Final report

Development of an application for portable E+V objective measurement technologies for Australian red meat producers and processors

Abstract

This project aims to deliver an early adoption and evaluation of an application for the portal E+V device to measure ribeye grading characteristics in beef to improve accuracy and consistency compared to current visual grading methods. This project will develop operating protocols to enable adoption of a grading solution using an application for the portal E+V device to measure ribeye grading characteristics in beef for future adopters. Specifically, the project will evaluate the integration of E+V into a beef processor's workflows and business operating systems, including feedback to producers. General learnings from this project will be used to develop generic guidelines for adoption and integration of new OM technologies.

The E+V mobile camera is based on its fixed camera cousin. When used in the same environment as the fixed camera operated equally as well and no doubt would have gained approval in the same group of attributes that its fixed camera cousin achieved.

When used in in the beef carcase chillers it became a little limited as it required more space around the carcase to facilitate the correct placement of the mobile camera. This made the results that were obtained from grading in the carcase chillers less reliable that those gained whilst using it on the fixed grading stand. The ability to use the E+V portably camera would be improved is the shroud and trigger mechanism were constructed from a light material.

There were some key lessons. The most important being that gold standards to calibrate both humans and devices against is necessary. The variability between Graders including between the expert graders as well as the plant graders would make calibrating a device against human graders almost impossible in certain circumstances.

That same variability also shows Teys operations need better Objective Carcase Measurement devices to ultimately replace human graders.

Executive summary

Background

Red meat traits are graded using manual and primarily visual subjective methods. Not only are these manual grading methods tedious, they are also open to inaccuracies in the data captured. Developing precise objective measurement methods is an industry strategic 2025 imperative to capture more accurate data to support alternative pricing methods for producers. This project was submitted in response to an open call for co-investment proposals from businesses seeking to trial and adopt emerging objective carcase and/or live animal assessment technologies. While some technologies may not yet have achieved AUS-MEAT accreditation, the opportunity was open to all technologies for businesses to test and trial integration of developing equipment, and, where applicable, integration of software to enable MSA grading outputs from these technologies to plant systems.

The opportunity exists to develop an adoption case study of a grading solution using an application for the portal E+V device to measure ribeye grading characteristics in beef.

E+V is a world leading company in Germany having its core business developing objective carcase measurement technologies. E+V has already achieved widespread use of its beef rib-eye grading camera technology in almost all US plants as an approved solution by USDA. It also has established track record working with Teys Australia meeting industry requirements in two plants, conforming to AUS-MEAT specification and gaining formal approval for its fixed camera system. E+V possesses considerable background know-how and intellectual property, placing it at the forefront of innovations in beef grading with practical installations in daily use all around the world. This project aims to continue the success at Teys by demonstrating a portable hand-held rib-eye camera already developed by E+V. The 'mobile-ribeye' camera provides further advantages as it may be used to grade carcasses in a chill facility, assisting graders with their assessment improving the evaluation process.

Objectives

The specific objectives of the project are:

- Test and trial integration of developing equipment and integration of software into feedback systems, including MSA grading outputs
- Demonstration of capabilities of E+V mobile ribeye camera against AUS-MEAT requirements
- Evaluate the integration of the E+V portal device into Teys' workflows and business data management systems, including feedback to producers
- Adoption procedures for the technology to reach Australian beef processors
- Validation of test results contributing to AUSMEAT review of the mobile version of the E+V cold carcase grading camera
- Evaluate device grading capabilities across multiple classes of animals and sites

Methodology

Teys will partner with MLA Donor Company and E+V to trial and validate their portal E+V camera across multiple sites. The methodology will involve the grading of the same carcases by 2 MSA expert graders and 1 plant Grader and three mobile E+V Camera graders. For a selection of carcases the cameras will be re-positioned three times on each carcases cut rib-eye surface to check for repeatability within each camera unit as well as consistency between the different cameras.

The cameras must come within a set of predetermined correlations with the grading results of the 2 Expert and 1 plant grader.

Results/key findings

Compliant data was achieved for only one carcase attribute and that was AUSMEAT marbling low range (1 – 6).

The E+V mobile camera is based on its fixed camera cousin. When used in the same environment as the fixed camera operated equally as well and no doubt would have gained approval in the same group of attributes that its fixed camera cousin achieved.

When used in in the beef carcase chillers it became a little limited as it required more space around the carcase to facilitate the correct placement of the mobile camera. This made the results that were obtained from grading in the carcase chillers less reliable that those gained whilst using it on the fixed grading stand. The ability to use the E+V portably camera would be improved is the shroud and trigger mechanism were constructed from a light material.

There were some key lessons. The most important being that gold standards to calibrate both humans and devices against is absolutely necessary. The variability between Graders including between the expert graders as well as the plant graders as highlighted in section 4.3.9 would make calibrating a device against human graders almost impossible in certain circumstances.

Benefits to industry

There were no immediate benefits to industry as a result of this project. However, given the performance of the mobile device on the fixed grading platform there is no doubt that re-engineering it into a form that was more suitable for use in the more cramped environment of a beef carcase chiller there could be benefits to the industry.

Future research and recommendations

Teys considers the mobile cameras hasn't quite been the success that Teys would have hoped. The compliant data Teys collected was collected on the same fixed stand that Teys uses use for the E+V fixed camera. In addition, compliant data has been achieved for 1 attribute only when used in the beef carcase chillers.

On review of the data and the analysis done by independent analyst, the mobile cameras have only met compliance on one grading attribute criteria when used in the intended mobile way. Teys was hoping to get the same approval scope for the mobile camera that Teys got for the fixed camera but that hasn't been the case.

There were some key lessons, including:

- Teys has maintained its desire to move to the use of Objective Carcase Measurement devices
  - To make the process more consistent
  - To make the process more transparent to producers
    - Also should allow the producer to be present remotely if they so wish
- The development of scientifically based "Gold" standards to calibrate both humans and devices against is absolutely necessary.

- o The variability between Graders including between the expert graders as well as the plant graders as highlighted in section 4.3.9 would make calibrating a device against human graders almost impossible in certain circumstances.
- The variability between Graders including between the expert graders as well as the plant graders as highlighted in section 4.3.9 shows Teys need better Objective Carcase Measurement devices to ultimately replace human graders.
- The ability to use the E+V portably camera would be improved is the shroud and trigger mechanism were constructed from a lighter material.

Table of contents

1. Project background, scope and objectives

1.1 Background

Red meat traits are graded using manual and primarily visual subjective methods. Not only are these manual grading methods tedious, they are also open to inaccuracies in the data captured. Developing precise objective measurement methods is an industry strategic 2025 imperative to capture more accurate data to support alternative pricing methods for producers. There are a number of objective measurement technologies at various stages of validation and accreditation for grading red meat traits. This project was submitted in response to an open call for co-investment proposals from businesses seeking to trial and adopt emerging objective carcase and/or live animal assessment technologies. While some technologies may not yet have achieved AUS-MEAT accreditation, the opportunity was open to all technologies for businesses to test and trial integration of developing equipment, and, where applicable, integration of software to enable MSA grading outputs from these technologies to plant systems.

There are currently no protocols for the adoption, implementation and integration of new objective measurement technologies into processor business operational and feedback systems. An early adoption process is required to drive the adoption of OM technologies for Australian red meat producers & processors. An open call process attracting various partners across several OM technologies at various stages of development and validation provided an opportunity to engage both the users (processors) and providers. Specifically, the opportunity exists to develop an adoption case study of a grading solution using an application for the portal E+V device to measure ribeye grading characteristics in beef.

E+V is a world leading company in Germany having its core business developing objective carcase measurement technologies. E+V has already achieved widespread use of its beef rib-eye grading camera technology in almost all US plants as an approved solution by USDA. It also has established track record working with Teys Australia meeting industry requirements in two plants, conforming to AUS-MEAT specification and gaining formal approval for its fixed camera system. E+V possesses considerable background know-how and intellectual property, placing it at the forefront of innovations in beef grading with practical installations in daily use all around the world. This project aims to continue the success at Teys by demonstrating a portable hand-held rib-eye camera already developed by E+V. The project will prepare and ship the mobile rib-eye camera to Australia and examine its use and accreditation challenges with the intent to establish approval under AUSMEAT requirements. The 'mobile-ribeye' camera provides further advantages as it may be used to grade carcasses in a chill facility, assisting graders with their assessment improving the evaluation process. The proposed work will provide a comprehensive report of all findings and potentially approval of the already developed technology for use at Teys potentially the whole Australian Beef sector.

The project has been initiated through the MLA tender invitation and the desire from Teys to expand on the beef grading solution achieved in collaboration with E+V focusing on the mobile rib-eye camera. The standard widely used 'static' rib-eye camera from E+V has been advanced and mobile (cordless) version has already been developed as a hand-held unit. The technology, already approved for use in many beef operations in the world is to be calibrated against the Australian Grading standards and an application for approval submitted to AUSMEAT and Meat Standards Australia.

The E+V system is significantly advanced and has provisional approval to measure ribeye grading characteristics in beef. This project aims to deliver an early adoption and evaluation of an application

for the portal E+V device to measure ribeye grading characteristics in beef. This early adoption project will be undertaken with Teys beef processing facilities and will accelerate adoption and industry uptake, subject to forthcoming accreditation. This project will contribute to a series of case studies generated through concurrent early adoption projects of several objective measurement (OM) technologies that were identified through an Open Call process. General learnings from this project will be used to develop generic guidelines for adoption and integration of new OM technologies.

1.2 Project Scope

This project aims to deliver an early adoption and evaluation of an application for the portal E+V device to measure ribeye grading characteristics in beef to improve accuracy and consistency compared to current visual grading methods. This project will develop operating protocols to enable adoption of a grading solution using an application for the portal E+V device to measure ribeye grading characteristics in beef for future adopters. Specifically, the project will evaluate the integration of E+V into a beef processor's workflows and business operating systems, including feedback to producers. General learnings from this project will be used to develop generic guidelines for adoption and integration of new OM technologies.

1.3 Expected outcomes

The outcomes of the project are expected to include:

- Consistent and uniform grading results across all sites:
- Ability to grade more carcases more efficiently with less labour and less cost
- Improve the transparency of the grading process to the producer
- Improve livestock selection to better meet brand and/or product specification
- Improved Data analysis
- Improved accurate and consistency of measurement of ribeye grading characteristics in beef compared to current visual grading methods
- Feedback on carcase traits back to the producer

This project will contribute to a series of case studies generated through concurrent early adoption projects of several objective measurement (OM) technologies that were identified through an Open Call process. General learnings from this project will be used to develop generic guidelines for adoption and integration of new OM technologies. The outcome will be a comprehensive final report that captures the lessons learnt, including challenges encountered and solutions identified to improve opportunities for future adopters.

2. Objectives

The overall objective of the project is to deliver an early adoption and evaluation of an application for the portal E+V device to measure ribeye grading characteristics in beef to improve accuracy and consistency compared to current visual grading methods. This project will contribute to a series of case studies generated through concurrent early adoption projects of several objective measurement (OM) technologies that were identified through an Open Call process. General learnings from this project will be used to develop generic guidelines for adoption and integration of new OM technologies.

This project's primary objective is to ensure consistent grading results to provide the most accurate supply chain feedback. This will drive producer engagement with brand specifications and improve genetic gain.

The specific objectives of the project are:

- Test and trial integration of developing equipment and integration of software into feedback systems, including MSA grading outputs
- Demonstration of capabilities of E+V mobile ribeye camera against AUS-MEAT requirements
- Evaluate the integration of the E+V portal device into Teys' workflows and business data management systems, including feedback to producers
- Adoption procedures for the technology to reach Australian beef processors
- Validation of test results contributing to AUSMEAT review of the mobile version of the E+V cold carcase grading camera
- Evaluate device grading capabilities across multiple classes of animals and sites

3. Methodology

Teys will partner with MLA and E+V to trial and validate their portal E+V camera across multiple sites. The methodology will use the past E+V extensive experience to significantly advance the MLA objectives to drive the adoption of such solutions within the MSA and AUS-MEAT process, procedures and practices.

The steps will include:

1. Engagement of Teys user site(s)
2. Preparation of the mobile unit for delivery to site
3. Preparation of the site and training for all those to be engaged at Teys
4. Engagement for the purposes of industry awareness of Beef processors other than Teys
5. Detailing of steps to be considered and compliance cross checks with AUS-MEAT requirements
6. Configuration and pre-shipment set up of first mobile unit
7. Shipment and first trials
8. Tuning of practices and repeat of trials
9. Collection of data
10. Assessment of results and review of status in consultation with all concerned
11. Repeat of trials and mapping against AUS-MEAT requirements
12. Review and planning of shipment of a second unit as may be required
13. Further trials and reporting
14. Submission of application to approve the mobile version for all (or the majority) of the carcase grading attributes
15. Final report to the MLA

3.1 Project planning & design

Project planning and design (Milestone 1). Conduct start-up meeting with Teys, E+V and MLA. Form steering project group. Develop trial plans Design & integration requirements. The progress report, including trial plans, design and integration requirements will be submitted to MLA for approval.

3.2 Equipment Ordering and Commissioning

Equipment ordering and commissioning including:

- **Preparation of mobile units for shipment to Australia**

- **Order & commission trial ready E+V App device(s)**

- **Data integration protocols**

- **Device training & technical support**

- **Conduct initial device trials at Teys site(s)**

- **Initiate testing protocols**

3.3 Conduct device trials across Teys sites as per the trial plan

Conduct device trials across Teys sites as per the trial plan, including:

- **Data Collection and Data Integration**

- **Review device performance and usability**

- **Optimisation and redesign**

3.4 Dissemination activity

No dissemination work has been conducted due to the device only meeting the criteria for one measurable attribute.

3.5 Final report

Final confidential and public versions was submitted and MLA approved.

4. Results

4.1 Project planning & design

4.1.1 Start-up meeting

The initial project planning meeting with Teys and MLA was conducted on February 10, 2022. Subsequently, the initial start-up meeting with the project steering group, including Teys, E+V and MLA was conducted.

Ongoing engagement and project planning between Teys and the E+V group was conducted, as required.

4.1.2   Develop trial plans

The project trial plans were developed, including estimated timelines, based on work previously done at Wagga Wagga with the E+V fixed camera but must meet the AUS-MEAT guidelines for conducting a trial and the aim is to gain enough data showing how the cameras perform when compared to the export MSA graders. [Refer to Section 4.2.5].

4.1.3   Design & integration requirements

Design plans, design & integration requirements, including the required components:

- Data collection and data integration
- Device performance and usability
- Optimisation & redesign
- Plant accessibility, livestock supply and available grading staff
- Availability of MSA graders for validation trials

Critical design elements considered:

1) Engagement of Teys user site(s)
   - Project kickoff meeting
   - Form steering project group
2) Preparation of the mobile unit for delivery to site
   - Preparation of mobile units for shipment to Australia
   - Order & commission trial ready E+V App device(s)
   - Data integration protocols
   - Device training & technical support
   - Conduct initial device at Teys site(s)
   - Initiate testing protocols
3) Preparation of the mobile unit for delivery to site
4) Preparation of the site and training for all those to be engaged at Teys
5) Engagement for the purposes of industry awareness of Beef processors other than Teys
6) Detailing of steps to be considered and compliance cross checks with AUS-MEAT requirements
   - Application for approval submitted to AUSMEAT
   - MSA grader assisting in comparison of grading vs E+V data capture
7) Configuration and pre-shipment set up of first mobile unit
8) Shipment and first trials
9) Tuning of practices and repeat of trials
10) Collection of data
    - Data collection and data integration
    - Conduct device trials across Teys sites as per trial plan
    - Review device performance and usability
    - Optimisation & redesign
11) Assessment of results and review of status in consultation with all concerned
12) Repeat of trials and mapping against AUS-MEAT requirements
13) Review and planning of shipment of a second unit as may be required
14) Further trials and reporting
15) Submission of application to approve the mobile version for all (or the majority) of the carcase grading attributes
16) Reporting

- Confidential report of commissioned, training and testing protocols, data collection, integration systems, and trial results
- Public case study of lessons learnt for early adoption of E+V Mobile App
- Future R&D submitted & approved by MLA

4.2 Equipment order and commission

Equipment order and commission, including:
- Preparation of mobile units for shipment to Australia
- Order & commission trial ready E+V App device(s)
- Data integration protocols
- Device training & technical support
- Conduct initial device trials at Teys site(s)
- Initiate testing protocols

4.2.1   Preparation of mobile units for shipment to Australia

Three (3) cameras, each with their own PC, were selected, programmed and calibrated by E+V in Germany. Each Smart phone Camera is validated against the E+V master calibration standards in the E+V factory in Germany. The three units were shipped to Australia and arrived mid-May 2022.

4.2.2   Order & commission trial ready E+V App device(s)

The cameras were ordered and were commissioned at the Teys Head Office in the first week in May. Refer to Figure 1 for image of the beef grading VBG Smart camera, which is similar to the one commissioned at Teys trial operation site.

Figure 1. E+V beef grading VBG Smart camera unit similar to the one commissioned at Teys trial site.

The original repeatability trial was to be conducted in the week commencing the 25th of April 2022 at Teys Beenleigh. As the cameras arrived late it was decided to combine the repeatability trial with the first validation trial which was conducted at Beenleigh in the week commencing the 23rd of May 2022.

There were significant issues with the quality of the quartering (consistency) and problems with the close proximity of carcases in the chillers which interfered with the way in which that camera interpreted the image (the camera had difficulty differentiating fat from adjacent carcases as not being part of the image to be assessed).

A second trial was conducted at the Wagga Wagga site later in May using the mobile camera but on the Fixed grading stand. This allowed more precise control over quartering and better positioning of the camera as there were minimal outside interferences. Refer to Figure 2 showing in chiller grading application of beef grading VBG Smart camera, and example of a screen display immediately after a grading measurement is taken.
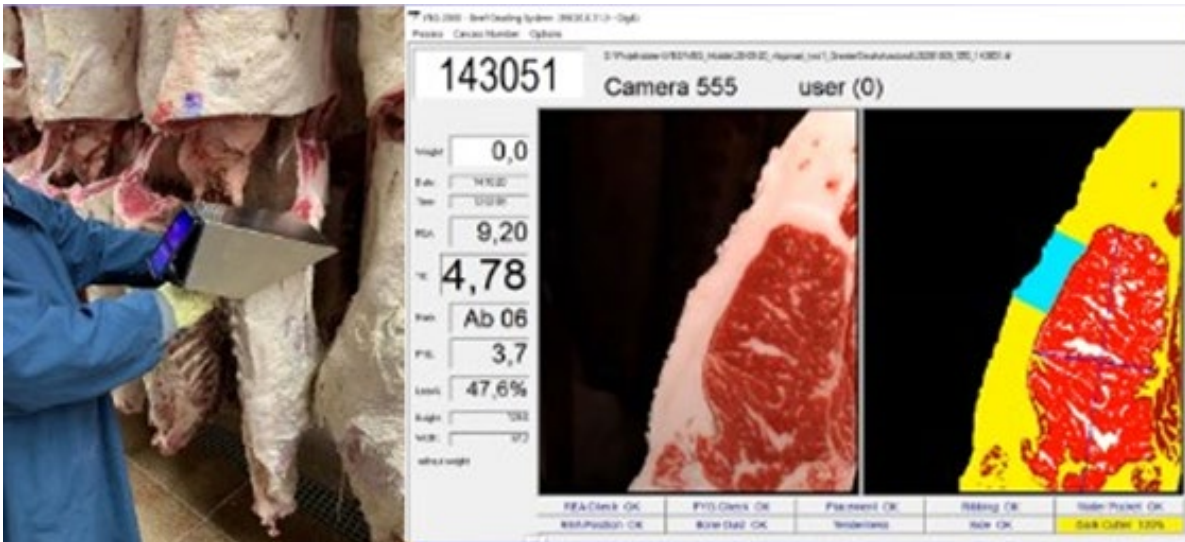
Figure 2. Application of the beef grading VBG Smart camera used in chiller grading of beef carcases, and an example of a screen display including grading score of a grading measurement.

4.2.3   Data integration protocols

The project trial plans were developed, including estimated timelines, based on work previously done at Wagga Wagga with the E+V fixed camera but must meet the AUS-MEAT guidelines for conducting a trial and the aim is to gain enough data showing how the cameras perform when compared to the export MSA graders.

4.2.4   Conduct initial device trials at Teys site(s)

Specifically, the agreed plan is to do the repeatability trial during the week commencing the 25th of April 2022 at Teys Beenleigh and the validation trial in the week commencing the 23rd of May 2022 again at Beenleigh. AUSMEAT will oversee the repeatability work. There was in principle support to provide at least two expert MSA graders for the validation trial, and AUS-MEAT's oversight of the trial is confirmed. The latest standards for validation were provided to Teys by AUS-MEAT after being recently updated and approved.

Collection of data, including:
- Data collection and data integration
- Conduct device trials across Teys sites as per trial plan
- Review device performance and usability
- Optimisation & redesign

E+V providing technical support and their own camera operator.

Assessment of results and review of status was in consultation and technical support with MSA and E+V.   Repeatability trial was not conducted during the week commencing the 25th of April 2022 at Beenleigh due to problems with correct quartering and placement of the device in the tight confines of the Beef chillers.

It was decided to move the initial repeatability work to Wagga Wagga and use the fixed camera stations to reduce the potential for the variability introduced by trying to use the device within the tight confines of the beef Chillers at Beenleigh. This work was done in Wagga Wagga in the commencing the 23rd of May 2022. AUSMEAT were present to oversee the repeatability work, requiring at least two expert MSA graders for the validation trial.

The cameras were taken back to Beenleigh for a further trial using the cameras in a more mobile manner. This happened on the 15th of June 2022.

Repeat of trials and mapping against AUS-MEAT requirements. AUSMEAT (Kurt Steele) provided Teys with the latest compliance standards that will be considered in the trial design. The guidelines and guidance documents have been recently updated at February's 2022 AMILSC meeting (and ongoing technical consultation with ALMTech).   AUS-MEAT in the process of making them publicly available online through the AUS-MEAT website. AUS-MEAT provided a copy of the updated documents:

- Guidance for Conducting a Trial [AUS-MEAT Requirements for Approving Equipment (25 Feb 2022)]
- AMILSC approved minimum requirements of accuracy standards for cut surface cameras [EAI002 Version 5.0 21/02/2022]
- AUS-MEAT confirmed their willingness to participate in the May proposed trial. [Confirmed in correspondence with Kurt Steele, AUS-MEAT on 25/2]

4.2.5   Proposed sampling plan

Overall, sampling has been substantially completed, however there are certain attribute classes and ranges that required more sampling. The intention is to collect these at the Beenleigh site over the next few weeks. The Beenleigh site offers a wider range of carcase types. Below is a chart of the approximate number of each Chiller Assessment attributes collected by the human graders at Teys Wagga. See table below (i.e. Table 1).

Table 1: Proposed sampling plan for E+V portable camera trial to be assessed and compared for various traits.

AUS-MB Score	AUS - MB	MC Score	MC	FC Score	FC	EMA Score	EMA	Rib Fat	Rib Fat
0	42	1B	0	0	113	<40	0	0 to 5 mm	266
1	384	1C	3	1	125	<60	11	5.1 to 10 mm	161
2	77	2	12	2	111	<80	233	10.1 to 15 mm	59
3	20	3	91	3	115	<100	259	15.1 to 20 mm	32
4	5	4	319	4	45	<120	28	20.1 to 25 mm	9
5	1	5	77	5	11	<140	0	25.1 to 30 mm	3
6	2	6	28	6	7	<190	0	30.1 to 35 mm	1
7	0	7	1	7	3			35.1 to 40 mm	0
8	0			8	1			40.1 to 45 mm	0
9	0			9	0				
# of Bodies	531	# of Bodies	531	# of Bodies	531	# of Bodies	531	# of Bodies	531

i)   *MSA and AUS-MEAT marbling (100 to 1190 MSA and 0 to 9+ AUS-MEAT)*

Tables 1 to 7 below propose minimum numbers of sides in each category. 40 was chosen for most categories because a standard calibration 'test' for AUS-MEAT graders is 20 random images, hence 40 can allow for two perfectly separate 'tests' for each category. Or any combination of images from multiple groups/categories would allow for many different tests to be conducted. Hence, the minimum number of sides from a marbling point of view is 440 but to fulfil all matrices for EMA, rib fat depth, meat colour and fat colour, it will take more than 440 sides over the sampling period.

Table 2: Suggested MINIMUM number of sides in each MSA marble category

MSA Marble Score	Minimum sides
100 - 200	55
201 - 300	55
301 to 400	55
401 to 500	55
501 to 600	55
601 to 700	55
701 to 800	55
801 to 900	55
901 to 1000	55
1001 to 1100	55
1101 to 1190	55
TOTAL	605

Table 3: Suggested MINIMUM number of sides in each AUS-MEAT marble category

AUS-MEAT Marble Score	Minimum sides
0	55
1	55
2	55
3	55
4	55
5	55
6	55
7	55
8	55
9	55
9+	55
TOTAL	605

ii)   Eye muscle area (EMA)

Table 4: Suggested MINIMUM number of sides in each EMA Range

Eye Muscle area	Minimum sides
<50	60
50 to 60	60
60 to 70	60
70 to 80	60
80 to 90	60
90 to 100	60
100 to 110	60
110 to 120	60
120 to 130	60
>130	60
TOTAL	400

iii) Rib fat depth

Table 5: Suggested MINIMUM number of sides in each rib fat depth category

Rib Fat depth	Minimum sides
<3	75
3 to 5	75
5 to 10	75
10 to 15	75
15 to 20	75
20 to 25	75
>25	75
TOTAL	600

iv) AUS-MEAT meat colour (1A to 7)

Table 6: Suggested MINIMUM number of sides in each AUS-MEAT meat colour category

AUS-MEAT meat colour	Minimum sides
1A	40
1B	40
1C	40
2	120
3	120
4	120
5	40
6	40
7	40
TOTAL	600

v) AUS-MEAT fat colour (0 to 7)

Table 7: Suggested MINIMUM number of sides in each AUS-MEAT fat colour category

AUS-MEAT fat colour	Minimum sides
0	75
1	75
2	75
3	75
4	75
5	75
6	75
7	75
TOTAL	600

4.3 Validation trial results

4.3.1 Device vs grader assessment

The following analysis was independently conduct by Garth Tarr working for Polkinghornes Pty Ltd.

For this analysis it is restricted only to bodies where there were three images taken from each device and where there is an average grader score across three graders.

Benchmarks are from V3.0 of AMILSC approved minimum requirements of accuracy standards for cut surface devices.

For the continuous traits, there are output measures of accuracy and consistency:

- **bias**: sample mean of the grader score minus the device score
- **slope**: slope of the simple linear regression of grader score (y) against device score (x)
- **rmse**: root mean squared error
- **rsq**: r-squared value
- **ccc**: concordance correlation coefficient

Even though the analysis is only considering the first image, it only retains the carcases with at least 3 images on each of the three devices - this helps to ensure that the samples that are being evaluated are quality images, if there was only one image, for example, taken that might indicate issues with the cut surface that caused issues with the device and therefore no further attempts to image that carcase were made.

4.3.2 Acceptable Images for analysis

The project team only retain observations where Teys have a first image and corresponding complete grading data [i.e. three graders]. This is implemented as an inner join between the device data and the grader data using body number and grade date as the identifier.

4.3.3 Application for approval submitted to AUSMEAT

No application has been submitted due to the mobile camera's not yet meeting the approval criteria for more than one grading trait when used in its mobile mode. That trait is MSA marbling.

The mobile device narrowly missed meeting the approval criteria for Fat colour and AUSMEAT Marbling.

This milestone has not yet been met due to the mobile device only meeting the criteria to measure one grading attribute. The fixed device had provisional approval to measure 4 attributes and was a more attractive proposition to be commercialised but was restricted as it was not mobile and therefore did not suit the majority of Australian plants grading requirements.

Further validation work will need to be conducted on the mobile version of the camera. What may also help is to make the camera particularly the shroud and trigger mechanism lighter.

On review of the data and the analysis done by independent analyst, the mobile cameras have only met compliance on one grading attribute criteria. Teys was hoping to get the same scope for the mobile camera that Teys got for the fixed camera but that hasn't been the case. More data was

collected at Beenleigh to evaluate the Mobile device to achieve the same grading data compliance as the fixed camera but given the variability of that data that made gaining compliance more difficult.

Teys considers the mobile cameras hasn't quite been the success that they would have hoped.

4.4 Finalise commercialisation plan

No commercial plan has yet been formulated until the device becomes approved to measure more attributes.

5. Key considerations on adoption of OM [Teys E+V Case study]

There were some key lessons, including:

- Teys has maintained its desire to move to the use of Objective Carcase Measurement devices:
    - To make the process more consistent
    - To make the process more transparent to producers
        - Also should allow the producer to be present remotely if they so wish
- Gold standards to calibrate both humans and devices against is absolutely necessary.
    - The variability between Graders including between the expert graders as well as the plant graders as highlighted in section 4.3.9 would make calibrating a device against human graders almost impossible in certain circumstance.
- The variability between Graders including between the expert graders as well as the plant graders as highlighted in section 4.3.9 shows Teys need better Objective Carcase Measurement devices to ultimately replace human graders.
- Fixed grading areas where some of the variability can be controlled give better results
    - But don't reflect the day to day reality of plant
- The ability to use the E+V portably camera would be improved is the shroud and trigger mechanism were constructed from a light material.

5.1 Process of adoption

Need to make the current E+V Camera lighter so make it easier to handle in the tight confines of a beef chiller before continuing the validation process.

5.2 Key considerations, insights & lessons learned

There were some key lessons:

- Teys has maintained its desire to move to the use of Objective Carcase Measurement devices
    - To make the process more consistent
    - To make the process more transparent to producers
        - Also should allow the producer to be present remotely if they so wish
- Gold standards to calibrate both humans and devices against is absolutely necessary

o The variability between Graders would make calibrating a device against human graders almost impossible in certain circumstances.

- The variability between Graders demands that Teys need better Objective Carcase Measurement devices to ultimately replace human graders

- Fixed grading areas where some of the variability can be controlled give better results, but don't reflect the day to day reality of most plants operations.

- The ability to use the E+V portably camera would be improved is the shroud and trigger mechanism were constructed from a light material.

5.3 Benefits, value proportions & potential impacts

No benefits are possible until the above issues as listed in 5.3 are resolved.

However, potential benefits are included in Table 8.

Table 8. Potential benefits of application of the E+V beef grading camera.

Technology enables	Value created by
1. Increased consistency and efficiency in carcase grading	Increase in supplier and customer confidence in product grading outcomes and feedback.
2. Improved feedback to suppliers	Confidence in data enables producers to improve compliance to specification
3. Improved transparency to the supplier of the grading process and outcomes of that process	Confidence in the process builds trust with the processors supply chain

5.4 Potential barriers to adoption

Conversely, potential barriers to adoption were consider (Refer to Tables 9 and 10).

Table 9: Barriers to adoption of the E+V beef grading camera.

Barrier / challenge	Mitigation
1. Validating against a variable set of human graders. The more graders used in the process, the greater the variation	Development of real scientifically based gold standards (e.g. intra-muscular fat measurement - Soxhlet and correlate that to marbling).
2. Designing technologies that suitable for the tight confines of a carcase chiller	Think laterally, you don't have to replicate the current human visual process (e.g. IMF). Maybe use AI to analyse smart phone images on the rib-eye which allows for human variation in quartering, camera placements and lighting variations.

Table 10. Apparent barriers to OM adoption from TeysOM early adoption journey.

Apparent barrier	Opportunity
Trust the data	• Continue to support early OM Adoption. • Support data comparison and benchmarking
Capability and Capacity	• Training device company champion • R&D investments in semi & full automation devices • Support data integration in business systems
OM impacts on $	• Support s=data comparison and benchmarking • Support provided to help review/revise business rules
Om Solution(s) costly	• Customised support offering for each early OM adoption pilot
Right time to adopt OM	• Enhanced awareness that both accredited & non-accredited solutions can provide value

6. Conclusion and recommendations

6.1 Conclusion

The E+V mobile camera is based on its fixed camera cousin. When used in the same environment as the fixed camera operated equally as well and no doubt would have gained approval in the same group of attributes that its fixed camera cousin achieved.

When used in in the beef carcase chillers it became a little limited as it required more space around the carcase to facilitate the correct placement of the mobile camera. This made the results that were obtained from grading in the carcase chillers less reliable that those gained whilst using it on the fixed grading stand. The ability to use the E+V portably camera would be improved is the shroud and trigger mechanism were constructed from a light material.

There were some key lessons. The most important being that gold standards to calibrate both humans and devices against is absolutely necessary. The variability between Graders would make calibrating a device against human graders almost impossible in certain circumstances.

That same variability shows Teys need better Objective Carcase Measurement devices to ultimately replace human graders.

6.2 Key findings

6.2.1   Project planning and design [Milestone 1]

Project planning and design was successfully achieved, including:

- Conducted start up meeting with Teys, E+V and MLA
- Form steering project group
- Develop trial plans
- Design & integration requirements

6.2.2 Equipment order and commission [Milestone 2]

Equipment order and commission was successfully achieved, including:

- Preparation of mobile units for shipment to Australia
- Order & commission trial ready E+V App device(s)
- Data integration protocols
- Device training & technical support [Status: completed
- Conduct initial device trials at Teys site(s) [Status: completed
- Initiate testing protocols

6.2.3 Conduct device trials across Teys sites as per the trial plan [Milestone 3]

Conduct device trials across Teys sites as per the trial plan, including:
- Data Collection and Data Integration
- Review device performance and usability
- Optimisation and redesign

Overall, sampling has been substantially completed, however there are certain attribute classes and ranges that required more sampling in order to show that the technology can meet the validation criteria for the same range of attributes that the fixed camera previously held provisional approval for. The intention is to collect these at the Beenleigh site when the MSA expert graders are available. The Beenleigh site also offers a wider range of carcase types.

6.2.4 Dissemination activity [Milestone 4]

This milestone has not yet been met due to the mobile device only meeting the criteria to measure on grading attribute. The fixed device had provisional approval to measure 4 attributes and was a more attractive proposition to be commercialised but was restricted as it was not mobile and therefore did not suit the majority of Australian plants grading requirements.

6.3 Benefits to industry

No benefits at this time due to the not having yet gained approval for a reasonable number of grading attributes. However, given the performance of the mobile device on the fixed grading platform there is no doubt that re-engineering it into a form that was more suitable for use in the more cramped environment of a beef carcase chiller there could be benefits to the industry.

6.4 Future research and recommendations

Teys considers the mobile cameras hasn't quite been the success that Teys would have hoped for. Compliant data has been achieved for 1 attribute only when the camera was used in mobile mode.

There were some key lessons, including:

- Teys has maintained its desire to move to the use of Objective Carcase Measurement devices
  - To make the process more consistent
  - To make the process more transparent to producers
    - Also should allow the producer to be present remotely if they so wish

- The development of scientifically based Gold standards to calibrate both humans and devices against is absolutely necessary
    - The variability between Graders would make calibrating a device against human graders almost impossible in certain circumstances.
- The variability between Graders shows Teys need better Objective Carcase Measurement devices to ultimately replace human graders
- The ability to use the E+V portably camera would be improved is the shroud and trigger mechanism were constructed from a light material.