Australian Government
Department of Agriculture, Water and the Environment

# Rural R&D for Profit Program

## Advanced Livestock Measurement Technologies for Globally Competitive Australian Meat Value Chains (ALMTech)

## Final Report

**Meat & Livestock Australia Limited**

Australian Meat Processor Corporation
Australian Pork Limited
Teys Australia
JBS Australia
Australian Country Choice
Australian Cattle and Beef Holdings Pty Ltd

**June 2016 – July 2020**

# Contents

# Executive summary

## Objectives

Accurate, objective measurements of meat quality and quantity will enhance the beef, lamb and pork industries' ability to respond to market demands, while minimising value-chain wastage. In the Australian beef industry, wastage costs an estimated $130 million/year from producers supplying cattle not meeting customer requirements, with similar inefficiencies in lamb and pork. This lack of objective measurements and feedback impedes transparency of trading and erodes trust across the livestock value chain. Therefore, the project rationale was to realise significant productivity and profitability improvements for primary producers, via the following objectives:

- Provide beef, lamb and pork producers with access to more accurate descriptions of the attributes that influence the value of their livestock: carcase lean meat yield (LMY), eating quality (EQ), and compliance to market specifications; delivered via advanced measurement technologies, in synergy with abattoir automation where appropriate;
- Develop an early-stage equipment prototype to objectively determine offal condemnation;
- Enhance feedback systems to provide producers with new information to improve decisions on breeding and compliance to market specifications;
- Deliver new tools and data to processors to improve processing efficiency, optimise capacity to allocate product to the most valuable market-endpoint, and provide feedback to producers to increase genetic gain and improve livestock management;
- Capitalise on the co-operation of industry stakeholders to maximise effective decision making, reduce risk and optimise profit for all partners; and
- Develop and improve these technologies and systems to increase competitiveness and profitability in Australian meat value chains.

## Methodology

The project prioritised development of new technologies for measuring LMY and EQ. These technologies needed to be able to be deployed pre- or post-chill, be robust, and capable of operating at the fastest chain-speeds. On-farm, cost of using new technology becomes crucial given that farms generally will not achieve the same "economies of scale". To increase adoption, the project incorporated several strategies to enhance the integration of the new technologies into industry:

- We collaborated with supply chains, resulting in the direct implementation of technologies at completion of the experimental work, Dual Energy X-Ray Absorptiometry (DEXA) being a key case-in-point.
- We integrated the resulting data flow into existing industry data platforms and feedback systems, including MLA's Livestock Data Link (LDL), as well as other proprietary feedback systems. This included linkage to genetic databases and the development of new and enhanced genetic tools stemming from the new measurements.
- We developed "data-to-decision" packages to help industry use the new technologies.
- Also, to facilitate the compatibility of technologies to existing infrastructure, we focused on automation, given the potential dual roles for many of the sensing technologies.

## Scientific & Industry Outcomes

- The estimated Net Present Value (NPV) for the beef industry scenarios (prior to accounting for R&D costs) is $316 million; the NPV for the sheep meat industry scenarios is $145 million; and the NPV for the pork industry scenarios is $49 million. Aggregating the Return On Investment (ROI) measures across the three industries gives an estimated NPV, projected to 2040, of $510 million. Adjusting R&D costs to real 2020 values and summing across the three industries generates a discounted cost aggregate of $127 million. So the overall OM theme of work has resulted in a discounted net benefit of $383 million with an estimated Benefit Cost Ratio (BCR) of 4:1. For the combined industries scenario, livestock producers were estimated to receive about 40%, domestic and overseas consumers about 50%, and all input suppliers together (processors, feedlotters, retailers and exporters) receiving less than 10%.
- The project developed direct and indirect measurement technologies for LMY of live animals and their carcases.
  - On farm, these included 3D imaging cameras for cattle, and microwave back-fat scanners for cattle and sheep.
  - In abattoirs, DEXA imaging systems were installed and calibrated in three lamb abattoirs, with plans for installation at two more plants underway. A DEXA system was installed in a commercial beef abattoir, with early results demonstrating robust translation into this environment.

    - Indirect technologies were developed in abattoirs, including a 3D imaging camera for beef, a microwave fat-depth scanner for lamb and beef, and the PorkScan Mk2 system.
- The project developed a suite of technologies for predicting EQ traits in beef and lamb carcases, including loin eye cameras requiring a cut surface, and probe and X-ray technologies that do not require a cut surface.
    - The probe technologies included two inter-muscular needle–probe designs using differing applications of spectral imaging to measure hot or cold carcase intramuscular fat (IMF)% in both lamb and beef.
    - Four loin-eye cut surface technologies were investigated: Frontmatec, E+V, Meat Imaging Japan and TenderSpec. The E+V camera was successfully installed, and AUS-MEAT accredited, in one beef abattoir. The Frontmatec beef hyperspectral camera has been successfully calibrated, progressed to manufacture, and is due for Meat Standards Australia (MSA) and AUS-MEAT accreditation and full commercialisation in 2021.
    - In lamb and beef, the potential of DEXA and Computed Tomography (CT) technology to predict EQ including IMF% has been demonstrated.
- To deliver an early-stage prototype of objective measurement equipment for offal condemnation, equipment tested included the Rapiscan Dual View multi-energy X-ray absorptiometer augmented with hyperspectral imaging, the 4DDI robotic CT scanner, and the Rapiscan RTT110 CT scanner.
- The newly available data from technologies have been used to provide new and enhanced genetic tools to select for LMY and EQ on-farm, ensuring compatibility with the MSA EQ prediction system.
- The Beef Value Calculator, Lamb Value Calculator, and Optimiser were developed to enable processors to define the true value of carcases, and to optimise market-specific carcase use, based upon predicted cut weights prior to carcase fabrication.
- ALMTech worked closely with supply chain partners to ensure the flow of data from new measurement technologies into MLA's LDL online feedback system, and other proprietary systems owned by individual processors.
- The Industry Calibration Working Group (ICWG) produced a dynamic document known as the ICWG Traits Manual to record trait definitions, and the methods and technologies for their measurement. A major achievement was the development of new accuracy standards, endorsed by the Australian Meat Industry Language & Standards committee, for AUS-MEAT accreditation of cut surface cameras.
- Key collaborators included 22 Australian industry bodies, including our investing partners Teys Australia, JBS Australia, Australian Country Choice and Australian Cattle and Beef Holdings, plus 18 Australian research provider organisations. We also collaborated with 10 international technology providers and research organisations.
- ALMTech established a new network of scientists from universities and research institutes across Australia, and trained 13 early career scientists, 7 PhD students, 6 Masters students, and 1 Honours student. The ALMTech team have submitted 24 papers for publication in peer-reviewed international journals and 41 peer-reviewed conference papers.

## Conclusions & Recommendations

The ALMTech project has generated discounted NPV of $383 million and an estimated BCR of 4:1. In the immediate future, industry will require continued support to adopt and make best use of the new measurement technologies, and for ongoing auditing and calibration testing. Furthermore, the coordination of calibration/validation testing across common groups of genetically defined animals enables transparent comparison between technologies, and the seamless integration of their measurements into new or enhanced genetic tools. While meeting these needs is a central goal of ALMTech II, industry should consider sustained support of these aspects beyond the ALMTech II project.

## Acknowledgements

ALMTech acknowledges collaboration and cash and/or in-kind support from: MLA; AMPC; APL; ACC; ACBH; Teys; JBS; TFI; GMP; Frewstal; WAMMCO; NCMC; Bindaree; Prestige Foods; Harvey Beef; John Dee; Woolworths; Angus Australia; Herefords Australia; ALFA; ALC; ABBA; ISC; LDL; AUS-MEAT; MSA; AMILSC; MEQ; Murdoch University; UNE; AGBU; UAdel; UTS; DPI NSW; AgBiz Solutions; SunPork; PorkScan; UMelb; USyd; DJPR; DPIRD; SARDI; Health 4 Wealth; Sheep CRC; Sheep Genetics; EAS; Frontmatec; TenderSpec; E+V; Rapiscan; 4DDI; SOMA Optics; MIJ; Obihiro University; NH Foods; AgResearch; SAR; Meat Technology Ireland; Santa Gertrudis Australia; Droughtmaster Stud Breeders' Society.

# Abbreviations

| Acronym | Description |
|---|---|
| AAAS | Australian Association of Animal Sciences |
| ACBH | Australian Cattle and Beef Holdings Pty Ltd |
| ACC | Australian Country Choice |
| AGBU | Animal Genetics and Breeding Unit |
| ALC | Australian Lamb Company |
| AMILSC | Australian Meat Industry Language and Standards Committee |
| AMPC | Australian Meat Processor Corporation Ltd |
| APL | Australian Pork Limited |
| BCR | Benefit Cost Ratio |
| BIN | Beef Information Nucleus |
| CRC | Co-operative Research Centre |
| CT | Computed Tomography |
| DPIRD | Department of Primary Industries and Regional Development |
| DAWE | Department of Agriculture, Water and the Environment |
| DJPR | Department of Jobs, Precincts and Regions Victoria (previously DEDJTR) |
| DEXA | Dual Energy X-Ray Absorptiometry |
| DPI NSW | Department of Primary Industry NSW |
| EC | Executive Committee |
| EMA | Eye Muscle Area |
| EQ | Eating Quality |
| ICWG | ALMTech Industry Calibration Working Group |
| IMF | Intra-Muscular Fat |
| IP | Intellectual Property |
| ISC | Integrity Systems Company |
| HSI | Hyper Spectral Imaging |
| KPI | Key Performance Indicator |
| LDL | Livestock Data Link |
| LMY | Lean Meat Yield |
| MDC | MLA Donor Company |
| MINTRAC | National Meat Industry Training Advisory Council |
| MLA | Meat & Livestock Australia |
| MSA | Meat Standards Australia |
| MU | Murdoch University |
| NCMC | Northern Cooperative Meat Company |
| NIR | Near-infrared |
| NPV | Net Present Value |
| OM | Objective Measurement |
| pHu | Ultimate pH |
| PRIPCC | Progress Review and Intellectual Property and Commercialisation Committee |
| R&D | Research and Development |
| ROI | Return On Investment |
| SARDI | South Australian Research and Development Institute |
| SC | Steering Committee |
| SAR | Scott Automation and Robotics |

| | |
|---|---|
| UAdel | University of Adelaide |
| UMelb | University of Melbourne |
| UTS | University of Technology Sydney |
| WAMMCO | Western Australian Meat Marketing Co-operative Limited |
| WTP | Willingness To Pay |

# 1 Project rationale & objectives

Historically, lean meat yield (LMY) and eating quality (EQ) have been difficult traits to measure in the beef, pork, and lamb industries (Bonny et al., 2016; Williams, Anderson, et al., 2017; Williams, Jose, et al., 2017). LMY is commonly estimated from rudimentary tissue depth measures in beef and lamb, while the pig industry enhances this with the use of an ultrasound measure of carcase fatness. For eating quality, neither lamb nor pork has measures that can differentiate carcases, while the internationally acclaimed Meat Standards Australia (MSA) system for predicting EQ in beef relies on visual grading (Polkinghorne, 2008), rather than objective measures to predict this trait. Accurate measurements of LMY and EQ enable the industry to be responsive to market demands, while minimising value-chain wastage. In the Australian beef industry, wastage costs an estimated $130 million/year from producers supplying cattle not meeting customer requirements, with similar inefficiencies in the lamb and pork industries. In addition to the cost of wastage, the lack of measurements and feedback impedes transparency of trading, thus eroding trust across the livestock value chain.

Therefore, the project rationale was to realise significant productivity and profitability improvements for primary producers, via the following objectives:

**Generating knowledge, technologies, products or processes that benefit primary producers**

- The project was undertaken to enable beef, sheep and pig producers to access more accurate descriptions of the key attributes that influence the value of their livestock: carcase LMY, EQ, and compliance to market specifications.
- This was delivered through advanced measurement technologies, in synergy with abattoir automation where appropriate.
- The project also aimed to develop an early-stage prototype of objective measurement equipment for offal condemnation.

**Strengthening pathways to extend the results of rural R&D, including understanding the barriers to adoption**

- Enhanced feedback systems provide producers with new information to improve decisions on breeding and management to improve compliance to market specifications.
- Value-chain partners were delivered new tools and data which can be used by producers to improve the rate of genetic gain, and by processors to enhance processing efficiency, and their capacity to allocate product to the most valuable market end point, thereby increasing the wealth of the value-chain participants.

**Establishing and fostering industry and research collaborations that form the basis for ongoing innovation and growth of Australian agriculture**

- The project capitalised on the cooperation of industry stakeholders to maximise effective decision making, reduce risk and optimise profit for all partners. Where-ever possible, the development and testing of technologies was integrated into the daily operations of producers and processors, enhancing the adoption of successfully developed technologies.
- Integrating experimental work directly into the commercial operations of producer and processor collaborators has significantly enhanced the capacity of industry to facilitate research. This has occurred through the expansion of the collaborative industry-researcher network, up-skilling of the industry professionals involved, and through clarifying the shared business-case of the research undertaken.
- Developing and improving these technologies and systems will increase competitiveness and profitability of the collaborating meat value chains.

# 2 Methodology

A key priority for the project was to develop new technologies that can measure traits linked to LMY and EQ. Within abattoirs, these technologies needed to be adaptable to pre- or post-chill deployment, robust in an abattoir environment, and capable of operating at the fastest chain-speeds. On-farm, similar considerations apply, yet in this case cost becomes more crucial given that farms generally cannot achieve the same “economies of scale” through-put available to abattoirs.

To increase the likelihood of adoption, the project incorporated a number of crucial strategies to enhance the integration of the new technologies into industry. Firstly, the R&D was undertaken in collaboration with supply chains, resulting in the direct implementation of technologies at completion of the experimental work – DEXA being a key case in point. Secondly, significant effort was devoted to integrating the resulting data flow into existing industry data platforms and feedback systems, including MLA’s own Livestock Data Link (LDL) feedback system as well as other company-owned proprietary feedback systems. This also included linkage to genetic databases and the development of new and enhanced genetic tools stemming from the new measurements, which are being delivered through the well-established BREEDPLAN and Sheep Genetics programs. Thirdly, significant effort was focused on developing “data-to-decision” packages that would help industry generate profit from the new measurements. Lastly, to facilitate the compatibility of technologies to existing infrastructure, some investment was focused on automation, given the potential dual roles for many of the sensing technologies.

This work was divided among a series of project sub-programs, described in Section 2.1 below, which also became a key part of our administrative structure, described in Section 2.3. Activities and outputs, described in Section 2.2 below, were assigned to each of these sub-programs and formed the basis of the subsequent KPIs developed at the project Annual Review each financial year.

## 2.1 Programs

The project was organised into six programs and various sub-programs, as follows:

- **Program Executive**
  - **Sub-program E.1:** Project planning and management
  - **Sub-program E.2:** Communication and extension activities
  - **Sub-program E.3:** Industry liaison and value estimation
  - **Sub-program E.4:** General management of technology calibration
- **Program 1:** Development of lean meat yield (LMY) technology
  - **Sub-program 1.1:** Design prototype technology for the direct and indirect measurement of LMY on-farm, and establish the business case for its measurement
  - **Sub-program 1.2:** Design prototype technology for the direct measurement of LMY in an abattoir
  - **Sub-program 1.3:** Design prototype technology for the indirect measurement of LMY in an abattoir
- **Program 2:** Development of eating quality (EQ) measurement technology
  - **Sub-program 2.1:** Near infra-red/Boar taint
  - **Sub-program 2.2:** Imaging cut surface
  - **Sub-program 2.3:** Blue sky technologies
- **Program 3:** Development of robotic technology

- **Sub-program 3.1:** Development of an automation prototype for beef

- **Program 4:** Industry databases
  - **Sub-program 4.1:** Data flow to industry information delivery systems
  - **Sub-program 4.2:** Data flow to industry genetic evaluation systems

- **Program 5:** Data decision systems
  - **Sub-program 5.1:** Carcase value tools
  - **Sub-program 5.2:** Data decision tools
  - **Sub-program 5.3:** Supply chain engagement

## 2.2 Activities & outputs

The project spanned nine key activities and various outputs, as follows:

- **Activity B1:** Project initiation
  - **Output l(a):** Engage a project manager for the duration of the Activity.
  - **Output l(b):** Establish a project Steering Committee responsible for oversight of the Activity. The project Steering Committee will agree its terms of reference which will set out its membership, governance arrangements and responsibilities.
  - **Output l(c):** Execute agreements with partner organisations.
  - **Output l(d):** Agreement on the yearly breakdown of the cash and in-kind contributions to be provided by partner organisations for the duration of the Activity.

- **Activity B2:** Project planning and management
  - **Output 2(a):** Prepare a project plan, setting out the schedule for activities, and the human resources and financial resources required. Prepare a risk management plan as part of the project management plan.
  - **Output 2(b):** Prepare a communication and extension plan, setting out the schedule for communication and extension activities, and the human resources and financial resources required.
  - **Output 2(c):** Prepare a monitoring and evaluation plan, setting out timeframes for activities to be delivered, and the human resources and financial resources required.
  - **Output 2(d):** Provide a progress report on the evaluation of the project, delivered at the mid-point of the project.

- **Activity B3:** Communication and extension activities
  - **Output 3(a):** Identify target audiences and establish appropriate contacts and communication channels. This will include: primary producers involved in beef, sheep and pork production; processors; state departments of primary industries; value chain service providers; the media; and the general public, particularly those living in rural areas.
  - **Output 3(b):** Implement a communication and extension plan and promote project activities and outcomes at regional and national conferences, workshops and seminars relevant to the beef, sheep and pork industries, the broader farming community, external partner organisations and the wider community.
  - **Output 3(c):** Publish research findings. Research findings will be published, as appropriate, in peer- reviewed international scientific journals, conference papers, industry publications, RDC publications, industry partners' communications, and websites, in a form accessible to producers and value-chain stakeholders. MLA will publish a publicly available report for each contracted sub-project and a detailed Final Report on behalf of project partners.

- **Activity B4:** Industry liaison and value estimation

- **Output 4(a):** Establish a framework for estimating value of the project to beef, lamb, and pork industries.
- **Output 4(b):** Initiate planning for data capture in consultation with the managers of existing industry data platforms where carcase measurement data from this project will be used.
- **Output 4(c):** Consult with processors to establish initial estimates of the value of the project to the beef, lamb, and pork industries.
- **Output 4(d):** Generate draft estimates of the value of the project to the beef, lamb, and pork industries.
- **Output 4(e):** Generate final estimates of the value of the project to the beef, lamb, and pork industries.

- **Activity B5:** Information systems development and application
  - **Output 5(a):** Secure participation of relevant businesses in an analysis of current meat measurement, sorting and payment systems with the aim of developing methodologies and data standards to enable integration with commercial and proprietary industry systems.
  - **Output 5(b):** Work with relevant businesses, design and develop algorithms to integrate with information systems to link LMY and EQ data with prototype business payment systems.
  - **Output 5(c):** Work with relevant businesses, design and develop information systems for improved sorting and management of raw materials on the basis of LMY and EQ to meet customer specifications.
  - **Output 5(d):** Work with relevant meat processors to model the impact within their supply chains of prototype value-based payment options (5(b)) and prototype systems for the sorting and management of raw materials (5(c)).
  - **Output 5(e):** Work with relevant meat processors to develop and deliver enhanced feedback to producers on compliance to specifications and carcase value.

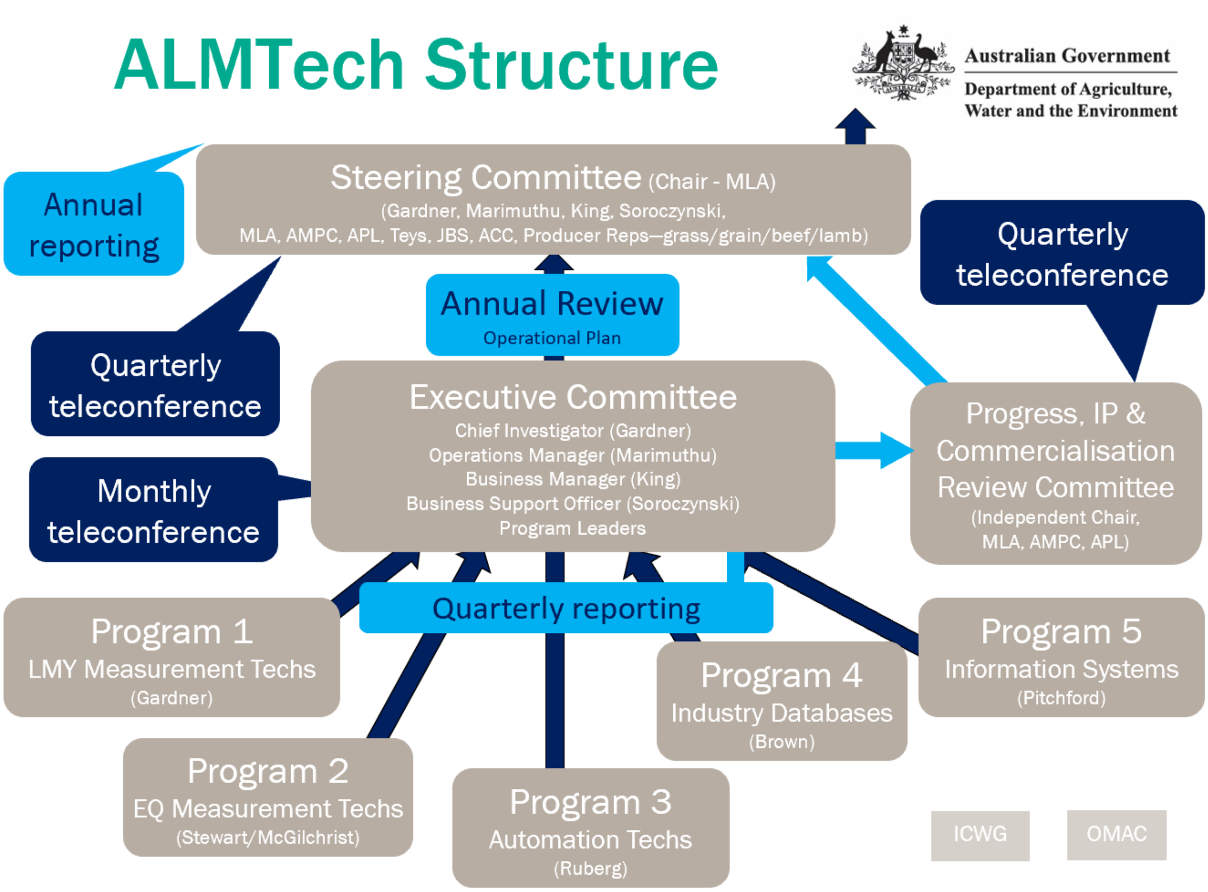
- **Activity B6:** Development of lean meat yield (LMY) technology
  - **Output 6(a):** Establish the business case for measuring LMY on farm, both within feedlots and the seed-stock sector. This output provides a 'Go/ No Go' decision point for Outputs 6(c) and 6(d), and subsequently 6(i) and 6(j).
  - **Output 6(b):** Identify the traits that require calibration for the measurement technologies.
  - **Output 6(c):** Design prototype technology for the direct measurement of LMY on-farm.
  - **Output 6(d):** Design prototype technology for the indirect measurement of LMY on-farm.
  - **Output 6(e):** Design prototype technology for the direct measurement of LMY in an abattoir.
  - **Output 6(f):** Design prototype technology for the indirect measurement of LMY in an abattoir.
  - **Output 6(g):** Test and calibrate prototype technology for the direct measurement of LMY in two abattoirs.
  - **Output 6(h):** Test and calibrate prototype technology for the indirect measurement of LMY in two abattoirs.
  - **Output 6(i):** Subject to viability, pilot and calibrate prototype technology for the direct measurement of LMY with two collaborating seed-stock producers.
  - **Output 6(j):** Subject to viability, pilot and calibrate prototype technology for the indirect measurement of LMY with two collaborating feedlots.
  - **Output 6(k):** Subject to viability, install prototype technology for the direct measurement of LMY in two abattoirs.
  - **Output 6(l):** Subject to viability, install prototype technology for indirect

measurement of LMY in two abattoirs.

- **Activity B7:** Development of eating quality (EQ) measurement technology
  - **Output 7(a):** Identify the traits that require calibration for the EQ measurement technologies.
  - **Output 7(b):** Design prototype technology for the measurement of EQ to be undertaken in the laboratory.
  - **Output 7(c):** Test and calibrate selected prototype technology for the measurement of EQ in two abattoirs.
  - **Output 7(d):** Subject to viability, install selected commercial prototype in two abattoirs.
- **Activity B8:** Development of robotic technology
  - **Output 8(a):** Design and develop early-stage prototype robotic technology for the objective assessment of offal or carcase down-grading, or condemnation.
  - **Output 8(b):** Test and calibrate robotic technology for the objective assessment of offal or carcase down-grading, or condemnation.
- **Activity B9:** Data flow to industry databases
  - **Output 9(a):** Enable data flow to industry information delivery systems.
  - **Output 9(b):** Enable data flow to industry genetic evaluation systems.

## 2.3 Administrative structure

The project was managed, monitored and evaluated via the following administrative structure, at six levels:




1. The **Executive Committee**, comprising of the Program Leaders and chaired by ALMTech Chief Investigator, A/Prof. Graham Gardner (Murdoch University), who met monthly to discuss the progress of each program and general project operational matters, alongside the development of newsletters, extension activities, publications, quarterly reports (for the PRIPCC and the Steering Committee) and milestone reports (for DAWE).
2. The **Progress Review and Intellectual Property and Commercialisation Committee (PRIPCC)**, consisting of independent members Professor Alan Bell (committee chair) and Professor John Thompson, along with representatives from MLA, AMPC, and APL. This group of technical experts met quarterly to provide feedback to the Steering Committee and the Executive Committee regarding the progress of each program, as documented in the quarterly and milestone reports.
3. The **Steering Committee**, chaired by Richard Apps (MLA), including representatives from all key stakeholders as well as three independent producers, who met quarterly to provide broad scrutiny of the project delivery and direction, as documented in the quarterly and milestone reports. The inclusion of both livestock producer and processor representatives provided oversight and guidance on priorities along the value chain.
4. The **Industry Calibration Working Group (ICWG)**, chaired by A/Prof. Graham Gardner (Murdoch University) met as required to develop trait and calibration standards associated with the new technologies, and to document these in a dynamic report known as the 'ICWG Traits Manual', to provide technical recommendations to industry.

5. The **Objective Measurement, Adoption and Commercialisation (OMAC)** committee, an initiative of MLA (outside of ALMTech), supporting the broader area of objective carcase measurement, in which ALMTech was a key project. A/Prof. Graham Gardner is scientific advisor to OMAC, while Richard Apps is an OMAC committee member. The ICWG makes recommendations to the OMAC committee and, in turn, responds to OMAC queries. For example, the ICWG proposed accuracy standards for the carcase quality grading cameras that were being developed via ALMTech, OMAC then endorsed those recommendations and they were presented to the Australian Meat Industry Language and Standards Committee (AMILSC) where they were endorsed and subsequently included in the AUS-MEAT language.
6. The **ALMTech Annual Review** was established to develop the ALMTech Annual Operational Plans. This three-day forum (held each April at Q Station in Manly NSW) convened all key stakeholders, the Executive Committee, the PRIPCC and the Steering Committee to review and critique the project's progress over the previous year against the designated KPIs, and to propose and refine work plans and budgets for the following financial year. In 2020, the ALMTech Annual Review was held as a virtual conference with speakers providing talks in MP4 format followed by interactive Zoom sessions.

## 2.4 Location of project activities

The location of project activities is listed as follows:

| Name & type of site | Postal Address | State | Postcode |
|---|---|---|---|
| Meat & Livestock Australia (Grantee) | PO Box 1961, North Sydney | NSW | 2059 |
| Murdoch University (project partner site, laboratory) | School of Veterinary and Biomedical Sciences, Murdoch | WA | 6150 |
| Australian Meat Processor Corporation (project partner site) | PO Box 6418, North Sydney | NSW | 2059 |
| Australian Pork Limited (project partner site) | PO Box 4746, Kingston | ACT | 2604 |
| PorkScan Pty Ltd (project partner site) | PO Box 4746, Kingston | ACT | 2604 |
| University of Adelaide (project partner and research site) | Roseworthy Campus, University of Adelaide, Roseworthy | SA | 5371 |
| JBS Australia (project partner site, field site) | PO Box 36, Altona North | VIC | 3025 |
| Teys Australia (project partner site, field site) | Building 3 Freeway Office Park, 2728 Logan Road, Eight Mile Plains | QLD | 4113 |
| South Australian Research and Development Institute (project partner site) | GPO Box 1671, Adelaide | SA | 5001 |
| DPI NSW (project partner site) | PO Box 865, Dubbo | NSW | 2830 |
| DJPR (project partner site) | 124 Chiltern Valley Rd, Rutherglen | VIC | 3685 |

| | | | |
|---|---|---|---|
| DPIRD (project partner site) | Baron-Hay Court, South Perth | WA | 6151 |
| University of New England (project partner site, laboratory) | Meat Science Building - W48, School of Environmental & Rural Science, University of New England, Armidale | NSW | 2351 |
| Animal Genetics and Breeding Unit (project partner site) | University of New England, Armidale | NSW | 2351 |
| University of Melbourne (project partner site) | Faculty of Veterinary and Agricultural Sciences, The University of Melbourne, Parkville | VIC | 3010 |
| University of Technology Sydney (project partner site) | PO Box 123, Broadway | NSW | 2007 |
| University of Sydney (project partner site) | Camperdown | NSW | 2006 |
| AgBiz Solutions (project partner) | 601 Wyn Wyn Road, Natimuk | VIC | 3409 |
| SunPork (project partner) | 1/6 Eagleview Place, Eagle Farm | QLD | 4009 |
| Frontmatec Group (project partner site) | Albuen 37, 6000, Kolding, Denmark | | |
| Scott Automation and Robotics (project partner site, laboratory) | Unit R / 10-16 South Street, Rydalmere | NSW | 2116 |
| Australian Country Choice (project partner site, field site) | 117 Colmslie Rd, Cannon Hill | QLD | 4170 |
| Northern Cooperative Meat Company (field site) | 10615 Summerland Way, Casino | NSW | 2470 |
| Gundagai Meat Processors (field site) | 2916 Gocup Road, South Gundagai | NSW | 2722 |
| Thomas Foods International (field site) | Level 2, 162 Fullarton Road, Rose Park | SA | 5067 |
| Frewstal (field site) | 46 Abattoir Road, Stawell | VIC | 3380 |
| WAMMCO (field site) | PO Box 703, Great Southern Highway, Katanning | WA | 6317 |
| Bindaree Food Group (field site) | PO Box 405, Inverell | NSW | 2360 |
| Prestige Foods (field site) | 221A Bay Street, Port Melbourne | VIC | 3207 |
| Harvey Beef (field site) | Lot 113 Seventh St, Harvey | WA | 6220 |
| John Dee (field site) | 97 Rosehill Rd, Warwick | QLD | 4370 |
| Woolworths (field site) | 1 Woolworths Way, Bella Vista | NSW | 2153 |
| NH Foods (field site) | Level 1, 107 Mount Street, North Sydney | NSW | 2060 |

# 3 Project outcomes

The Grant application for this project defined a series of scientific and industry outcomes. These are listed below, along with a brief statement defining our delivery against each of them. Detailed outcome reporting is contained in Appendix 7.8 (Technical Reports by Program).

The following reporting on project outcomes includes mention of ALMTech II. The spin-off project has been seamlessly underway since 1 July 2019. It spans three years, with its first year running concurrently with the final year of ALMTech I. While the inaugural project has generated enormous momentum in the objective measurement field and has delivered on its scientific and industry outcomes for the beef, pork and lamb industries, ALMTech II will go a step further in transforming the global competitiveness of Australia's meat value chains by developing and commercialising advanced measurement technologies and creating feedback and decision-making systems linked to accurate livestock and carcase measurement.

## 3.1 Scientific outcomes

(i) Develop at least **1 indirect and 1 direct measurement technology** for live animal LMY prediction using digital imaging and X-ray technologies.

This outcome has been delivered through the development of 3D imaging cameras, microwave back-fat scanners and a walk-through DEXA system for predicting lean meat yield in live cattle and sheep. The DEXA system was not pursued as the proposed commercialisation company felt that the commercialisation risk was too high. However, both the 3D imaging system in cattle and microwave fat depth scanner for cattle and sheep have been successfully developed and commercialisation options are being explored in ALMTech II. This outcome is detailed in “KPI 8.9 Sub-program 1.1 Summary Report” (Appendix 7.8).

(ii) Develop at least **2 direct measurement technologies** for LMY including X-ray, DEXA and regional line CT X-ray scanning. In beef, this will provide the capacity for directing future automated deboning.

This outcome has been delivered through the development of DEXA imaging systems for predicting carcase composition in both beef and lamb abattoirs. In lamb, this system has been installed and calibrated in three abattoirs, with two further installations contracted by MLA. In beef, a prototype DEXA system has been tested and demonstrated similar precision and accuracy to those of the lamb DEXA system. Subsequently, a DEXA system was installed in a commercial beef abattoir, and is part way through its calibration process, with early results demonstrating robust translation into this environment. Progress for DEXA systems is detailed in “KPI 8.10 Sub-program 1.2 Summary Report” (Appendix 7.8).

(iii) Develop at least **2 indirect measurement technologies** for LMY including ultrasound/digital imaging on a regional basis and hyperspectral imaging of a cut surface.

This outcome has been delivered through the development of a 3D imaging camera for beef, a microwave fat-depth scanner for lamb and a similar device for beef. Validation of these measurements has been demonstrated, and commercialisation options are being investigated in ALMTech II. In pork, considerable effort has been focused on the PorkScan Mk2 imaging system to predict lean meat yield and P2 fat depth. This device already has prototypes installed in commercial abattoirs that demonstrate adequate accuracy for these measurements. Progress for DEXA systems is detailed in “KPI 8.10 Sub-program 1.3 Summary Report” (Appendix 7.8).

(iv) Develop at least **2 direct measurement technologies** for factors impacting EQ (i.e. IMF, pH, colour) including NIR spectroscopy and hyperspectral imaging.

This outcome was focussed on developing a suite of technologies for predicting EQ traits (colour, pH, IMF%, marbling, ossification) in beef and lamb carcases. Technologies fell under three main areas: 1. Near infra-red (NIR) and invasive probes; 2. Cut surface camera devices; and, 3. DEXA, CT and other blue-sky technologies. There have been several key outcomes, including the calibration of two NIR probes for lamb and a spectral needle-probe for hot carcase IMF% measurement. Progress for NIR and other probes is detailed in "KPI 8.11 Sub-program 2.1 Summary Report" (Appendix 7.8).

For cut surface technologies, four grading camera technologies were investigated, including the Frontmatec camera, the E+V camera, the Meat Imaging Japan (MIJ) camera and the TenderSpec camera. The E+V grading camera has been successfully installed and AUS-MEAT accredited in one beef abattoir. The Frontmatec camera has progressed to commercial manufacture of a beef grading camera, given the successful calibration work conducted under ALMTech. The Frontmatec commercial grading camera is expected to be accredited for MSA and AUS-MEAT beef grading and fully commercialised in 2021. Progress for cut surface technologies is detailed in "KPI 8.11 Sub-program 2.2 Summary Report" (Appendix 7.8).

In lamb and beef, DEXA and CT technologies were used to predict EQ traits including IMF% and ossification score. Early calibration work demonstrated the potential of these technologies and future work will seek to expand on these early studies. Progress for DEXA and CT technologies is detailed in "KPI 8.11 Sub-program 2.3 Summary Report" (Appendix 7.8).

(v) Develop **an early-stage prototype** of objective measurement equipment for offal condemnation and other carcase defects. The prototype would provide key diagnostics prior to manufacture of the pre-commercial solutions for processors for individual carcase fabrication and marketing options.

Several technologies have been tested to deliver this outcome, each of these leveraging off MLA projects being run in parallel with the ALMTech project. These technologies include:

- Rapiscan Dual View multi-energy x-ray absorptiometry: This device features multi-energy x-ray to potentially better differentiate tissue structures, including diseases and defects, with two views (above and from the side), augmented with multi-spectral surface imaging. Its advanced software algorithms, with comprehensive vendor engineering support, are considered the most practical and suitable for assisted offal inspection from a system imaging capability, footprint, and cost effectiveness. The issue of compliance to food processing environment requirements, i.e. washdown, is a factor requiring consideration.
- 4DDI robotic cone beam computed tomography scanner: This device is capable of clear, high-resolution tissue differentiation and diagnosis of health conditions utilising a flexible variety of imaging modalities; however, the system footprint and capability is considered more suited to yield and eating quality related scanning of livestock in feedlots and carcases pre-chiller in plants, rather than application in offal scanning and sortation.
- Rapiscan RTT-110 computed tomography gantry-less scanner: This device is capable of continuous CT imaging featuring full three-dimensional imaging of structures to a resolution approaching medical CT. The instrument has a large footprint, and significant relative cost, but may be a contingent data capture platform should a simpler technology not be sufficiently capable.
- Scott Technology Magnetic Resonance Imager: MRI is potentially the most capable technology to image soft tissue structures to a required resolution. Also, the Scott

system, featuring high temperature super conductivity, is a significant innovation; however, the technology features significant temperature control infrastructure to support the high strength magnetic fields and has exclusion zone requirements considered impractical in a production environment.

- Medical computed tomography: This technology is considered the gold standard in periodic non-invasive inspection; however, these devices are limited in continuous operation duty cycle in production situations due to cathode overheating, are not washdown, have a large impractical footprint, and analysis algorithms are generally tightly protected by vendors with limited interest or ability for development and enhancement to required red meat industry requirements.

Progress across these systems is detailed in "KPI 8.12 Program 3 Summary Report" (Appendix 7.8).

(vi) Develop **algorithms** that translate the carcase/meat quality measurements into value-based pricing (a combination of LMY and EQ) up and down the supply-chain.

This has been delivered through a number of outputs. In Program 5, the Beef Value Calculator (BVC) has been developed and the Lamb Value Calculator (LVC) has been enhanced to improve its functionality. Furthermore, a prototype tool has been developed to optimise the use of lamb carcases within available markets, based upon predicted cut weights prior to carcase fabrication. Each of these tools enables a processor to define the true value of each carcase within their business, enabling optimised allocation of carcases to their most valuable market and informing pricing. These activities are detailed in "KPI 8.8 Program 5 Summary Report" (Appendix 7.8).

(vii) Work strategically with international partners to **publish** and collaboratively expand this research creating a sustainable base to continually refine and update the grading technologies.

The ALMTech team have developed an extensive collaborative network, both locally and internationally. Within Australia, the project directly collaborated with 22 industry partners, including our investing partners Teys Australia, JBS Australia, Australian Country Choice and Australian Cattle and Beef Holdings; and 18 research provider organisations, predominantly universities and state departments of primary industries. Internationally, ALMTech collaborated with a further 10 technology provider companies and research organisations.

The international companies listed (except Meat Technology Ireland) are currently working with the ALMTech team to develop measurement technologies that they intend to commercialise in Australia. Furthermore, we are in the process of publishing a combined special edition of the international journal *Meat Science* with our New Zealand collaborators at AgResearch. This special edition is focused on objective measurement of carcase and meat quality attributes in livestock and highlights the effectiveness of our international collaboration.

Our collaborators are listed in Section 4 below.

(viii) Develop early career (Post-Doctoral fellows) and trainee scientists (PhD/Masters) to leave a **legacy of scientific and technical capacity**.

One of the key legacies of the ALMTech project is the development of early career and trainee scientists. This project has either fully or partly employed 13 post-doctoral fellows, and these individuals have been the cornerstone for the delivery of the research undertaken, in part evidenced by the number of publications they have co-authored. Furthermore, this project has provided research opportunities for 7 PhD students, 6 Masters students, and 1 Honours student. In undertaking their research, each of these individuals has worked closely with industry and commercial partners, equipping them with deep industry knowledge and an understanding of the commercial constraints faced by producers and processors. The list of post-doctoral fellows, PhD, Masters, and Honours students is detailed in Appendix 7.0 Early Career & Trainee Scientists.

(ix) Develop **15 refereed publications in international scientific journals** to internationally underpin the integrity of the key scientific and industry objectives and outcomes.

The collaborative ALMTech team have submitted a range of papers for peer-reviewed publication in international journals (n=24) and at international conferences (n=41), which are detailed in the Publications Log in Appendix 7.3. The journal publications highlight the quality of the science undertaken, as the peer review process in this case is extensive. The conference publications highlight the extent to which the ALMTech team have sought additional exposure to, and critique from, international scientific audiences, and also the international interest in the industry-leading research and development delivered by ALMTech.

## 3.2 Industry outcomes

(i) Develop **reliable technologies operating within intensive feedlots**, or mobile units for use in the **seed-stock sector**, for assessment of carcase LMY ready for final commercialisation by 2021.

As reported under Section 3.1 Scientific outcome (i), this has been delivered through the development of 3D imaging cameras, and microwave back-fat scanners. Commercialisation options for these technologies are being explored in ALMTech II. This progress is detailed in "KPI 8.9 Sub-program 1.1 Summary Report" (Appendix 7.8).

(ii) Develop **reliable technologies operating at line speed** for assessment of carcase LMY and EQ attributes ready for final commercialisation by 2021.

As reported under Section 3.1 Scientific outcomes (ii), (iii), (iv), this has been delivered through the development of abattoir DEXA systems installed in lamb and beef abattoirs, 3D imaging cameras, microwave back-fat scanners, and a range of technologies suitable for measuring traits linked to EQ. Commercialisation options for these technologies are being progressed in ALMTech II. This progress is detailed in the following summary papers in Appendix 7.8:

a) "KPI 8.10 Sub-program 1.2 Summary Report"
b) "KPI 8.10 Sub-program 1.3 Summary Report"
c) "KPI 8.11 Sub-program 2.1 Summary Report"
d) "KPI 8.11 Sub-program 2.2 Summary Report"
e) "KPI 8.11 Sub-program 2.3 Summary Report"

(iii) Finalise the design of production prototype **equipment for identifying offal condemnation**.

Of the technologies tested within Program 3, the most successful prototype was the Rapiscan Dual View multi-energy X-ray absorptiometer augmented with hyperspectral imaging. Progress in designing and testing this system is detailed in "KPI 8.12 Program 3 Summary Report" (Appendix 7.8).

(iv) Develop **standardised industry calibration systems** that are internationally recognised to underpin the integrity of the new objective carcase measurement technologies.

Each new technology created requires standardised industry calibration and auditing systems. In a number of cases, these technologies required new traits to be established in the Australian meat industry language, with examples including IMF% and CT carcase composition. To address this, the ALMTech Industry Calibration Working Group (ICWG) was established. This group uses a dynamic document known as the ICWG Traits Manual to record the trait definitions, their measurement methodology, detail of the technologies that can measure them, and their precision and accuracy. Noting this a living document that will continue to evolve, the ICGW Traits Manual is included among the Technical Reports in Appendix 7.8 (under Program Executive).

A major achievement of the ICWG was the development of new accuracy standards for AUS-MEAT accreditation of cut surface cameras. The outcome had a number of immediate ramifications. Firstly, this enabled the E+V camera system to be installed and AUS-MEAT accredited in one beef abattoir, as reported under scientific outcome (iv). Secondly, this provided Frontmatec with the confidence to move to a commercialisation phase for their beef hyperspectral grading camera.

(v) Link objective carcase measurement with **data capture, storage, dissemination and management systems** for use up- and down-stream within the value chains to maximise communication between, and profit for, all partners.

Programs 4 & 5 have worked closely with supply-chain partners to ensure the flow of data from new measurement technologies into MLA's Livestock Data Link (LDL) online feedback system, and other proprietary systems owned by individual processor companies. These activities are detailed in "KPI 8.13 Sub-program 4.1 Summary Report" (Appendix 7.8).

(vi) Harmonise the data management across abattoir platforms to **link with other industry data bases** such as Meat Standards Australia (MSA) and genetic improvement programs in sheep, beef and pigs to maximise genetic gain and drive greater productivity changes in all three industries.

This has been delivered by Program 4, who have used the newly available data from technologies to provide new and enhanced genetic tools for selecting for LMY and EQ on-farm. All programs have worked via the Industry Calibration Working Group (ICWG), and the beef and lamb MSA Pathways Committees, to ensure the compatibility of data from new technologies with the MSA EQ prediction model. Given that no technologies have been commercialised at this point, none are populating either the beef or lamb MSA systems with data. This will be progressed in the ALMTech II project. The development of new and enhanced genetic tools are detailed in "KPI 8.13 Sub-program 4.2 Summary Report" (Appendix 7.8).

(vii) Develop **software systems to optimise sorting of raw materials** to best meet customer specifications for finished products, utilising LMY and eating quality data generated for carcases and primals, thereby capturing productivity and profitability benefits.

This has been delivered through the development of a prototype tool to optimise the use of lamb carcases within available markets, based upon predicted cut weights prior to carcase fabrication. This tool works in synergy with the Lamb Value Calculator (LVC) and support for its adoption by processors will be ongoing in the ALMTech II project. This tool is also being adapted to operate in beef abattoirs, and to incorporate EQ predictions for trimmed cuts, an activity that will continue within the ALMTech II project. These activities are detailed in "KPI 8.8 Program 5 Summary Report" (Appendix 7.8).

## 3.3 Project level achievements

| KPI | Progress |
|---|---|
| **1.1** Confirm the engagement of a project manager (Output 1(a)). | ☒ Achieved<br>☐ Partially achieved<br>☐ Not achieved<br>• Refer to **Annual Operational Plans [Appendix 7.7]** |
| **1.2** Provide the agreed membership, governance arrangements and terms of reference for the project Steering Committee (Output 1(b)). | ☒ Achieved<br>☐ Partially achieved<br>☐ Not achieved<br>• Refer to **Annual Operational Plans [Appendix 7.7]** |
| **1.3** Provide a list of all partner organisations and the status of partner agreements, including the date signed or the date expected to be signed (Output 1(c)). | ☒ Achieved<br>☐ Partially achieved<br>☐ Not achieved<br>• Refer to **Annual Operational Plans [Appendix 7.7]** |
| **1.4** Provide a list of cash and in-kind contributions for each partner, for each financial year of the Activity and the total amount of funding and in-kind contributions (Output 1(d)). | ☒ Achieved<br>☐ Partially achieved<br>☐ Not achieved<br>• Refer to **Annual Operational Plans [Appendix 7.7]** |
| **1.5, 2.1** Provide the project plan endorsed by the project Steering Committee (Output 2(a)). | ☒ Achieved<br>☐ Partially achieved<br>☐ Not achieved<br>• Refer to **Annual Operational Plans [Appendix 7.7]** |
| **2.2** Provide the communication and extension plan (Output 2(b)). | ☒ Achieved<br>☐ Partially achieved<br>☐ Not achieved<br>• Refer to **Annual Operational Plans [Appendix 7.7]** |
| **2.3** Provide the monitoring and evaluation plan (Output 2(c)). | ☒ Achieved<br>☐ Partially achieved<br>☐ Not achieved<br>• Refer to **Annual Operational Plans [Appendix 7.7]** |
| **2.4, 3.1, 4.2, 5.1, 6.1, 8.2, 8.3** Provide an account of communication and extension activities (Outputs 3(a), 3(b) & 3(c)). | ☒ Achieved<br>☐ Partially achieved<br>☐ Not achieved<br>• Refer to **Newsletter Archive [Appendix 7.1]**<br>• Refer to **Extension Activity Log [Appendix 7.2]**<br>• Refer to **Media & Publications Log [Appendix 7.3]**<br>• Refer to project website: www.almtechau.com |
| **2.5, 3.3, 6.2, 8.4** Provide estimates of the value of the project to the beef, sheep, and pork industries (Outputs 4(a), 4(c), 4(d) & 4(e)). | ☒ Achieved<br>☐ Partially achieved<br>☐ Not achieved<br>• Refer to **Technical Reports by Program [Appendix 7.8] Program Executive** KPI 8.4 Technical Reports<br>• Refer to **Final Project Evaluation Report [Appendix 7.5]** |
| **2.6, 3.2** Provide an account of the | ☒ Achieved<br>☐ Partially achieved |

| KPI | Progress |
|---|---|
| development of the data capture methodology for existing industry data platforms (Output 4(b)). | ☐ Not achieved<br>• Refer to **Technical Reports by Program [Appendix 7.8] Program 4** KPI 3.2 Technical Reports |
| **2.7, 3.4, 5.2, 6.3, 7.2** Provide an account of the development of meat measurement, sorting and payment systems (Output 5(a)). | ☒ Achieved<br>☐ Partially achieved<br>☐ Not achieved<br>• Refer to **Technical Reports by Program [Appendix 7.8] Program 5** KPI 7.2 Technical Reports |
| **2.8, 3.5, 5.3, 6.4, 7.3, 8.5, 8.6, 8.7** Report on the development of algorithms and information systems to link business payment systems and raw material sorting systems with measurement data & the modelled impact of prototype value-based payment options within supply chains (Outputs 5(b), 5(c) & 5(d)). | ☒ Achieved<br>☐ Partially achieved<br>☐ Not achieved<br>• Refer to **Technical Reports by Program [Appendix 7.8] Program 5** KPI 7.3, KPI 8.5 and KPI 8.7 Technical Reports |
| **2.10, 7.1** Provide an account of the traits identified for calibration (Outputs 6(b) & 7(a)). | ☒ Achieved<br>☐ Partially achieved<br>☐ Not achieved<br>• Refer to **Technical Reports by Program [Appendix 7.8] Program Executive** KPI 7.1 Technical Reports |
| **2.15, 4.10, 5.11, 6.12, 7.12, 8.12** Provide a brief account of the design, laboratory testing, calibration and accuracy of robotic technology for objectively measuring offal or carcase down-grading or condemnation (Outputs 8(a) & 8(b)). | ☒ Achieved<br>☐ Partially achieved<br>☐ Not achieved<br>• Refer to **Technical Reports by Program [Appendix 7.8] Program 3** KPI 6.12 and KPI 8.12 Technical Reports |
| **4.1, 8.1** Provide a report on the evaluation of the project (Output 2(d)). | ☒ Achieved<br>☐ Partially achieved<br>☐ Not achieved<br>• Refer to **Final Project Evaluation Report [Appendix 7.5]** |
| **2.12, 4.3, 4.7, 5.4, 5.8, 6.5, 6.9, 7.5, 7.9, 8.10** Provide an account of the testing, calibration, viability and installation of prototype technology for the direct measurement of LMY in two abattoirs (Outputs 6(e), 6(g) & 6(k)). | ☒ Achieved<br>☐ Partially achieved<br>☐ Not achieved<br>• Refer to **Technical Reports by Program [Appendix 7.8] Program 1** KPI 2.12, KPI 4.3, KPI 6.5, KPI 7.5, KPI 7.9 and KPI 8.10 Technical Reports |
| **2.12, 4.4, 4.8, 5.5, 5.9, 6.6, 6.10, 7.6, 7.10, 8.10** Provide an account of the testing, calibration, | ☒ Achieved<br>☐ Partially achieved<br>☐ Not achieved |

| KPI | Progress |
|---|---|
| viability and installation of prototype technology for the indirect measurement of LMY in two abattoirs (Outputs 6(f), 6(h) & 6(l)). | • Refer to **Technical Reports by Program [Appendix 7.8] Program 1** KPI 2.12, KPI 4.4, KPI 4.8, KPI 6.6, KPI 6.10, KPI 7.6, KPI 7.10 and KPI 8.10 Technical Reports |
| **2.9, 2.11, 4.5, 5.6, 6.7, 7.7, 8.9** Provide an account of the piloting and calibration of prototype technology for the direct measurement LMY in two collaborating seed-stock producers (Outputs 6(a), 6(c) & 6(i)). | ☒ Achieved<br>☐ Partially achieved<br>☐ Not achieved<br>• Refer to **Technical Reports by Program [Appendix 7.8] Program 1** KPI 4.5, KPI 7.7 and KPI 8.9 Technical Reports |
| **2.9, 2.11, 4.6, 5.7, 6.8, 7.7, 8.9** Provide an account of the piloting and calibration of prototype technology for the indirect measurement of LMY at two collaborating feedlots (Outputs 6(a), 6(d) & 6(j)). | ☒ Achieved<br>☐ Partially achieved<br>☐ Not achieved<br>• Refer to **Technical Reports by Program [Appendix 7.8] Program 1** KPI 6.8, KPI 7.7 and KPI 8.9 Technical Reports |
| **2.13, 2.14, 4.9, 5.10, 6.11, 7.11, 8.11** Provide an account of the testing, calibration and accuracy of prototype technology for measuring EQ in two abattoirs (Outputs 7(b), 7(c) & 7(d)). | ☒ Achieved<br>☐ Partially achieved<br>☐ Not achieved<br>• Refer to **Technical Reports by Program [Appendix 7.8] Program E** KPI 7.11 Technical Report<br>• Refer to **Technical Reports by Program [Appendix 7.8] Program 2** KPI 2.13, KPI 4.9, KPI 6.11, KPI 7.11 and KPI 8.11 Technical Reports |
| **5.12, 6.13, 7.13, 8.13** Provide an account of the development of data flow to industry information delivery systems (Output 9(a)). | ☒ Achieved<br>☐ Partially achieved<br>☐ Not achieved<br>• Refer to **Technical Reports by Program [Appendix 7.8] Program 4** KPI 8.13 Technical Reports |
| **5.13, 6.14, 7.14, 8.13** Provide an account of the development of data flow to genetic evaluation systems (Output 9(b)). | ☒ Achieved<br>☐ Partially achieved<br>☐ Not achieved<br>• Refer to **Technical Reports by Program [Appendix 7.8] Program 4** KPI 5.13, KPI 6.14 and KPI 8.13 Technical Reports |
| **7.4, 8.8** Report on the development of information systems to improve feedback to producers on market compliance, carcase value and animal health (Output 5(e)). | ☒ Achieved<br>☐ Partially achieved<br>☐ Not achieved<br>• Refer to **Technical Reports by Program [Appendix 7.8] Program 5** KPI 8.8 Technical Report |

## 3.4 Contribution to program objectives

ALMTech's ambition was to realise significant productivity and profitability improvements for primary producers, via the following objectives:

- Provide beef, lamb and pork producers with access to more accurate descriptions of the key attributes that influence the value of their livestock: LMY; EQ; and compliance to market specifications, delivered via advanced measurement technologies, in synergy with abattoir automation where appropriate;
- Enhance feedback systems so as to provide producers with new information to improve decisions on breeding and compliance to market specifications;
- Deliver new tools and data to processors that can be used by producers to improve the rate of genetic gain and processing efficiency, while optimising their capacity to allocate product to the most valuable market end-point, thereby increasing the wealth of the value chain participants;
- Capitalise on the co-operation of industry stakeholders to maximise effective decision making, reduce risk and optimise profit for all partners;
- Develop an early-stage prototype of objective measurement equipment for offal condemnation; and
- Develop and improve these technologies and systems so as to increase competitiveness and profitability in the Australian meat value chain.

The "Final Project Evaluation Report" (Appendix 7.5) estimates the most likely economic value of the ALMTech project to the Australian beef, sheep meat, and pork industries as at the end of 'phase 1' of the project (i.e. as at the end of ALMTech I, whereby 'phase 2' refers to ALMTech II). These estimates are to be updated at the end of 'phase 2' as more information becomes available about the accuracy, reliability and commercial usability of the various objective measurement (OM) technologies being investigated, and about the actual adoption rates for these technologies.

ALMTech's "Final Project Evaluation Report" was based on the six value proposition scenarios as per MLA's revised objective measurement report (Greenleaf et al., 2019b). This modelled annual 'first round' adoption and direct impacts to 2040 of the six value propositions. These were then discounted at 5% to provide a Net Present Value (NPV) 'first round' benefit of $1.007 billion for full implementation of objective measurement within the red meat industry. A similar approach was taken to estimate benefits for the pork industry. Recognising that not all of these benefits would be retained within the red meat and pork industry over time, and would also be redistributed between industry segments and other economic sectors such as consumers, 'second round' impacts were calculated using economic models specifically tailored for the ALMTech project to reflect the Australian pork, beef and sheep meat industries (Zhang et al. 2018b, Zhang et al. 2018a; Mounter et al. 2019). The objective was to estimate the magnitude and distribution of gross benefits over the range of possible uses of new information potentially available through recent advances in OM technologies in the pork, beef and sheep meat industries. An additional objective was to illustrate the differences in the size and distribution of benefits using different methodologies, and to estimate the benefit for on-farm measurement technologies.

For beef, the combined 2023 'second round' benefit from all scenarios covered in the ALMTech economic analysis is estimated to be $5.8 million (for the 'likely' outcomes). For the combined scenario, livestock producers receive about 40%, domestic and overseas consumers together receive about 50%, and all input suppliers together (processors, feedlotters, retailers and exporters) receive less than 10%. These shares correspond to the hypothetical simulations done as part of the model validation exercise (Zhang et al., 2018a) and also accord well with the expected patterns from prior research, reported almost 20 years ago (Zhao et al., 2001a,b; Zhao et al., 2003). That is, as is well known, much of the benefit from the technology eventually makes its way to consumers in the form of extra consumption at lower prices.

For the sheep meat scenarios, the same general comments apply as for the beef scenarios. The 2023 'second round' benefit across all sheep meat scenarios estimated using the ALMTech economic model is $0.2 million. Across the scenarios, sheep meat producers receive 43%, and conversely, domestic and overseas consumers together receive 43%. All input suppliers into lamb and mutton transformation (lamb and mutton processors, retailers and exporters) receive 14% of the benefits. Again, these shares correspond to the hypothetical simulations done as part of the model validation exercise (Mounter et al., 2019) and also match with the expected patterns from prior research (Mounter et al., 2008a,b).

The gross benefits across both pork scenarios estimated using the economic model is $3.16 million. Across the scenarios, pork producers receive just 8.5% of total benefits, domestic consumers receive 78.6%, and all input suppliers into pork transformation (primary and secondary processors, retailers and exporters) and overseas consumers receive the remaining 13% of the benefits. Again, these shares correspond to the hypothetical simulations done as part of the model validation exercise (Zhang et al., 2018b) and also are consistent with the expected patterns from prior research (Mounter et al., 2005a,b).

In relation to the potential benefits from on-farm measurement technologies, the assumed on-farm unit price enhancement for lamb results in an aggregate gross benefit of $0.91 million in 2023. The beneficiaries of this technology application are lamb producers who receive about 36% of the gross benefits, other input suppliers about 10%, overseas consumers 15% and domestic consumers about 39%. The assumed on-farm unit price enhancement for beef results in an aggregate gross benefit of $5.74 million in 2023. Farmers receive about 40% of the gross benefits, other input suppliers about 10%, overseas consumers 14%, and domestic consumers about 36%.

Aggregating across all three industries for the year 2023, a total annual gross benefit of around $29 million is estimated. Around $16 million (or 56%) is attributable to the beef industry, about $10 million (or 34%) to the sheep meat industry and about $3 million (just over 10%) to the pork industry. In terms of scenarios, scenario 4 (Improving on-farm animal health from processor feedback) is the one which produces the greatest gross benefit of over $13 million (or 46% of the total). Scenario 3 (Genetic trait selection for increasing marbling and improving feed conversion in feedlot cattle) makes only a minor contribution, but all other scenarios including the on-farm scenario offer annual benefits in the order of $3-7 million.

The estimated NPV for the beef industry scenarios (prior to accounting for R&D costs) is $316 million; the NPV for the sheep meat industry scenarios is $145 million; and the NPV for the pork industry scenarios is $49 million. Aggregating the Return On Investment (ROI) measures across the three industries gives an estimated NPV through to 2040 of $510 million. Adjusting R&D costs to real 2020 values and summing across the three industries generates a discounted cost aggregate of $127 million. So, the overall OM theme of work has resulted in a discounted net benefit of $383 million with an estimated BCR of 4:1 by 2040. These values are quite consistent with the returns from other large R&D programs in the livestock industries, such as the Cooperative Research Centre for Beef Genetics Technologies. Again, we should point out these estimates exclude any consideration of the benefits and costs from animal health related outcomes. The combined discounted gross benefits for scenario 4 for the beef and sheep meat industries are estimated to sum to close to $200 million.

In ALMTech's "Final Project Evaluation Report", a formal sensitivity analysis was not undertaken. The input data used were sourced from a number of different, in some cases inconsistent, sources. However, we have followed the cautious, "most likely" assumptions in MLA's Revised OM Report, and where we have had to make additional assumptions, these too have been made in a cautious, "most likely" fashion. We acknowledge that there are still many unknowns associated with the performance and implementation of these OM technologies, and that as better information becomes available, the assumptions can be revised, and the results updated. This will also allow a more formalised approach to sensitivity analysis in the future.

The series of MLA-funded OM reports pay particular attention to the supporting structures required to facilitate industry uptake and so capture as many of the potential benefits available as possible. The Willingness To Pay (WTP) by end users for better information which enables better decisions can only be captured if there are suitable incentive systems in place to facilitate these better decisions. New information has to be measured, recorded, and shared with those who have the most use for it. Value-based payment and marketing systems have to be implemented in parallel to the implementation of the new technologies to enable the potential benefits to be captured. The ALMTech project works closely with processors and retailers to demonstrate value and provide suggested pricing structures to reward improvements in LMY and EQ. Yet ultimately, this outcome is in the hands of the commercial supply chains who must remain competitive irrespective of changes to their pricing/marketing structures. The current environment of low supply and high prices is particularly challenging for processors looking to implement change.

# 4 Collaboration

## 4.1 Australian industry collaborators

Most crucial to the ALMTech project were our Australian industry collaborators. Engagement with these collaborators has been formally and informally structured at a number of levels, with examples including the following:

a) In most cases, experimental work undertaken to develop ALMTech technologies has been done within abattoirs and on farms of our collaborating industry partners. This provides them with a first-hand experience of the technologies being tested and is a crucial mechanism to create a commercial needs-driven focus and enhance future adoption.
b) The four private companies that have invested cash into the ALMTech project include JBS Australia, Teys Australia, Australian Country Choice and Australian Cattle and Beef Holdings. These companies have representatives that sit on our Steering Committee and formally provide direction for the experimental work.
c) We have producer representatives from the sheep meat industry, the grass-fed cattle industry and the beef feedlot industry who also sit on our Steering Committee and formally provide direction for the experimental work.
d) Companies that are actively supporting the ALMTech project, particularly those with an expressed intent to adopt a new measurement technology or enhance their producer feedback, are offered quarterly confidential supply-chain meetings. These include a selection of key ALMTech personnel with a knowledge of the technologies of interest to that business. Within these meetings, the business case and the practical logistics of adopting new measurement technologies are established.
e) The companies described in d) above, as well as representatives from MLA, AMPC, MSA, commercial partners, state departments of primary industries, and all ALMTech personnel also participate in twice-yearly national supply-chain meetings. These are used as update and discussion forums across a range of topics relevant to enhancing lean meat yield and eating quality within the livestock industries.

These collaborative activities have created an extensive industry network. The companies involved, and examples of their collaboration include:

- Meat & Livestock Australia (project partner) – Contributes access to Resource Flock, Beef Information Nucleus R&D herds, and producer feedback portals
- Australian Meat Processing Corporation (project partner) – Contributes extensive processor network.
- Australian Pork Limited (project partner) – Contributes extensive processor and producer network.
- Australian Country Choice (project partner) – Collaboration enabling Beef Value Calculator proof-of-concept.
- Australian Cattle & Beef Holdings Pty Ltd (project partner) – On-farm testing of measurement technologies
- Teys Australia (project partner, field site) – Abattoir testing of beef DEXA, E+V grading camera, MEQ probe
- JBS Australia (project partner, field site) – Abattoir testing of lamb DEXA, hyperspectral cameras, and Lamb Value Calculator
- Thomas Foods International (field site) – MLA Resource Flock processing.
- Gundagai Meat Processors (field site) – Abattoir testing of lamb DEXA, Lamb Value Calculator, Carcase Optimisation tool
- Frewstal (field site) – Abattoir testing of lamb DEXA, and Lamb Value Calculator

- Western Australian Meat Marketing Co-operative Limited (field site) – DEXA installation; MLA Resource Flock processing
- Northern Cooperative Meat Company (field site) – understanding the potential to use whole-of-supply chain data to optimise enterprise performance; time of grading of IMF investigation; supply chain data exploration
- Bindaree Beef (field site) – Abattoir testing of hyperspectral cameras and microwave scanners.
- Prestige Foods (field site) – Abattoir testing of hyperspectral cameras.
- Woolworths (field site) – Retailer testing of Lamb Value Calculator
- Angus Australia – Beef Information Nucleus R&D herd
- Herefords Australia – Beef Information Nucleus R&D herd
- Harvey Beef (field site) – Abattoir testing of hyperspectral cameras
- John Dee (field site) – Beef Information Nucleus R&D herd processing, and abattoir testing of hyperspectral cameras and 3-D imaging system
- NH Foods (Japan) – Abattoir testing of Beef Value Calculator
- Australian Lot Feeders Association (ALFA) – R&D planning
- Australian Brahman Breeders Association – Beef Information Nucleus R&D herd
- Santa Gertrudis Australia – Beef Information Nucleus R&D herd
- Droughtmaster Stud Breeders' Society – Beef Information Nucleus R&D herd
- Australian Lamb Company – Abattoir testing of Lamb Value Calculator
- Integrity Systems Company – Provides red meat value chain network through integrity and information systems programs
- Livestock Data Link advisory group – integration of new data into industry feedback systems
- AUS-MEAT – accreditation of new grading technologies
- Meat Standards Australia – integration of new grading technology outputs into the MSA language
- Australian Meat Industry Language and Standards Committee – approval of new language stand for beef grading cameras
- MEQ – technology development collaboration in Resource and Beef Information Nucleus herds

## 4.2 Australian research collaborators

The ALMTech project has brought together a network of scientists distributed across universities and research institutes across Australia. In many cases these networks did not previously exist and have entrenched collaborative activities that will extend beyond the term of the ALMTech project. These organisations include:

- Murdoch University (project partner)
- University of New England (project partner)
- Animal Genetics and Breeding Unit (project partner)
- University of Adelaide (project partner)
- University of Technology Sydney (project partner)
- Department of Primary Industries NSW (project partner)
- AgBiz Solutions (project partner) – meat industry supply chain analyst
- SunPork (project partner)
- PorkScan (project partner)
- University of Melbourne (project partner)
- University of Sydney (project partner)
- Department of Jobs, Precincts and Regions Victoria (project partner)
- Department of Primary Industries and Regional Development Western Australia (project partner)

- South Australian Research and Development Institute (project partner)
- Health 4 Wealth
- Sheep Co-operative Research Centre
- Sheep Genetics
- Enhanced Abattoir Surveillance (EAS) program. This includes data collection with Thomas Foods International (Lobethal), and collaboration with GMP on collection methodology and analysis.

## 4.3 International collaborators

Our international collaborators are crucial to the outcomes of the ALMTech project. We have actively sought international partners who were interested in developing their own technologies, specifically tailoring them to the Australian livestock industries. This has markedly diversified the technologies that we have tested and introduced numerous companies with a track record of successful commercialisation to the Australian livestock industry. In other cases, our collaboration has provided an ideal forum in which to critique our own innovation program by contrasting it with that of other countries that are active in this space, with AgResearch New Zealand and Meat Technology Ireland being prime examples. These collaborators include the following:

- Frontmatec (Denmark)
- TenderSpec (United States of America)
- E+V (Germany)
- Rapiscan (United Kingdom)
- 4DDI (United States of America)
- SOMA Optics (Japan)
- MIJ: Meat Imaging Japan
- Obihiro University (Japan)
- AgResearch (New Zealand)
- Scott Automation and Robotics (project partner – New Zealand)
- Meat Technology Ireland – an organisation similar to ALMTech, where A/Prof. Gardner is a member of their scientific peer review panel.

# 5 Extension & adoption activities

## 5.1 Engagement

Arguably the most crucial mechanism of industry engagement within the ALMTech project has been the design of experimental work undertaken in direct collaboration with the industry end-user of the technology. Excellent examples include the installation and testing of the lamb and beef DEXA systems within abattoirs, enabling us to test equipment in-production. As previously described, this provides our collaborating industry partners with a first-hand experience of the technologies being tested and is a crucial mechanism for encouraging future adoption. Indeed, the last 6 months of COVID-19 travel restrictions have highlighted the strength of these relationships, with at least 6 experiments undertaken on our behalf by industry staff located on-site. The success of this strategy is also illustrated in ALMTech II, which has attracted several new commercial participants from the feedlot, processing and retail sectors.

One of the strengths of the ALMTech research team is their ability to extend research to non-technical industry audiences. This is well demonstrated through the Extension Activity Log in Appendix 7.2, which lists 276 separate events where ALMTech members presented at field days, industry workshops, training events, and most recently, Zoom-based webinars. Almost all of the current ALMTech research staff have contributed to these industry presentations, which have been delivered across all states of Australia in a truly national out-reach program, and internationally.

Also crucial to our industry engagement are the formal activities coordinated through Program 5.3, which are entirely focused upon supply chain engagement. These activities include national Supply Chain Group meetings, confidential company-based supply chain meetings, and training workshops delivered through the producer networks of MLA and our key collaborating processor partners. These activities are detailed in “KPI 8.8 Program 5 Summary Report” (Appendix 7.8).

## 5.2 Appropriateness

Indicators that demonstrate alignment of ALMTech project technologies with stakeholder expectations include:

a) Installation of 1 DEXA system in a commercial beef abattoir, and 3 DEXA systems in commercial lamb abattoirs, with a further 3 due to be installed by the end of 2020.
b) Expressed demand from processors in the beef industry for improved methods of determining marbling in beef, and the number of companies collaborating to test and install loin eye cameras.
c) Expressed demand from processors in the lamb industry for a measure of eating quality, enabling them to roll-out an individual carcase grading system (MSA Mk2). This is well demonstrated by the number of companies collaborating to test and install intramuscular fat measurement technologies.
d) The expanded support of commercial participants from ALMTech I to ALMTech II. The new participants from the feedlot, processing and retail sectors illustrate alignment with industry stakeholder needs.
e) Additionally, the relevant industry Peak Councils have positively engaged with ALMTech and provided formal endorsement for ALMTech II.
f) The broad level of industry interest and support for ALMTech’s work is illustrated by team members’ participation in numerous industry forums and workshops, presenting to producers and processors (see Appendix 7.2: Extension Activity Log).
g) The National Meat Industry Training Advisory Council (MINTRAC) has actively engaged with ALMTech to ensure that its stakeholders are well informed of developing

technologies to enable their consideration of value to their business. They are looking at creating a series of training modules structured around outcomes from the ALMTech project.

## 5.3 Future adoption plans

To ensure the ongoing future adoption of ALMTech technologies, it is crucial that the individual supply-chain engagement strategy is maintained. A vital component of this is the national Supply Chain Group meetings and the confidential company-based supply chain meetings. The technical expertise provided by the ALMTech team of researchers is an essential component that provides the scientific content for these meetings. Furthermore, this facilitates a supporting structure to those companies looking to adopt a measurement technology or enhance their producer feedback.

With an even greater industry commitment than ALMTech I—in terms of number and breadth of partners, and both in-kind and cash contributions—ALMTech II aims to commercialise successful technologies that predict LMY and EQ, commercialise genetic tools, feedback and decision support systems using data stemming from these technologies, and support the adoption and creation of systems for industry-wide auditing and calibration of new technologies.

# 6 Lessons learnt & recommendations

## 6.1 Lessons learnt

1. *Addressing the key risk area: calibration of beef DEXA.* While simple calibration can be achieved from manual bone-out data, a robust and transportable calibration is dependent upon access to computed tomography (CT). In lamb this was not a limitation, as carcases involved in calibration experiments were simply purchased out-right after in-plant experimental work and transported to the site of collaborating universities that owned CT scanners. Protracted industry debate on the funding model (external to ALMTech) delayed development of a portable CT. Procurement of a portable CT is now underway, with calibration work planned under ALMTech II.

2. *Supporting the commercial use of devices after their initial installation*. One of the key successes of ALMTech has been supporting the development of new technologies, including the lamb Dual Energy X-ray Absorptiometry (DEXA) system and hyperspectral imaging devices. The roll-out of lamb DEXA systems across Australia has commenced, with three systems installed and another two contracted for installation, all of which require scientific support to ensure their calibration. ALMTech has identified and subsequently developed a solution for routine across-site calibration to underpin the integrity of data and provide confidence to producers and processors. The adoption of hyperspectral imaging systems and red-green-blue camera systems to determine IMF% will enable new inputs for the existing beef MSA system and the first-ever deployment of a lamb cuts-based MSA system. Continued scientific support is required to enable all of these developments. Some of this has been conducted in the final year of ALMTech I, and some will be conducted in ALMTech II.

3. *Adopting and validating new technologies*. The focused effort to develop objective carcase measurement technologies has led to an array of new technology concepts for measuring LMY and EQ traits. Given their timing, some of these will still be in a pre-commercial development phase by the end of ALMTech I, while others will have reached the commercial prototype phase. This includes simple hand-held devices through to automation-ready computed tomography systems that can scan at abattoir chain-speed. Continued support for the adoption and validation of these promising new technologies will ensure their commercial delivery. One of the key areas the internal review process identified is additional support for the development of technologies for live animal measurement, with this testing aligned with live-animal performance prediction platforms like BeefSpecs and AskBill. Ongoing development and support for these new technology concepts has been integrated into the ALMTech II workplan.

4. *Developing genetic tools and feedback systems*. Given the diversity of objective carcase measurement technologies, and the potential new traits that they can measure, there is an ongoing need to capture this information in a standardised format for feedback systems and genetic databases. Each new technology developed requires careful data capture from sufficient numbers of pedigree-recorded animals to enable the generation of breeding values. This is crucial to maximise the benefit of new technologies to improve genetic gain and on-farm impacts. There were concerns about the timeline for generating 3 new or improved genetic products or tools due to in the timing of the availability of fully calibrated new measurement technologies, but ALMTech's Program 4 are working through these limitations. Some of this has been conducted in the final year of ALMTech I, and some of this will be conducted in ALMTech II.

5. *Supporting farmers and processors to use new data*. Given the complexity and richness of this new dataflow, there is an urgent need to provide ongoing industry support for both producers and processors. This involves industry engagement events, supply-chain workshops, and the continuation of the highly successful "Supply Chain Group" initiative. As indicated in the Extension Activity Log (see Appendix 7.2), the ALMTech team have been particularly successful at engaging industry. However, with the outbreak of COVID-19 these activities have been severely hampered. Indeed, in 2020 we had intended to roll out the "ALMTech Roadshow", a series of field days enabling us to signal to industry stakeholders the key outcomes of the ALMTech project. These plans have been postponed. Therefore, a new industry engagement strategy is required. In part, this is already being met through "Zoom Webinars", and other online media events. This work, and the development of other forms of industry extension, will be ongoing in ALMTech II.

6. *Auditing and calibrating new traits.* In many cases, technologies are being developed that measure traits by different means than are currently traded on within industry, or that measure new traits that previously did not exist. For example, photonic devices are being developed that determine chemical fat percentage in muscle, yet this trait is not measured in the lamb and pork industries, and in beef only visual marbling is graded as an indicator of fat percentage. Similarly, new on-line DEXA systems can measure whole carcase lean meat yield in lamb and beef, yet only GR tissue depth or P8 fat depth are currently traded on. Therefore, work is needed to develop the industry systems to underpin the ongoing calibration and auditing of these new measurement technologies. These new traits will be structured around "gold-standard" measurements of carcase composition determined by computed tomography and chemical fat composition determined by Soxhlet fat extraction. Close interaction will be required between producers, processors, auditors and regulating authorities for industry to stay abreast of this technological transformation. The need for these auditing and calibration systems was identified from the start of the ALMTech project. While the work required to establish new traits upon which the industry can trade is more substantial than was originally envisaged, a process has been established through the successful development and formal adoption of standards for AUS-MEAT accreditation of beef grading cameras. This work will continue in ALMTech II, and we envisage an ongoing need beyond the life of the project.

## 6.2 Recommendations

One of the key successes of the ALMTech project has been the efficiencies achieved through the coordination of the development, calibration and validation of new measurement technologies, ultimately accelerating the speed-to-market for these devices. Wherever possible, this testing has been undertaken across genetically defined resource flocks and herds, integrating as many technologies in parallel as possible. The use of common animal resources has ensured the following:

- Reduced experimental costs through the utilisation of pre-existing resource herds and flocks. Simultaneous deployment of many measurement technologies across the same animals further enhances this efficiency.
- Maximised phenotypic and genotypic ranges within the sample population across which technologies are being calibrated and validated. Commercial flocks/herds are generally less variable, thus easier to predict.
- Direct comparison of technologies that are attempting to predict the same trait.
- Using genetically defined animals has enabled predictions from measurement technologies to be directly uploaded into genetic databases, and the seamless assessment of their capacity to inform new or enhanced genetic tools.

Lastly, the structure of the ALMTech project has created a platform on which trust and engagement occurs simultaneously along the value-chain through accurate, credible and transparent information that is validated by an independent industry representative. If this same body of work were undertaken independently by any of the research development corporations or participants, the transformation would be fragmented, take much longer, be at greater expense, and likely fail to deliver increased revenue to producers and other value-chain participants. Therefore, industry should consider the continuation of this coordinated structure in some form beyond the term of ALMTech II.

# 7 Appendix

## 7.0 Early Career & Trainee Scientists

## 7.1 Newsletter Archive

## 7.2 Extension Activity Log

## 7.3 Media & Publications Log

## 7.4 Intellectual Property Register

## 7.5 Final Project Evaluation Report

## 7.6 Budget Summary Statement

Refer to the "ALMTech signed financial statements FY17-20".

The grant funding summary for the life of the project, up to 30 June 2020:

| | | |
|---|---|---|
| Approved grant funding | $ | 4,850,000 |
| Grant funding received to date | $ | 4,365,000 |
| Grant funding received since the previous milestone report | $ | - |
| Grant funding expended to date | $ | 4,104,608 |
| Grant funding yet to be paid | $ | 485,000 |

It is currently forecast that there will be an underspend of $192,574 at the completion of the project. The grant portion of this underspend, i.e. $91,973, and all interest earned from the grant will be returned to the Department of Agriculture, Water and the Environment when the project has been completed and the financials have undergone external auditing. As of 30 June 2020, the interest earned on the grant income amounts to $158,220.

The final financial report will be submitted to the Department of Agriculture, Water and the Environment within 60 days of submitting this report.

## 7.7 Annual Operational Plans

## 7.8 Technical Reports by Program

Please note that the following Technical Reports that have been marked as '**CONFIDENTIAL**', due to commercially sensitive content, have been withheld from the public version of the **ALMTech I Final Report** and reside in the full version as archived with Meat & Livestock Australia.

**Program Executive**

**Sub-program E.1** **Project planning and management**

N/A

**Sub-program E.2** **Communication and extension activities**

N/A

**Sub-program E.3** **Industry liaison and value estimation**

| | |
|---|---|
| KPI 8.4 | Calibrating & validating equilibrium displacement models – lamb |
| KPI 8.4 | Updating & recalibrating equilibrium displacement models – beef |
| KPI 8.4 | Updating & recalibrating equilibrium displacement models – pork |

**Sub-program E.4** **General management of technology calibration**

| | |
|---|---|
| KPI 7.1 & KPI 7.11 | Accreditation standards for cut surface camera grading technologies **CONFIDENTIAL** |
| KPI 7.1 | ALMTech Industry Calibration Working Group Traits Manual |
| KPI 7.1 | Association between chemical intramuscular fat percentage determined by lab based near infrared spectroscopy and chloroform Soxhlet extraction in lamb and beef |
| KPI 7.1 | Prediction of consumer palatability in beef using visual marbling scores and chemical intramuscular fat percentage |
| KPI 7.1 | Repeatability of a chloroform Soxhlet extraction method used to determine chemical fat content in beef |
| KPI 7.1 | Repeatability of lab based Near Infrared (NIR) spectroscopy for the determination of chemical intramuscular fat in lamb |
| KPI 7.1 | The distribution of chemical Intramuscular fat percentage within M. *Longissimus Dorsi* in Australian beef carcases |

**Program 1**

| | |
|---|---|
| **Sub-program 1.1** | **Design prototype technology for the direct and indirect measurement of LMY on-farm, and establish the business case for its measurement** |
| KPI 4.5 | DEXA scanning live lambs to predict CT carcase composition |
| KPI 6.6 | Development and validation of a microwave system for live cattle and carcase for predicting carcase P8 and rib fat depth at ACC feedlots and abattoir with a wide range of genotype and phenotype animals **(also Sub-program 1.3)** **CONFIDENTIAL** |
| KPI 6.10 & KPI 7.6 | Prediction of lamb carcase C-site fat depth and GR tissue depth using a non-invasive portable microwave system **CONFIDENTIAL** |
| KPI 7.8 | Report on the validation of a pre-commercial prototype 3D imaging system for Angus cattle at feedlot exit, predicting rib fat depth, and P8 fat depth |
| KPI 7.10 | On-farm and abattoir suitability of microwave scanner system design **(also Sub-program 1.3)** **CONFIDENTIAL** |
| KPI 8.9 | Sub-program 1.1 Summary Report |
| **Sub-program 1.2** | **Design prototype technology for the direct measurement of LMY in an abattoir** |
| KPI 2.10 | Calibrating DEXA prediction of LMY |
| KPI 2.12 | DEXA prediction of bone composition |
| KPI 2.12 | Nearest neighbour analysis of DEXA images |
| KPI 4.3 | Short term repeatability of DEXA scanning beef sides at line speed |
| KPI 4.3 | Beef DEXA tissue calibration block scanning and base algorithm calculation |
| KPI 4.3 | Repeatability of beef DEXA scanning over 60 hours and the influence of hot trimming on DEXA outputs |
| KPI 6.5 & KPI 7.5 | A novel dual energy X-ray Absorptiometry (DEXA) system can rapidly scan beef carcases for prediction of CT composition |
| KPI 6.5 | DEXA prediction of beef cut weights |
| KPI 7.5 | Calibration of Gundagai Meat Processors lamb DEXA **CONFIDENTIAL** |
| KPI 7.5 | Cross-site Calibration of lamb DEXA |
| KPI 7.9 | Ongoing operation of in-line DEXA systems in beef and lamb abattoirs |

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|---|---|
| KPI 8.10 | Sub-program 1.2 Summary Report |
| **Sub-program 1.3** | **Design prototype technology for the indirect measurement of LMY in an abattoir** |
| KPI 4.4 | Non-invasive technology using low cost portable microwave systems on carcases for fat depth measurement **CONFIDENTIAL** |
| KPI 4.8 | PorkScan Plus prediction of ultrasound P2 fat depth **CONFIDENTIAL** |
| KPI 6.6 | Report on validation testing of microwave technology across separate devices to detect beef carcase fatness at the ribbing site and the P8 site in abattoirs **CONFIDENTIAL** |
| KPI 6.8 & KPI 7.7 | Report on initial experiments of a prototype microwave device to measure backfat depth at the C-site in the live lamb validated against abattoir C-site fat depth/GR tissue depth **CONFIDENTIAL** |
| KPI 7.6 | 3D imaging measurement of beef carcase composition, and analysis of improvement to 3D modelling |
| KPI 7.6 | Report on the calibration and validation of integrated hyperspectral and 3D imaging cameras to predict subcutaneous fat depth in lamb carcases |
| KPI 7.10 | Machine Learning Approach to Predict P2 Using PorkScan Plus Data **CONFIDENTIAL** |
| KPI 7.10 | Combining PorkScan Plus with carcase width measures to predict ultrasound P2 fat depth in pigs **CONFIDENTIAL** |
| KPI 8.10 | Sub-program 1.3 Summary Report |

**Program 2**

| | |
|---|---|
| **Sub-program 2.1** | **Near infra-red/Boar taint** |
| KPI 2.13 | Rapid assessment of boar taint |
| KPI 7.11 | Report on the feasibility/validation experiment of ASD NIR Probe |
| KPI 7.11 | Report on the validation of the MEQ probe for pHu, IMF and WBSF in Lamb |
| KPI 8.11 | Report on IMF% prediction using the SOMA NIR device in lamb |
| KPI 8.11 | Sub-program 2.1 Summary Report |
| **Sub-program 2.2** | **Imaging cut surface** |
| KPI 2.13 | Potential for MIJ camera to predict chemical IMF% in cut surfaces of loins |
| KPI 4.9 | Report on an analysis of colour phenotypes |
| KPI 4.9 | Report on MIJ parameters and data.: MIJ prediction of IMF%, MSA marbling and EMA |
| KPI 6.11 | Obihiro report on automatic grading by image analysis of meat quality traits in Australian cattle carcases |
| KPI 6.11 | Report on the MIJ prediction of MSA rib-eye grading (go / no go) based on the successful development of training algorithms |
| KPI 6.11 | Summary of the AMPC report on the ability of the TenderSpec camera to measure IMF, Warner-Bratzler Shear Force and Loin sensory data within beef |
| KPI 7.11 | Frontmatec automated MSA AUS-MEAT hyperspectral handheld grading for beef |
| KPI 7.11 | Association between visual marbling score and chemical IMF% with marbling percentage determined by image analysis in Australian beef carcases |
| KPI 7.11 | Report on the AUS-MEAT certification of the Frontmatec prediction of MSA rib-eye grading |
| KPI 7.11 | Report on the MIJ prediction of MSA AUS-MEAT rib eye grading and AUS-MEAT certification |
| KPI 8.11 | Automated grading of eye muscle area and intramuscular fat and marbling in Australian beef and lamb |
| KPI 8.11 | Report on experiments evaluating the impact of processing factors on the camera prediction of loin eye traits - grading time and temperature |

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|---|---|
| KPI 8.11 | Sub-program 2.2 Summary Report |
| **Sub-program 2.3** | **Blue sky technologies** |
| KPI 6.11 | The ability of dual energy x-ray absorptiometry to predict cattle ossification |
| KPI 6.11 | Report on the prediction of lamb age using bone DEXA values |
| KPI 6.11 | The ability of computed tomography to predict intramuscular fat % of muscles across the lamb carcase |
| KPI 8.11 | Sub-program 2.3 Summary Report |

**Program 3**

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|---|---|
| **Sub-program 3.1** | **Development of an automation prototype for beef** |
| KPI 6.12 | Summarising opportunities in automated inspection for beef |
| KPI 6.12 | Initial assessment of the image quality from the 4DDI Helios CT scanner |
| KPI 6.12 | Feasibility of MRI for offal sortation |
| KPI 6.12 | The potential application of augmented vision technologies to enhance the effectiveness of the equipment as interfaced with human inspection |
| KPI 8.12 | MEXA assisted offal sortation technical feasibility |
| KPI 8.12 | Program 3 Summary Report |

**Program 4**

| | |
|---|---|
| **Sub-program 4.1** | **Data flow to industry information delivery systems** |
| KPI 3.2 | Producer feedback systems - the value of feedback, current systems, past projects and future work |
| KPI 5.13 | Proposed models for data pipeline from processor to commercial producers, and seedstock breeders |
| KPI 8.13 | Case studies on processor-producer feedback systems, review of current systems and opportunities for enhanced feedback **CONFIDENTIAL** |
| KPI 8.13 | Sub-program 4.1 Summary Report |
| **Sub-program 4.2** | **Data flow to industry genetic evaluation systems** |
| KPI 3.2 | A preliminary study on visual marble score as a proxy for IMF for the genetic improvement of eating quality in lamb |
| KPI 3.2 | Prediction of selection responses for LMY & EQ utilising varying levels of trait recording & accuracy of IMF prediction |
| KPI 4.2 | Genetic evaluation of CT and DEXA image carcase traits for Merino and Merino Cross lamb |
| KPI 4.2 | Genetic evaluation of the relationship between lean meat yield and eating quality characteristics of lamb |
| KPI 4.2 | Investigation of the genetic variation in number of thoracic ribs in sheep |
| KPI 4.2 | The genetic relationship of intramuscular fat measured between five different muscles in lamb |
| KPI 5.13 | Data requirements from LDL and MSA for the genetic evaluation of carcase traits |
| KPI 6.14 | Review of the national genetic evaluation of beef cattle through BREEDPLAN opportunities **CONFIDENTIAL** |
| KPI 8.13 | Sub-program 4.2 Summary Report |

**Program 5**

| | |
|---|---|
| **Sub-program 5.1** | **Carcase value tools** |
| KPI 2.5 & KPI 7.3 | Report 5.1.1 Development and use of the lamb and beef value calculators in sheep and beef supply chains |
| KPI 8.5 | Report 5.1.2 Uploading DEXA data to the Integrity Systems Company data platform |
| KPI 8.7 | Report 5.1.3 Yield measurement is valuable for pricing beef carcases |
| **Sub-program 5.2** | **Data decision tools** |
| KPI 2.8 & KPI 6.3 | Report 5.2.1 Priorities identified from a review of available decision support tools |
| KPI 8.6 | Report 5.2.2 Optimal allocation of carcases to product types in lamb processing operations |
| **Sub-program 5.3** | **Supply chain engagement** |
| KPI 2.7 | Report 5.3.1 Beef Processor Prioritisation **CONFIDENTIAL** |
| KPI 6.1 | Report 5.3.2 The Supply Chain Group |
| KPI 6.1 | Report 5.3.6 Program 5 log of supply chain activities **CONFIDENTIAL** |
| KPI 7.2 | Report 5.3.3 Gundagai Meat Processors DEXA Implementation Support **CONFIDENTIAL** |
| KPI 7.4 | Report 5.3.4 Enhancing feedback to producers on compliance to specifications carcase value and animal health |
| KPI 8.8 | Report 5.3.5 Lamb lean meat yield and easting quality workshop supported learning program |
| KPI 8.8 | Program 5 Summary Report |

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