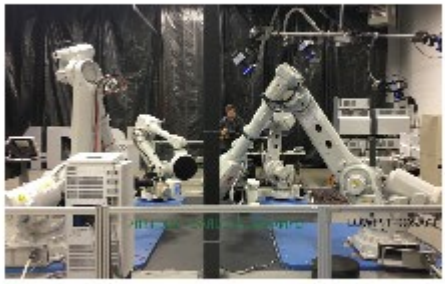
- System attributes employment
- Trial site location and suitability
- Detailed installation plan

Go/NoGo decision

6. Calibration and dedicated MLA software tuning testing facility



7. Panel testing completion with meat product



8. Multi-robot testing completion for meatpacking quality control-system ready

Figure 7: Preliminary scanning and system evaluation

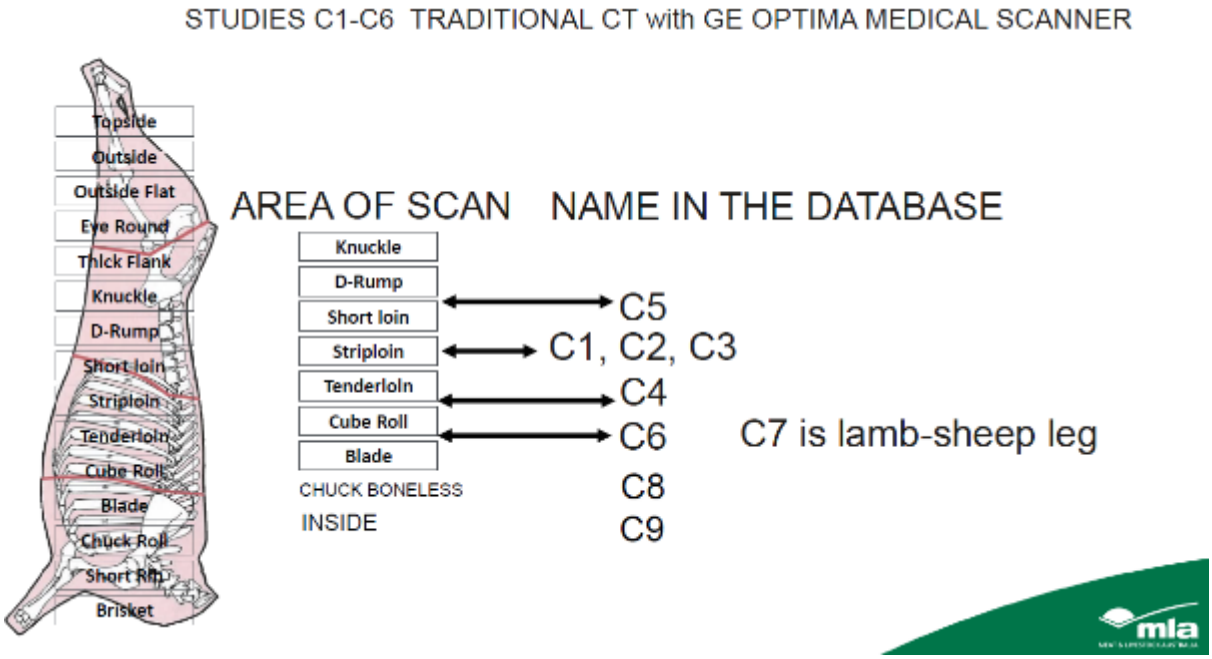


Figure 8: Identification and abbreviation of carcase primals

C1

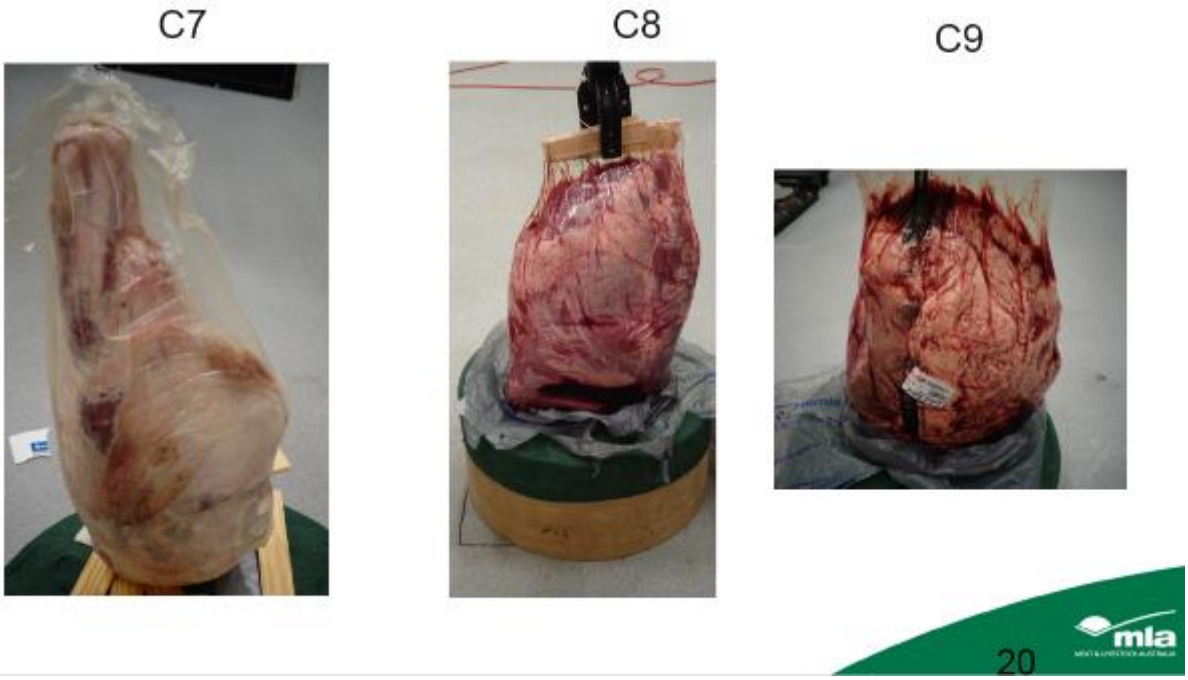
C2

C3

C4

C5

C6

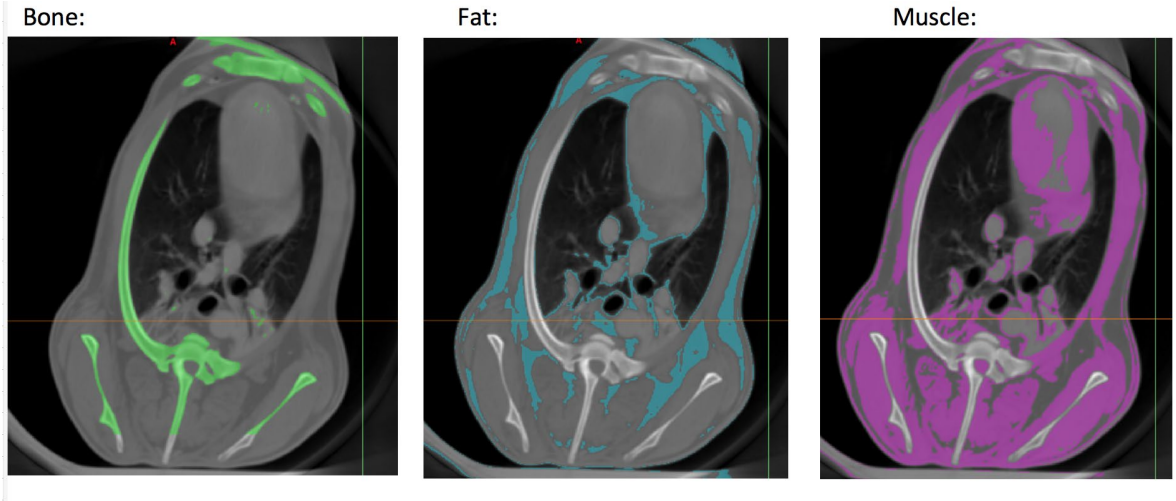


Medical CT imaging as a baseline.

Figure 9: Images from 4DDI testing against Medical CT baseline

4. Results

4.1 Sample Cone Beam Imaging



Carcase composition and tissue discrimination: bone, muscle, fat.

Comparison of medical CT and cone beam scanning.

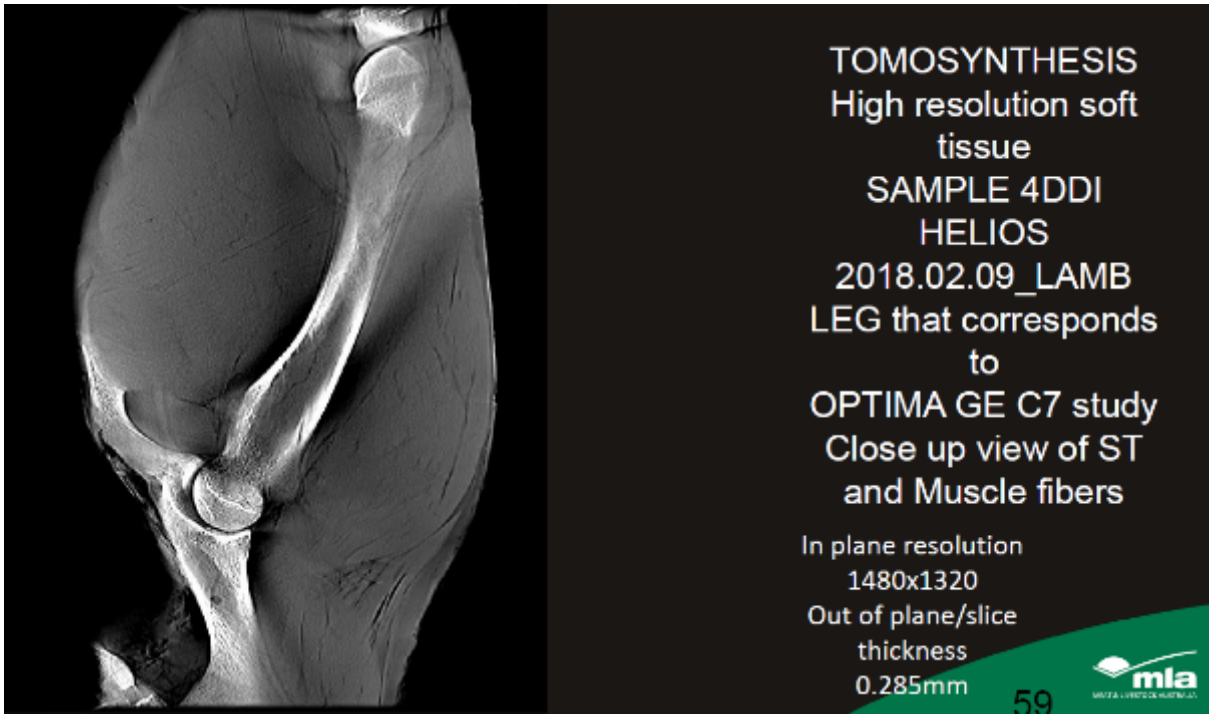


Figure 10: Example of high resolution cone beam scanning.

4.2 Initial assessment of the image quality from the 4DDI Helios CT scanner

ALMTech Report: 4DDI headquarters were attended and participation in the collection of a series of CT scans using their prototype Helios CT scanner. A variety of tissue types were scanned using the Helios scanner and then repeat scanned using a standard medical imaging CT scanner (GE Optima).

To assess the image quality of the 4DDI Helios CT Scanner compared to the medical scanner, images from the beef striploin and lamb leg were selected as they provide diverse tissue mixtures of fat, lean, and bone in a combination of industry relevant cuts.

Within the striploin the 4DDI Helios Scanner provided good visual differentiation of tissues within greyscale images. However, when simple thresholds were applied the differentiation of pixel values across the image delineated no clear pattern according to anatomical locations of fat and lean depots, and at times poorly delineated bone from soft-tissue depots. The lamb leg images showed similar trends although in this case the greyscale images did not effectively differentiate fat from lean tissue. This suggests that future development work should be focused on ensuring adequate calibration of HU values across the entire image cross-section to ensure that they accurately reflect tissue densities.

4.3 Australian site visit and fact finding

Site visits and case studies:

- Case study #1: Beef Processing High Throughput (Teys/Cargill Lakes Creek Plant, Rockhampton)
- Case Study #2: Beef Pastoral Group and Feedlot Long Fed Wagyu (Australian Agricultural Company AACo, Newstead HO Brisbane)
- Case Study #3 – Feedlot Long Fed Angus and Wagyu (KerWee/Stockyard – Toowoomba QLD)
- Case Study #4 – Feedlot Short Fed High Capacity (Mort & Co, Dalby Grassdale QLD)
- Case Study #5 – Feedlot Long Fed Angus and Wagyu (Rangers Valley, Glen Innes NSW)
- Case Study #6 – Multi-species Beef/Sheep Processing plant High Throughput (JBS Brooklyn VIC)
- Case Study #7 – Multi-species Sheep/beef Processing plant (V&V Walsh Bunbury WA)
- Case University Linkages
    - University of Queensland UQ - Gatton Equine Facility
    - University of New England UNE – Armidale Campus
    - Murdoch University – Murdoch Campus

5. Conclusion

5.1 Key findings

The robotic x-ray cone beam system was found to have capability to objectively measure yield, eating quality, and health attributes accurately and potentially at acceptable speeds for beef induction. The system flexibility with physical layout, and sensing configuration was noted.

5.2 Benefits to industry

This novel technology platform has the potential to offer unique objective measurement benefits to red meat value chains.

6. Future research and recommendations

The finalisation of evaluation activities and Australian site demonstration to an industry steering group is recommended.