Final report

Cone Beam X-ray Carcase 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 aimed to take 4DDI's equine robotic CT scanner and modify it to be suitable for scanning carcase yield, eating quality, and health attributes on Australian beef sides and lamb carcases. The scanner was intended to be trialled at an Australian beef processing facility, and at an Australian lamb processing facility. 4DDI would report to MLA the success of the scans, and whether they can be paired with 2D DEXA and CT LMY and EQ OM results for both beef sides, and lamb carcases.

The completed work in USA 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 aimed to enhance the recently developed 4DDI equine robotic CT scanner to be suitable for scanning carcase yield, eating quality, and health attributes, on Australian beef sides and lamb carcases. The 4DDI system features a flexible configuration of two scanning robots which can be positioned in many ways; for example beside, or above and upside down, etc. The end-of-arm sensors can also be selected for specific tasks.

Applications may include beef or lamb carcase grading of marbling, or IMF, pre-chiller.

The scanner was anticipated in 2020 to be trialled at an Australian beef processing facility, and at an Australian lamb processing facility. 4DDI aimed to report on the success of the scans, and whether they can be paired with 2D DEXA and CT LMY and EQ OM results for both beef sides, and lamb carcases.

4DDI has developed an equine CT scanner, capable of CT scanning a horse's entire body while standing, or even in motion, using two or four robots capable of operating several panels, high-speed cameras, 3D surface scanners, and emitters in coordinated manoeuvres. Equimagine allows a detailed, digital scan from every angle of an area of concern.

MLA believed that this technology could complement pending 2D DEXA LMY installations. 2D DEXA units would therefore ascertain beef and lamb carcase overall yield composition and ribs locations for robotic cutting, and the 4DDI system for OM eating quality measurements.

With the ongoing installation of 2D carcase DEXA units Australia wide there was an opportunity to progress the early development work in the area of Cone Beam – Flat Panel CT. Preliminary investigations demonstrated that the hardware developed good images for marbling, however was too slow for whole of carcase use. Pairing a 2D DEXA with the 4DDI robotic CT system enables the Cone Beam – Flat Panel CT to be focused on the marbling area of a carcase only. This pairing may result in a 2D DEXA and CT LMY and EQ OM result for both beef and lamb carcases. The system, if

successful on carcases, will also be evaluated for livestock application in feedlots (beef and lamb) and in paddock.

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;
- Scan a number of beef sides at an Australian beef facility
- Scan a number of lamb carcases at an Australian lamb processing 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.

Significant impacts during the outbreak of COVID-19 in USA led to mutual agreement for work to be terminated prior to any Australian demonstration.

Benefits to industry

A flexible CT x-ray carcase imaging system, with capability to fit into plants with limited floorspace, yet be able to grade carcases for eating quality and health attributes pre-chiller would allow for sortation and process optimisation value gains.

Future research and recommendations

The system concept is still considered technically and commercially interesting. MLA would likely seek to continue evaluations as part of overarching objective measurements investment portfolio.

Figures shown on the ensuing page displays the completed work prior to termination.

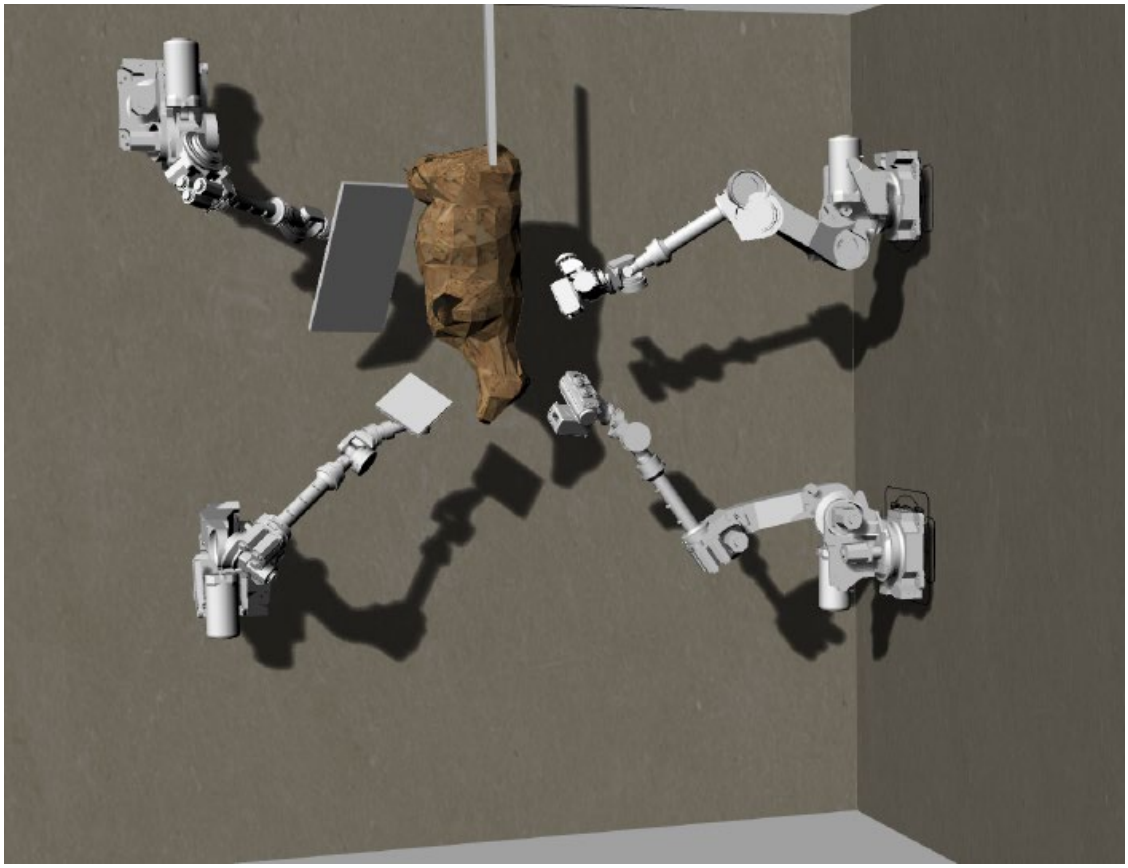


Figure 2: Initial concept of scanning beef carcases

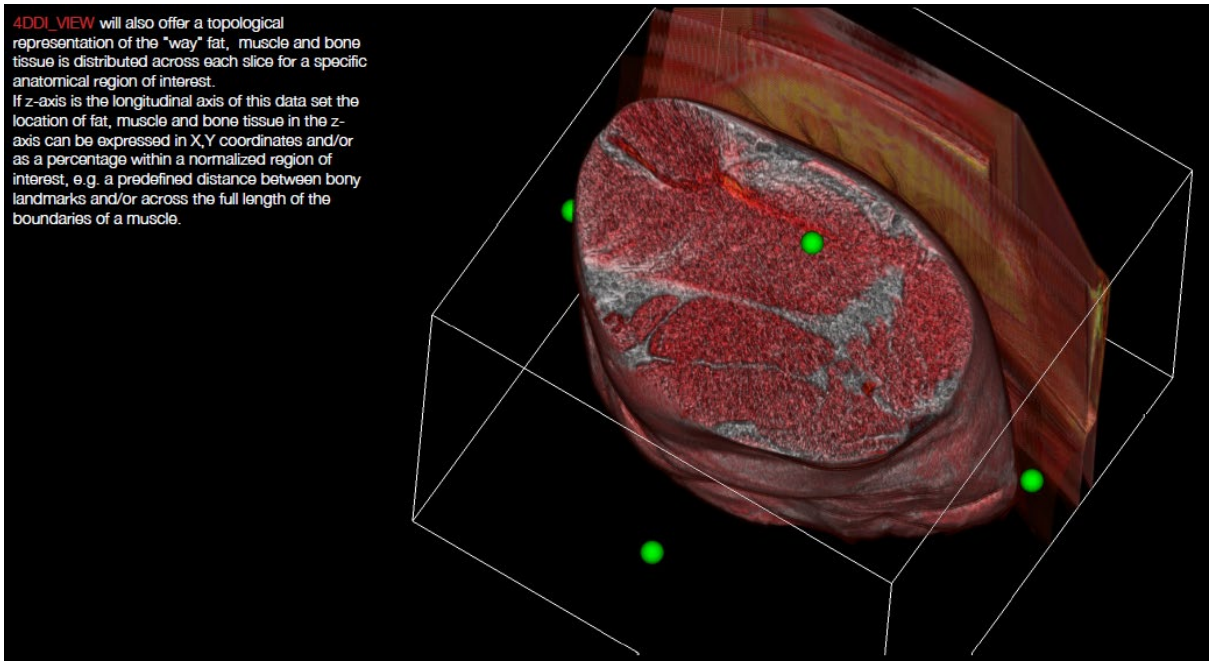


Figure 3: Example of cone beam tomographic reconstruction of rib area muscle.

Table of contents

List of Figures

1. Background

Global scanning of technology solutions potentially relevant to Australian red meat value chains gave rise to this evaluation program. This included leveraging opportunities from adjacent sectors such as scanning live horses and to determine predisposition for injury and changes in muscle composition following track work. The notion of better understanding live cattle or sheep and their pending quality for meat was therefore called out.

2. Methodology

2.1 Basic System and Evaluation

Below are illustrations of the planned approach.

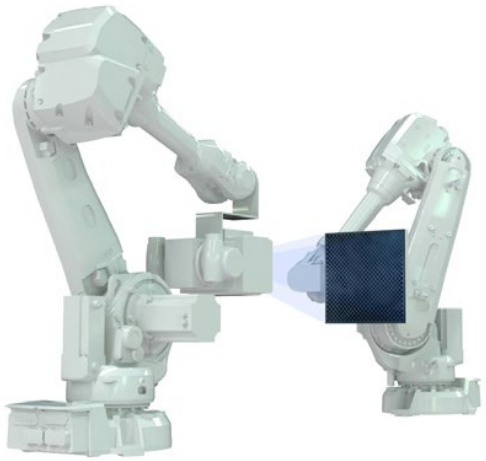


Figure 4: Basic configuration of robotic cone beam imaging with cone beam x-ray emitter and flat panel detector

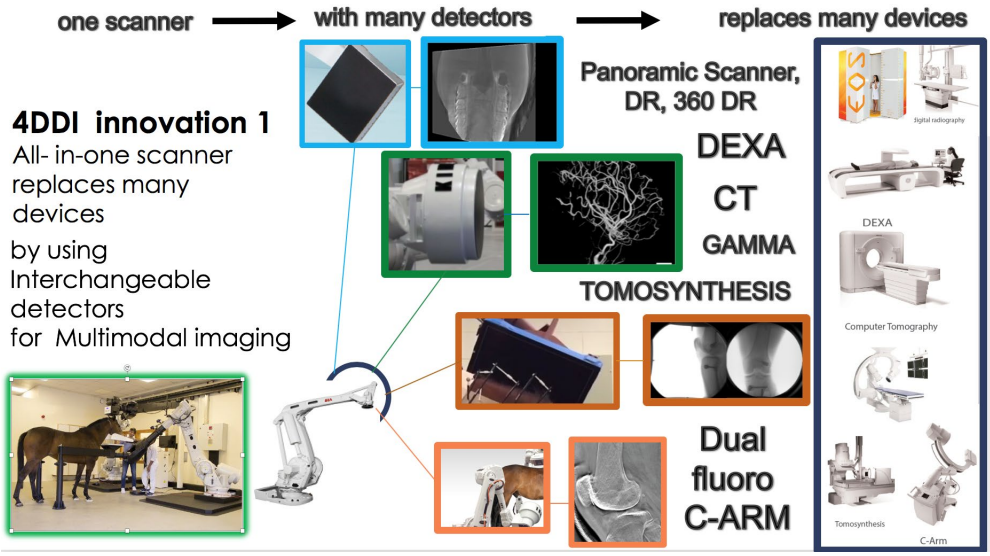


Figure 5: Summary of proposed system flexibility with a variety of customised end-of-arm sensing

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

The following work-plan was set:

Milestone 1: Report detailing outcomes of measuring the following attributes

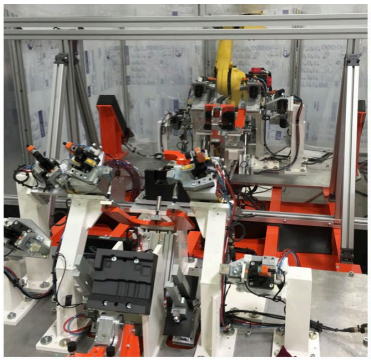
- A box/carton of approx. 90CL trim
- A box/carton of approx. 60CL trim
- A butt cut such as a **Rostbif**
- A chine bone in **Rib Roast** (with some level of marbling)
- A **striploin**, with chine bone and other bones still attached (with some level of marbling).
- Chuck, bone in

Go/NoGo decision: Assessment on system capabilities and whether to continue.

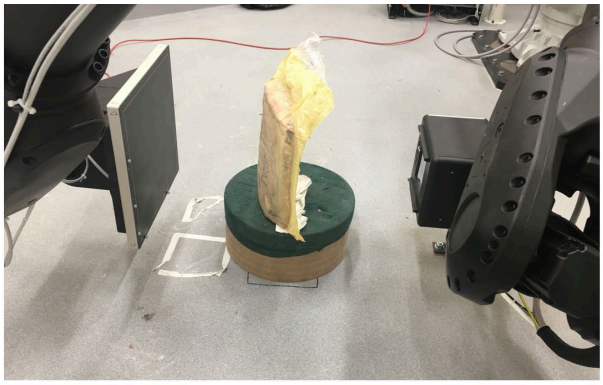
Milestone 2: System employment with special attributes for installation in 1 x Australian beef and 1 x Australian lamb plant. 4DDI to investigate the site to determine suitability. Installation location to be agreed with 4DDI, site and MLA. Report submitted to MLA to include:

- System attributes employment
- Trial site locations (x2) and suitability
- Detailed installation plan.

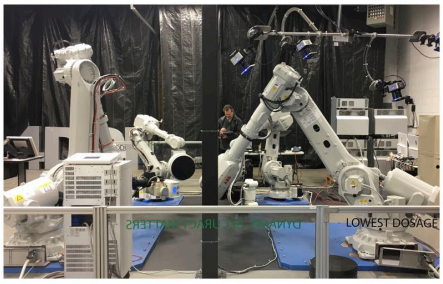
Go/NoGo decision: Assessment on system capabilities and whether to continue.



6. Calibration and dedicated MLA software tuning testing facility



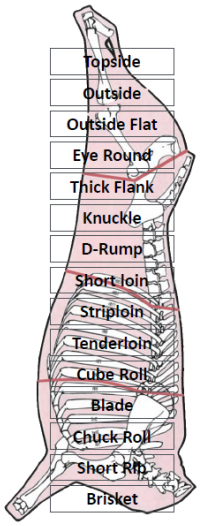
7. Panel testing completion with meat product



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

Figure 6: Preliminary scanning and system evaluation

STUDIES C1-C6 TRADITIONAL CT with GE OPTIMA MEDICAL SCANNER

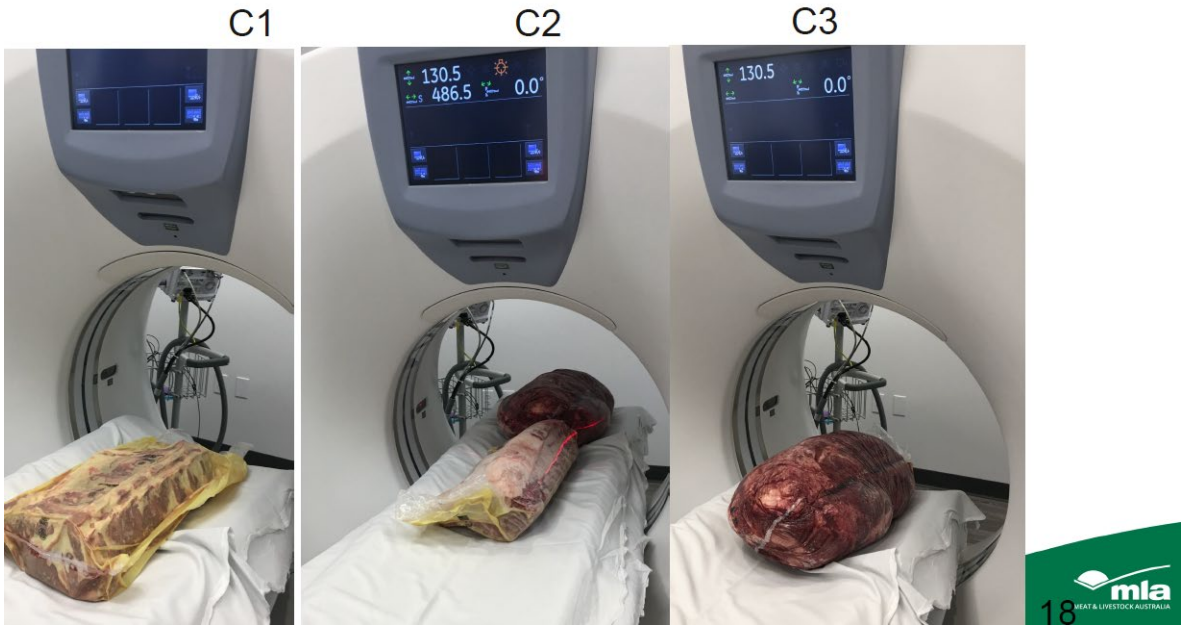


AREA OF SCAN NAME IN THE DATABASE

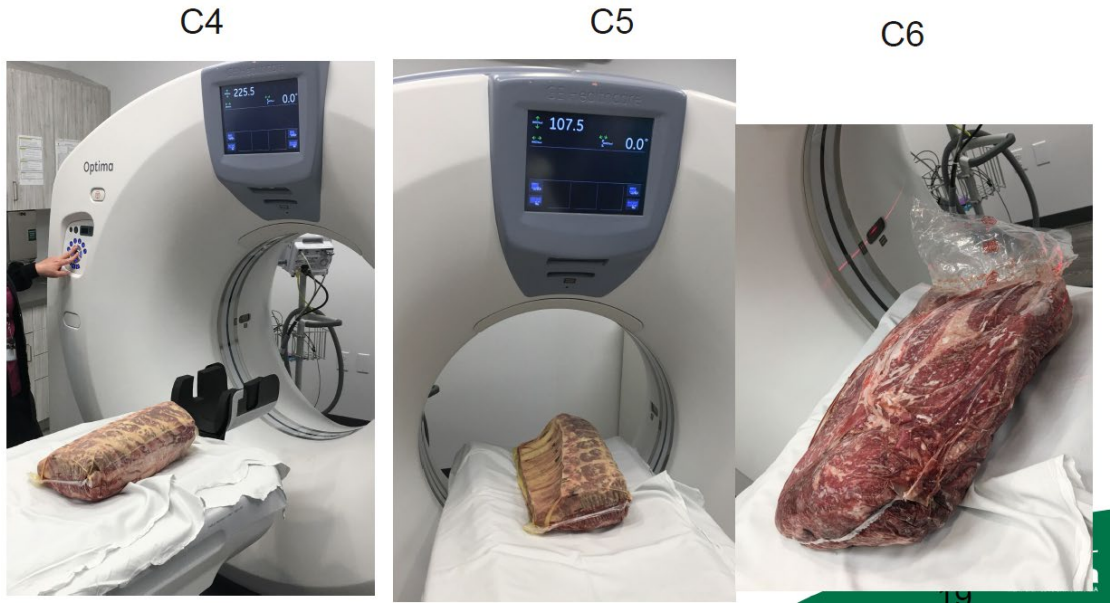
AREA OF SCAN	NAME IN THE DATABASE
Knuckle	C5
D-Rump	
Short loin	
Striploin	C1, C2, C3
Tenderloin	C4
Cube Roll	C6
Blade	
CHUCK BONELESS	C8
INSIDE	C9

C7 is lamb-sheep leg

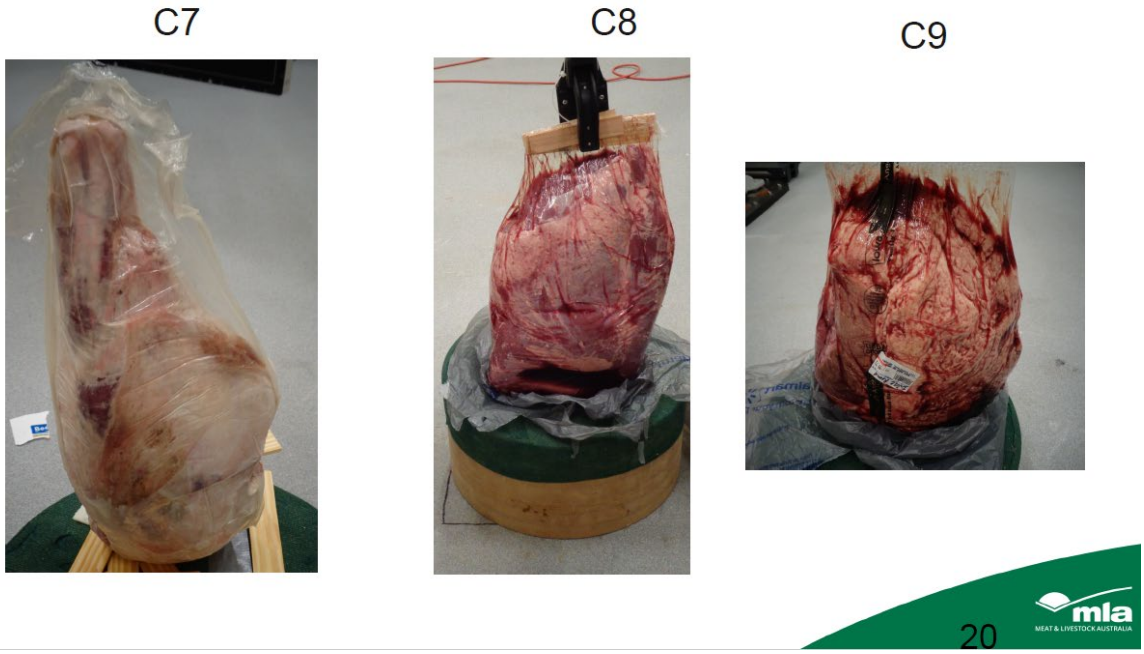
Collection of data.



Medical CT imaging as a baseline.



Medical CT imaging as a baseline.



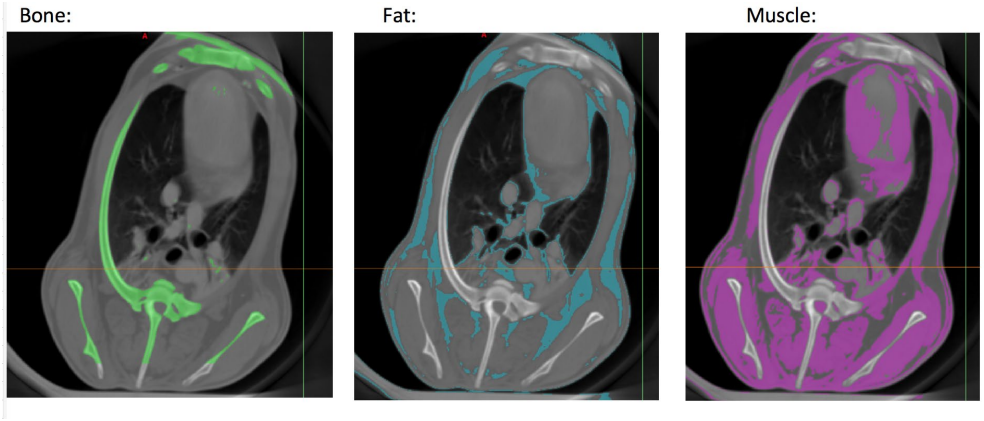
Medical CT imaging as a baseline.

Figure 7: Images from 4DDI testing against Medical CT baseline

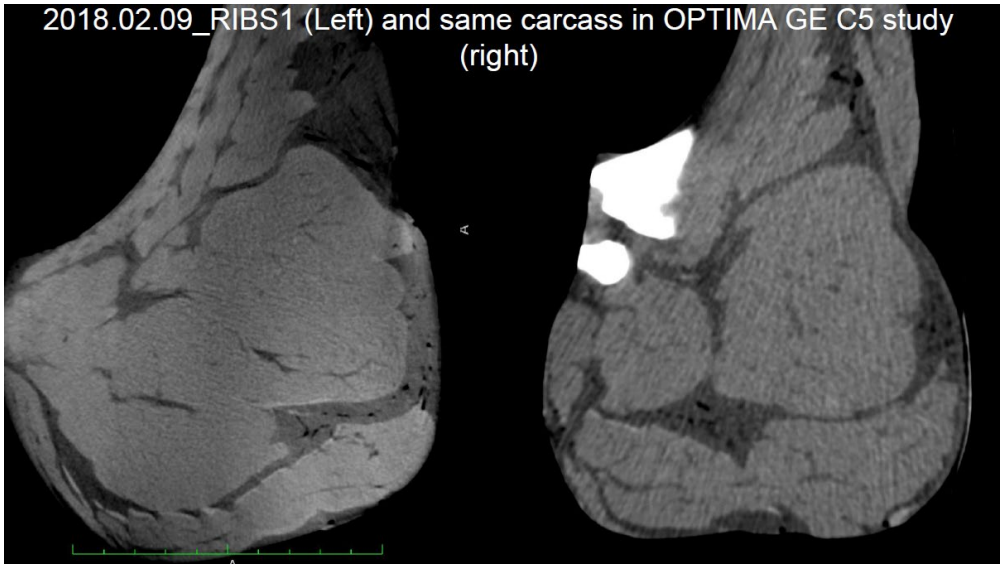
3. Results

3.1 Sample Cone Beam Imaging

On the ensuing pages are achieved imaging results respectively.



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



Comparison of medical CT and cone beam scanning.

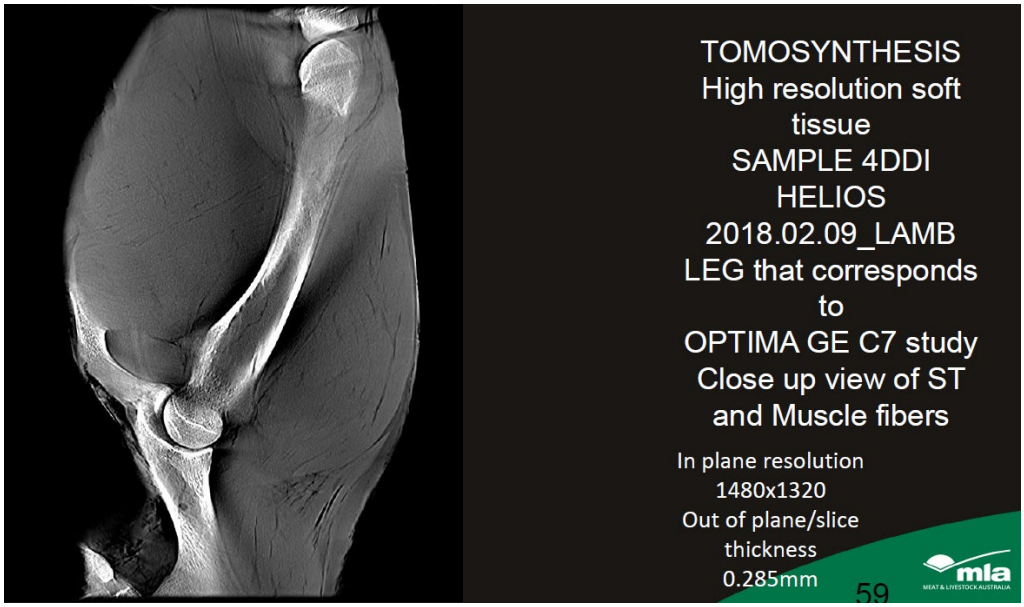


Figure 8: Example of high resolution cone beam scanning

3.2 Australian site visit and fact finding

Site visits and case studies that were provisionally planned by not actioned before project termination were:

- 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

4. Conclusion

4.1 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 line speeds for beef and potentially for lamb. The system flexibility with physical layout, and sensing configuration was noted.

4.2 Benefits to industry

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

5. Future research and recommendations

The finalisation of evaluation activities and Australian site demonstration to an industry steering group remains outstanding. Unfortunately due to COVID-19 impost in the USA, 4DDI and MLA mutually agreed to terminate the project in late 2020.