Milestone report

AMG Scribing Project

AMG Automated Robotic AI 3-cut Beef Scribing System

Public Interim report

Project code	Milestone no.	Prepared by	Date submitted
2024-1062	11	Allister Watson	24/10/2025

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1.0 Milestone description

Milestone 11

This Milestone requires a Public Interim report and Snapshot of the project thus far including images and photos and a video to be approved and published on the AMPC website.

The report also requires an independent audit conducted by Greenleaf to confirm the key performance specifications, run rate, cut specifications and yields that were assumed when the project commenced

2.0 Abstract

The public interim report outlines the process that AMG, IR and AMPC have gone through in the past 20 months from when the project commenced. There have been delays along the way due to construction delays, manufacturing delays and shipping issues, however, the project has delivered so far against the expectations that were set out in the original proposal.

The Greenleaf audit that is attached to this report shows that the expected return per carcass and payback period for the project is on target and will improve as the plant and the scribing system develop. We are all now looking at how we can enhance the system over the rest of the project timeline.

The video, also attached to this report, shows the Scribing saw robot in action running at 85 head per hour.

The project will move to the next milestone.

3.0 Project objectives

- Perform an initial kick-off meeting discussing all trialling and risk mitigation activities to date, as well as reviewing the design of the system and project plan.

- Design and manufacture an automated beef scribing system for AMG Cootamundra, which is able to perform the three scribing cuts required for their operations, as per their standard dressing, plant throughput, and capable of withstanding the environment

- Program and test key functionalities of the system, including automatic identification of the cut coordinates using sensing with AI, and communicating them to a robot(s) to perform the scribe cuts

- Install and commission the system on site at AMG's plant in Cootamundra

- IR to provide a 4-year advanced support plan which includes system monitoring and performance reporting to AMG and AMPC

4.0 Methodology

The planned methodology for the project is as follows:

1. Kick-off meeting to discuss review of pre-engineering project; IR-Scribe design for AMG; and project plan

2. Procure long lead time items for the system (preceded by finalising Electrical and Mechanical designs and equipment selection associated with these components)

3. Create electrical schematics and manufacturing drawings for the AMG IR-Scribe system

4. Perform programming for the key functionality of the AMG IR-Scribe system. Offline and unit testing of code to be performed.

5. Perform build and power-up testing of electrical panel, robots, and stabilisation conveyor before being transported to site. Extensive integrated testing of all programming elements (PLC, robot, vision PC) in Digital Twin environment to confirm functionality and error handling. Demonstration to AMG.

6. Perform building modifications, installation of required services, modification of rail works, and installation of new overhead chain

7. Perform site installation of the AMG IR-Scribe system at the AMG Cootamundra processing plant.

8. Perform 'dry commissioning' of the system (i.e., initial commissioning without processing carcases)

9. Perform 'wet commissioning' and production ramp up (i.e., beginning to introduce carcase to perform testing, and ramp into production with production runs of increasing length, eventually ramping into full production)

10. Provide documentation and training to AMG

11. Greenleaf to conduct an independent Audit.

12. IR advanced support plan, to provide spare parts and four years of advanced support once the system is in production which includes regular site visits, tuning of algorithms, and IR performance monitoring and reporting to AMG and AMPC (e.g., uptime, downtime, number of carcases cut vs not cut, etc)

As per step 1 of the project methodology the kick-off meeting between the key stakeholders was held on 15/03/2024 where the design and layout requirements were reviewed and agreed.

Key aspects of the electrical and mechanical design for the IR-SCRIBE system have been agreed upon between AMG and IR, as per the work done in AMPC project 2023-1045.

5.0 Stage summary (review of previous stage where applicable)

Stage 1 - An initial meeting was held on 15/3/2024 between all parties to agree the design and layout of the IR-Scribe system. The project schedule was agreed, and the site was ready for fit out. The following scope was agreed.

- The IR-SCRIBE system as detailed in the pre-engineering project (AMPC project 2023-1045) was reviewed in terms of scope of supply and operating principle, as well as high-level electrical and mechanical design
- No key changes were deemed necessary
- The system will be designed to work with AMG's RFID hook tracking
- Some clarifications to the requested cut specifications were noted.
- Standard dressing and carcass presentation were agreed upon.

Stage 2 - This stage was to ensure all suppliers were contracted and any delays from them would be worked through in the project plan.

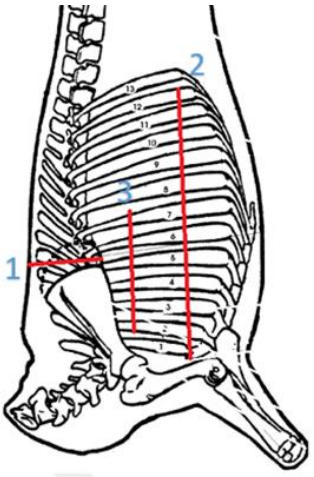
- AMG mobilised the suppliers for building construction, Electrical works and the overhead chain.
- IR mobilised suppliers of long lead-time items and key equipment including
    - turning and cutting robots and robot controllers
    - long lead-time controls equipment
    - stabilisation conveyors for infeed and cutting as well as hex transfer
    - safety fencing
    - main control panel
    - robot bases, camera enclosures and other key manufactured items

Stage 3 – The electrical design of the IR-Scribe system along with the schematics was completed. The mechanical design and manufacture drawings were also drafted up for the system.

- The system layout has been modified to suit the AMG plant, as well as to factor in changes and optimisations to the IR-SCRIBE system's operation. AMG performed a 3D scan of the area which was utilised to ensure everything could be positioned correctly, particularly with respect to beams, ducts, and other infrastructure.

Stage 4 – Key programming and testing for the IR-Scribe system for AMG was completed.

- The IR-Scribe system was programmed to perform the three cuts as per AMG's cut specifications:



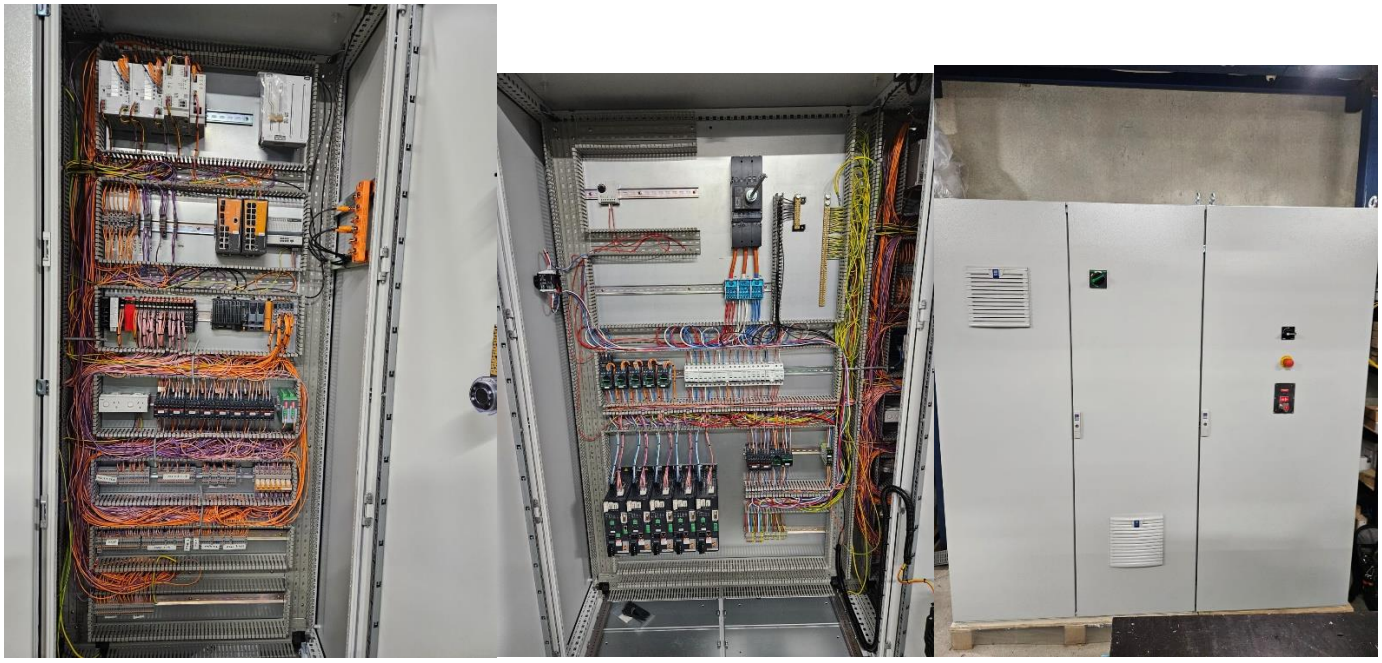
- In terms of process, the IR-SCRIBE system operates under the following conditions for AMG which needed to be considered for the programming:
- *Cut behaviour*
    - All cuts are performed with one cutting robot
    - Cut placed on side as per aforementioned specification, including automatic adjustments (e.g. short rib/chuck rib width)

    - Individual cuts to be able to be disabled
    - Carcases are to be presented with one side knifed out at the grading site (for chiller assessment), and the other side scored only at the grading site, resulting in a change in presentation between the two sides for a given body
    - Cut specifications can be identified from hook RFID information and automatically applied for that individual side
- *New scribing chain operation*
    - Additional sensing/hardware at feeder stations to prevent roll-on of roller hooks
    - Adjustments for different rail height
    - New stacker accumulation implementation for increased reliability and system uptime
    - Upgrade of conveyor control hardware for more accurate system speeds and cutting
- *Sensing upgrades*
    - Implementation of upgraded camera
    - New setup for orientation station sensing
    - Implementation of new re-fixturing methodology to incorporate more reliable and accurate point of interest information
- *Hardware upgrades*
    - Selection of new motor control drives for improved functionality
    - Additional conveyor sensing hardware to detect more hardware failure modes
    - Lighting simplification for decreased failure modes
    - Changes to safety implementations.

- The Vision Program, PLC, HMI, Safety PLC and motion control programs were updated, and the code modifications were unit tested within the development environments to ensure it operates as expected in isolation.

Stage 5 – The manufacture of the system components by the IR-Scribe team was completed

- The main electrical panel and field panels have been constructed and wired up.



- The build for the mechanical components for the IR-SCRIBE system got underway. The OEM components (including saw and vision lights) were ordered

Stage 6 – Integrated testing of the programming elements was done by Intelligent Robotics in a Digital Twin. The building modifications were completed, and the overhead chain was manufactured and installed on site.

- The IR-SCRIBE system for AMG had a Digital Twin developed, emulating the physical layout of the system. CAD models of the system were imported to recreate the layout, including components to create carcase objects and move them along the system's conveyors/chain, trigger sensors, and be moved by actuators such as cylinders. The programmable elements of the system (PLC, HMI and robot virtual controllers, together with the PC/vision processing software) were then linked into the digital twin, allowing them to communicate with the digital twin environment, and each other.
- By setting up the Digital twin, the HMI could be used to emulate programming sequences such as start-up routines, manual service routines (such as blade washing), as well as production simulation. To perform production simulation, the PC/vision software was set to run off log data to emulate the program flow of the final system as closely as possible.
- Performing this setup and testing has allowed all programming elements to be tested as extensively as possible before the system is installed on-site. It allows not just the individual programs to be tested, but also the communications and interactions with each other. It also allows for confirmation of timings and cycle time analysis as a result of the carcase object movements being simulated through the system.
- Throughout the digital twin testing the following sequences were tested, using previously attained vision data.
    - Scribing Robot and Turner Start up Sequences
    - Scribing Robot Manual and Calibration Functions
    - System running in normal operation, including
        - Typical running at design rate
        - Artificially inserted Vision Errors
        - Artificially inserted Robot Errors
        - Artificially inserted conveyor and chain errors

- Throughout integration testing, it was concluded that the various programs are ready for installation onto site.

Empty Digital Twin Picture

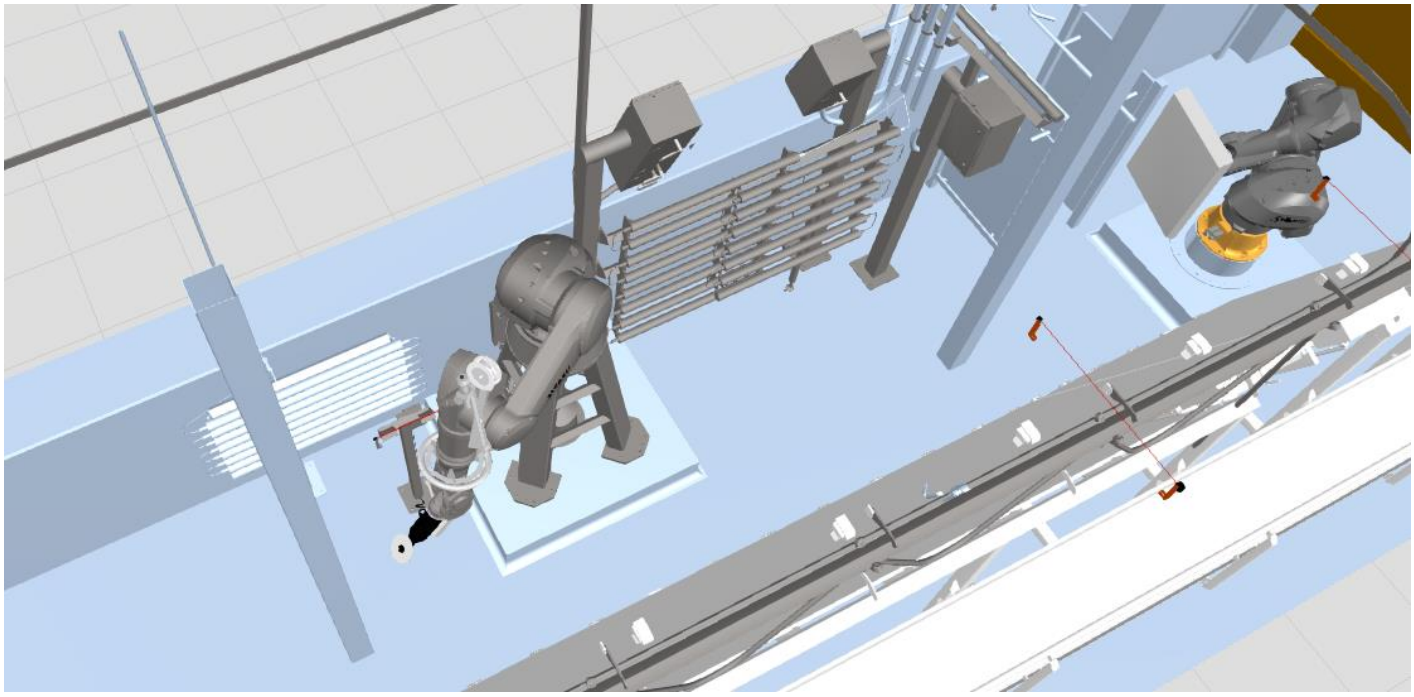


Figure 1- Scribe Robot Blade Change Position

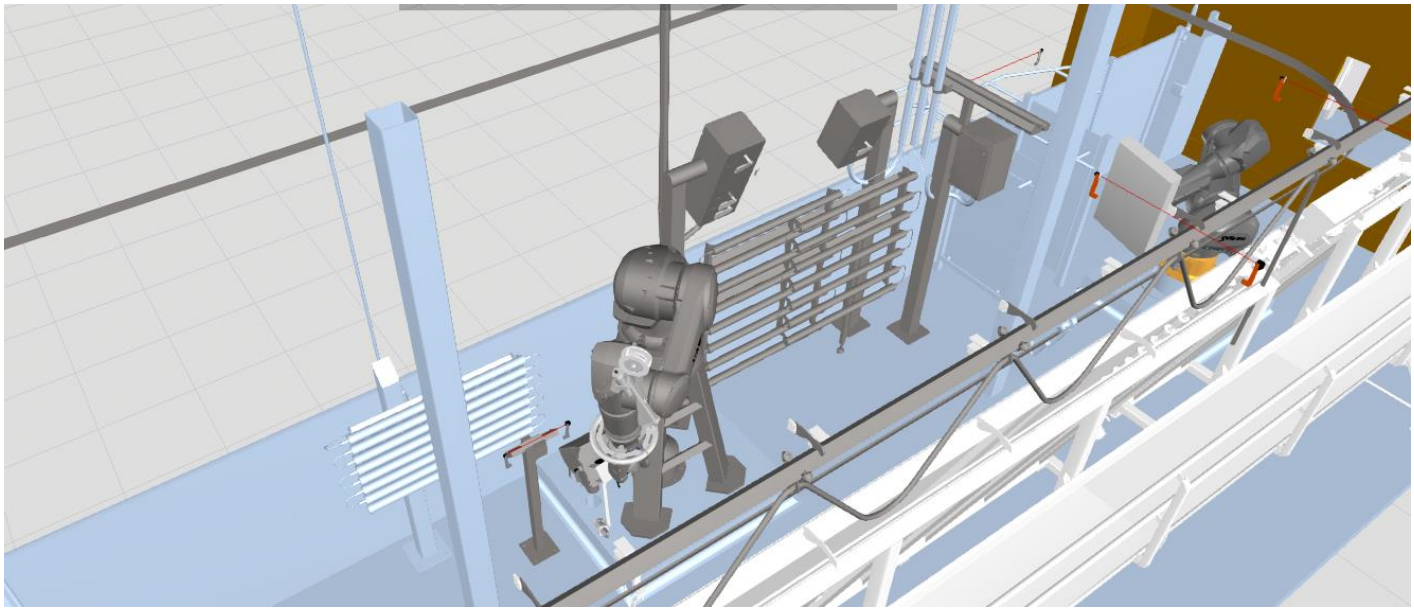


Figure 2- Scribe Robot Sterilize

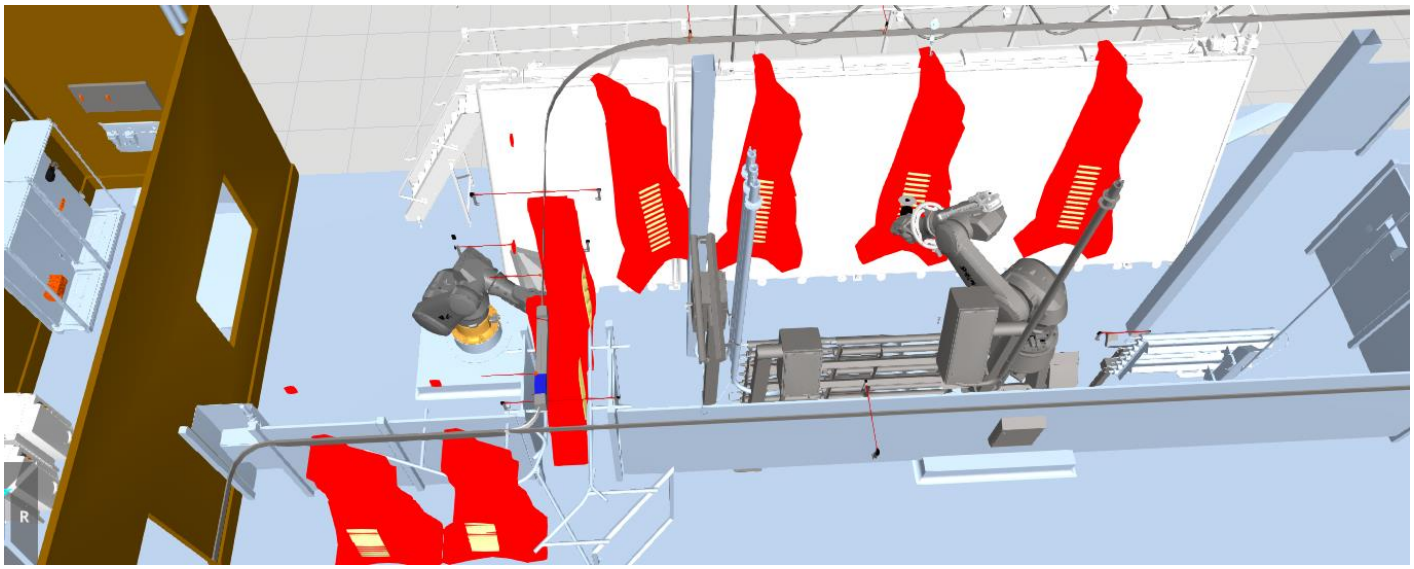


Figure 3- Scribe Robot Side 5/6 Cut

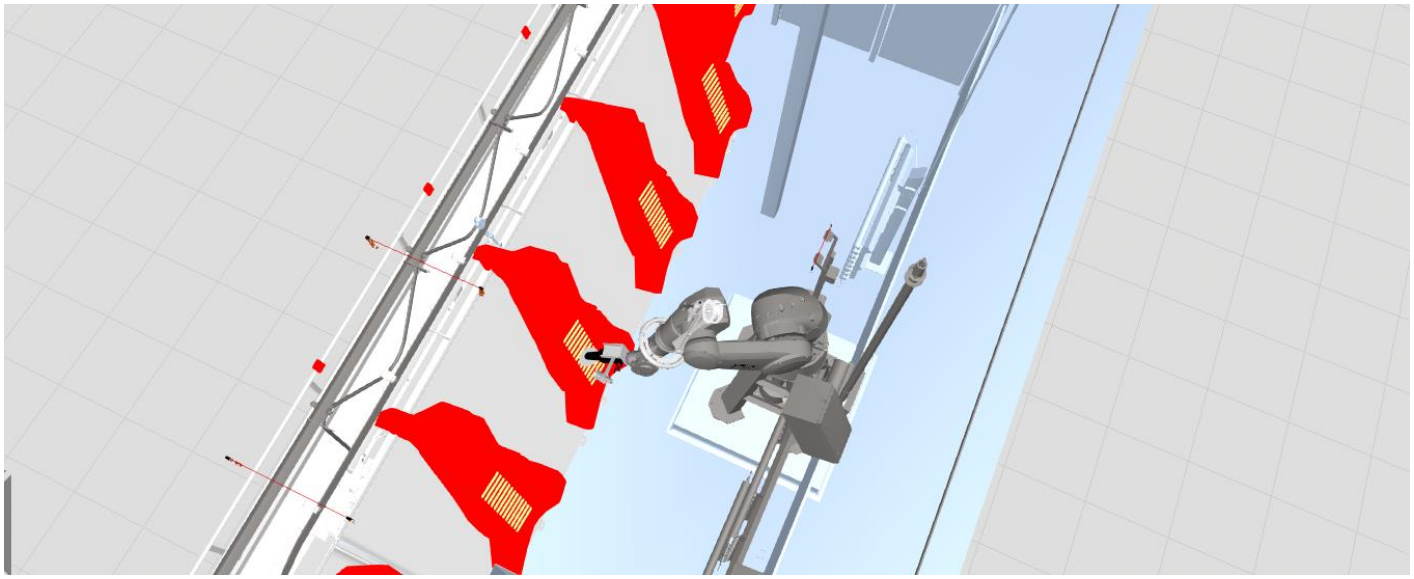


Figure 4- Scribe Robot Side 5/6 Cut

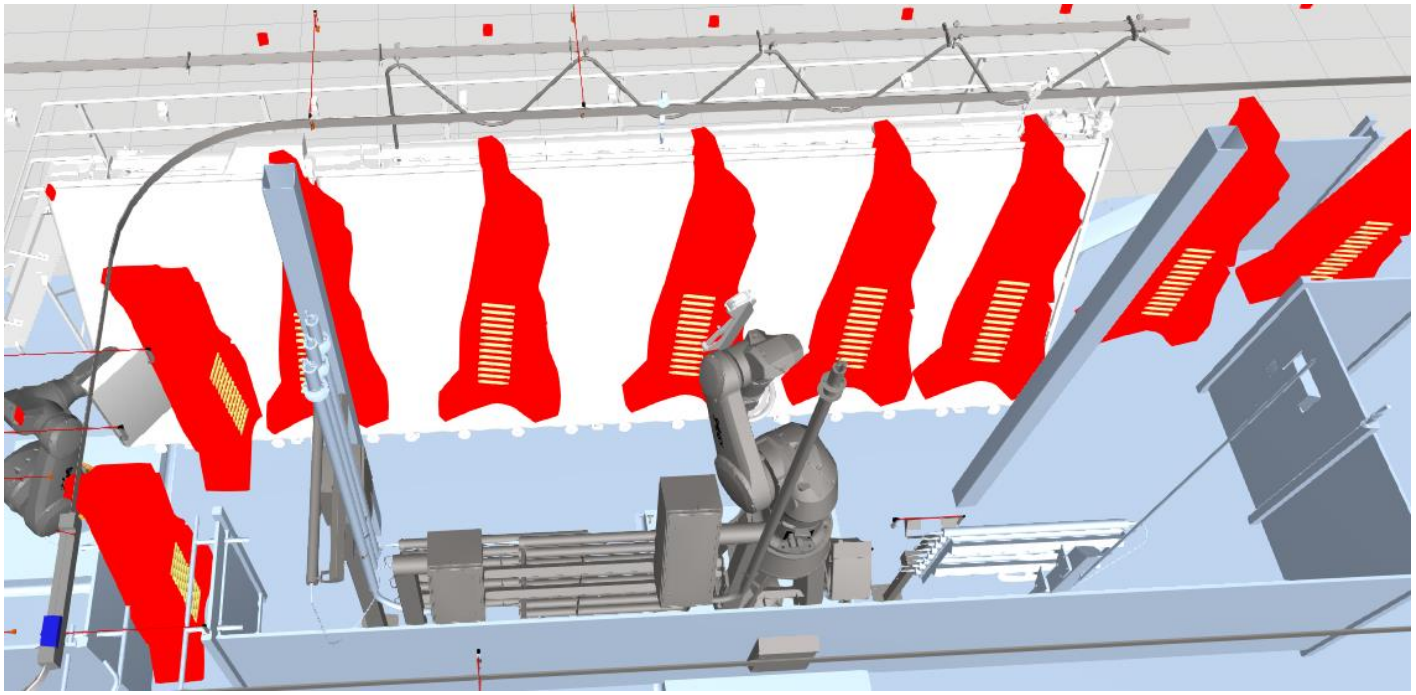


Figure 5- Scribe Robot Rib Cut Bottom

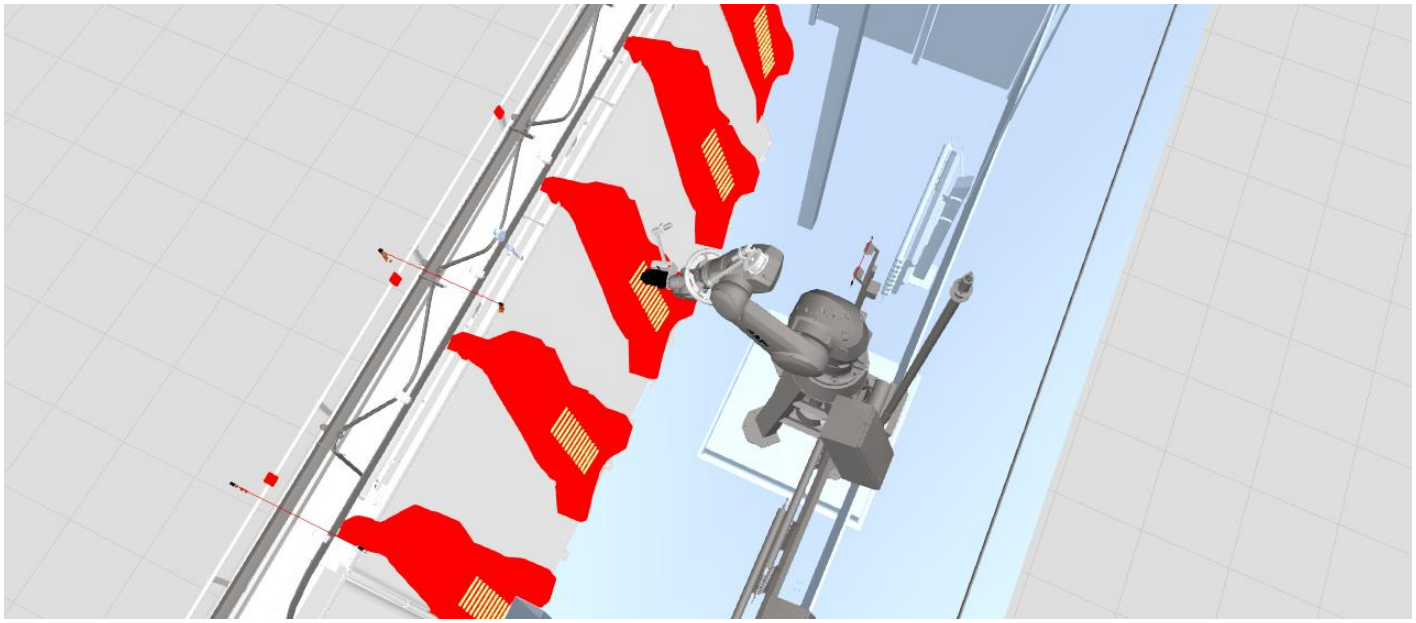


Figure 6- Scribe Robot Brisket Cut

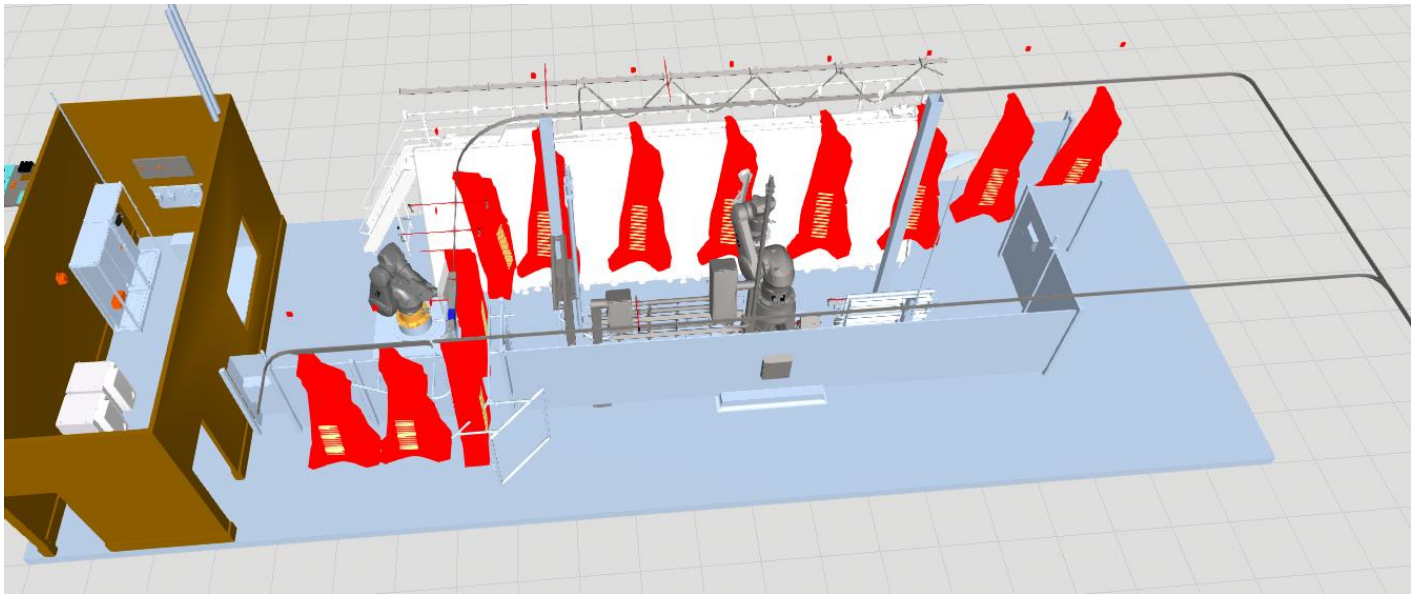


Figure 7- Digital Twin Running

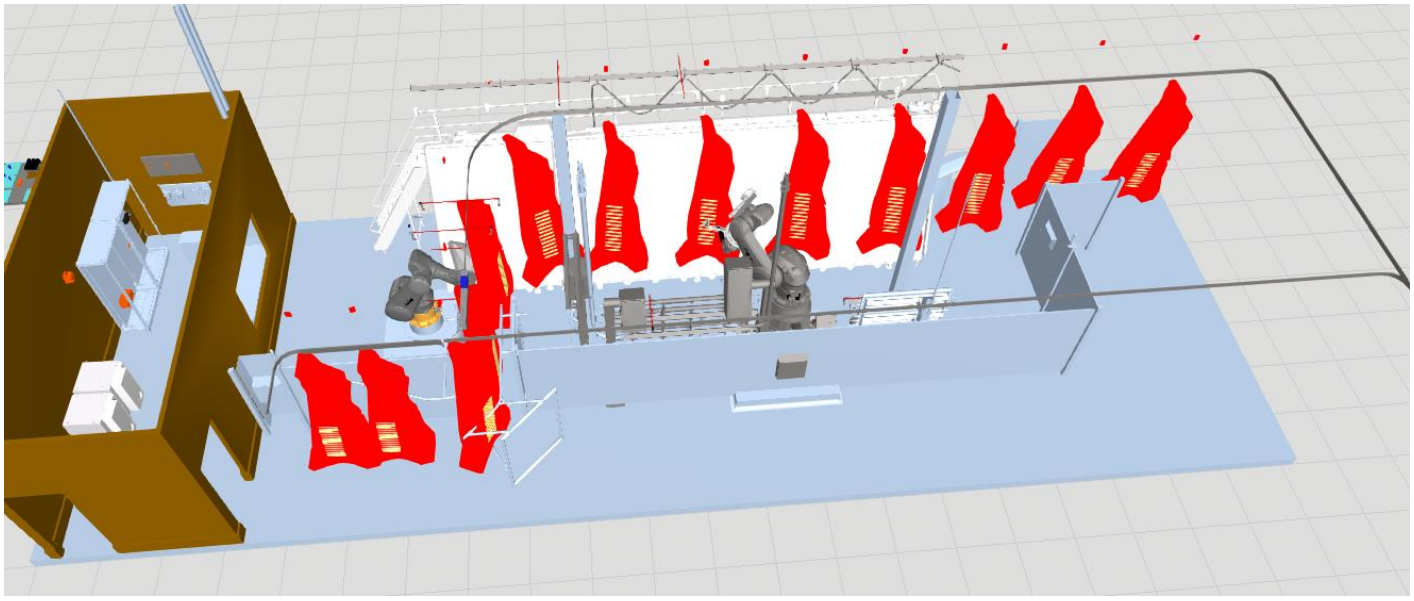


Figure 8- Digital Twin Running at design rate

- The building was completed, and the overhead rail was manufactured and fitted.









Stage 7 – The IR-Scribe system and components were installed as of 7/11/2024 and dry commissioning commenced on 12/11/2024


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- Tasks Completed on Site, By Electricians and Project Engineers
    - Electrical Installation
        - Installation of Cable Tray in roof and under the floor, and running of associated cables
        - Installation of J-Boxes and SMC nodes in the roof and underneath the floor
        - Wiring of all water valves underneath the floor (completed and waiting for plumbers to finish off their installation)
        - Install of all sensors, including Robot sensors, chain sensors, and cameras
        - Installation of user button boxes, and HMI
        - Installation of safety sensors, devices and Estop Pushbuttons
    - Robotic power-up testing
        - To ensure correct installation of the system, the robots were tested their
        - It was confirmed that the robots worked successfully, to ensure a smooth commissioning.
    - Motor drive testing
        - Each individual motor drive and encoder was tested individually post installation
        - Each motor was run and tested to ensure that the currents were okay, rotations were correct, and run for significant amounts of time to ensure that each motor and conveyor worked correctly
        - All motors had their currents recorded for future use and debugging
    - Electrical installation validation testing, including:
    - Insulation testing for all AC cabling at 1000V
    - Earth continuity to main Earth Bar in MCC
    - Motor winding resistance checks
    - MCC isolator verification

Stage 8 – Dry commissioning was to be completed, and the cell was readied for wet commissioning to begin.

The key tasks performed included:

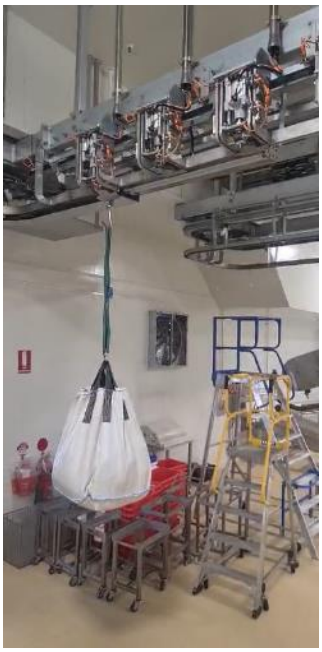
- IO Testing
    - All IO was tested to ensure correct wiring, including
    - All IO was confirmed, to ensure that all wiring was correctly installed for the whole system
- Safety Validation
    - Safety functionality was validated, to ensure that the safety system worked as expected. This included:
        - Estop testing for all estops and lanyards, including validation of category 4 protection through removing individual cores, shorting cores to 0V and 24V
        - Testing of entry request and interlocking key requirements, including validation of category 4 protection through removing individual cores, shorting cores to 0V and 24V
        - Testing of hot water valve safety requirements, including removal of cores to simulate valve failure in a redundant pair
        - Testing of External Device monitoring to ensure safe operations of safety contactors, including failure detection of a contactor.
    - Through this process, it was concluded the install was successful, and removed possible safety issues due to incorrect installation

SAFETY SYSTEM FUNCTIONAL TESTING

	SAFETY DEVICE VALIDATION		Test No.											
Device Function	SAFETY INPUT DEVICE	Device #	1.1	1.2	1.3	2.1	2.2	2.3	3.1	3.2	3.3	Pass / Fail
Emergency Stops	MCC Emergency Stop	S402J38				ALL OUTPUTS DE-ENERGISED	ALL OUTPUTS DE-ENERGISED			EDM DOES NOT ALLOW RE-ENERGISE IF OF LOST SET TO RE-ENERGISE	EDM DOES NOT ALLOW RE-ENERGISE IF OF LOST SET TO RE-ENERGISE (TRIES TO RE-ENERGISE AND DROPS BACK OFF	Pass
	Turning Station Estop	S405C37										Pass
	Al Station Estop	S405C28										Pass
	Scribing Robot Estop	U530										Pass
	Turning Robot Estop	U520										Pass
	Pushbutton Station Estop	S602J20										Pass
	Gate Entry Infeed Estop	S622J20										Pass
	Gate Entry Outfeed Estop	S612J20										Pass
Lanyards	Conveyor Lanyard	S406C20										Pass
Entry Gates	MCC Gate Entry	S406J11										Pass
	Gate Entry Infeed	S622J11										Pass
	Gate Entry Outfeed	S612J11										Pass
Safety Mats	Gate Entry Infeed (1-4)	S823										Pass
	Gate Entry Outfeed (1-4)	S613										Pass

- Overhead Chain and Conveyor travel testing
    - Logic for running overhead chain speed, feeders and stacking stations tested
    - Logic for running conveyor tested
    - Weighted bag moved into cell, into backing conveyor and through stacking stations successfully



- Conveyor and Overhead chain speed calibration and synchronisation
- Performing and testing all calibrations of robots and cameras

- Programming and testing of all maintenance positions with the robot



- Air swing dry cycle testing to confirm programming and cable runs
    - Turner robot dry cycled




- Cutting robot cycled through dummy cutting cycles





- With these tasks having been performed, the system was ready to be washed down and inspected for hygiene, before commencing wet commissioning testing involving carcases being in the cell.

Stage 9 – Wet commissioning was completed

- The work conducted at this stage culminated in continuous runs spanning over 30mins long to:
  - Demonstrate the suitability of all mechanical components (including overhead rail components) to cope with continuous running
  - Debug any issues with the controls code related to running, including continuous running as well as starting, stopping, slowing, and utilising stacking stations
  - Demonstrate the ability for the vision processing to identify cuts and for the robot to perform the cuts within cycle time, making any adjustments to the robot motions as necessary
  - Demonstrate the ability for the turner to perform both turning and guiding cycles during continuous running
- The key tasks performed during Wet Commissioning included:
  - Initial carcase running trials through the cell

- Initially one at a time, ramping up into short runs where carcases were run through the cell during production
- Confirm and tune chain and conveyor speed factors, and calibration to the robot conveyor tracking
- Tuning of guide bars
- Tuning of stacker station logic and timings
- Testing of starting, stopping, slow-downs and speed-ups
- Initial testing of ‘turning’ and ‘guiding’ cycles
- Cell was run for ~4 to 5 hours during the longest run, at approximately 70-75hd/hr (the line speed requested by the supervisor)

- Stationary cutting
  - Using initial AI algorithms and vision processing code to perform cuts on carcases on the backing conveyor
  - Performing initial tuning of vision parameters to position cuts accurately
  - Tuning of robot motions including approach and retract moves
  - Progressing to performing all three cuts (5/6 spine cut and two rib cuts) as per AMG specification



- Tracking Cutting
  - Tracking cuts were performed, to confirm similar accuracies between moving and stationary cutting
  - Multiple sides cut one at a time, and a few in a row

- Air swing testing and robotic turning on moving carcases
  - Starting with one side at a time moving from infeed to outfeed, and progressing to short production runs at target line speed
  - Running sides through the cell with Turner’s AI vision network to orient sides correctly, and tune robot motions
  - Perform air swings from the robot at the target line speed, utilising the cutting vision results, without the blade installed on the saw
  - Cell was run for ~4 to 5 hours during the longest run, at approximately 70-75hd/hr (the line speed requested by the supervisor)





- Cutting production runs
    - Performing short production runs with the cutting robot performing cuts to the vision results
    - Target was to isolate big issues / code problems preventing longer runs
    - Transitioning into these trials also coincided with AMG ramping up production, and therefore their required line speeds and target boning room throughputs. This led to a request to run faster than the previous runs performed.
    - In this phase, a significant issue with the cutting conveyor was encountered causing it to fault while running. It was assessed that the core issue was likely that the motor was undersized. A new, larger motor was arranged to address this.
    - Apart from this issue, no other significant issues were encountered which would prevent longer running lengths.



Stage 10 – Production Ramp up, System Documentation and Training

- The key tasks carried out within this milestone include:
    - System Reliability Tuning
        - Bugs and issues around running, and operations were found, and removed, through day-long run times
        - Working on development of code to avoid machine and carcase damage by hitting spines of sides of which the grading cut has been extended too far



- Vision Reliability tuning and cut-rate increase
    - Bugs were removed within the AMG vision processing
    - Extra developments were included to allow for higher cut rates, to attempt to cut all bodies including those with dressing defects
    - Cut rates were dramatically improved.
- Robot Cycle Time Improvements
    - The Robot motions were observed closely and improved to ensure that the system could meet cycle time requirements
    - Through analysis and testing, the robot was confirmed to be able to cut sides to specifications of 85 head/hour

    - Robot cutting 5/6 cut



- Robot cutting rib set





- System Accuracy
    - System accuracy was incrementally improved through continued tuning of cutting parameters and vision processing.
    - The specification of the system is:
        - Cutting the 5/6 cut within +/- 5mm of the 5th rib,
        - Cutting rib cuts to a maximum of 200mm (+/- 5mm) if it can fit, otherwise cutting the rib section to the biggest size that can fit inside the rib cage
        - Cutting rib cuts such that the rib width does not deviate more than +/- 5mm
    - This occurred over a few weeks, to bring the cut accuracies to be within specifications
    - These metrics were improved to levels well within the system specifications.
    - Cut accuracy specifications were confirmed by measuring ribs and 5/6 cuts at many different points throughout the day, on a multitude of different days, to ensure the system met specifications for all body types.
    - The body types tested among the rib and 5/6 measurement trials included, but are not limited to:
        - Angus
        - Bulls
        - Manufacture grade
        - Non-Halal
        - Grain fed
        - Premium
        - MSA at various grades
    - Daily Results for measurements below:

14-05-2025

Rib Measurements

Total Measured	Total Outside Parralel Specification	Total Outside Size Specification	Pass %
150	0	0	100%

5/6 Measurements

Total Measured	Total Outside Specification	Pass %
140	0	100%

15-05-2025

Rib Measurements

Total Measured	Total Outside Parralel Specification	Total Outside Size Specification	Pass %
139	0	0	100%

5/6 Measurements

Total Measured	Total Outside Specification	Pass %
150	0	100%

16/05/2025

Rib Measurements

Total Measured	Total Outside Parralel Specification	Total Outside Size Specification	Pass %
100	0	0	100%

5/6 Measurements

Total Measured	Total Outside Specification	Pass %
150	0	100%

19/05/2025

Rib Measurements

Total Measured	Total Outside Parralel Specification	Total Outside Size Specification	Pass %
200	1	2	99%

5/6 Measurements

Total Measured	Total Outside Specification	Pass %
174	0	100%

20/05/2025

Rib Measurements

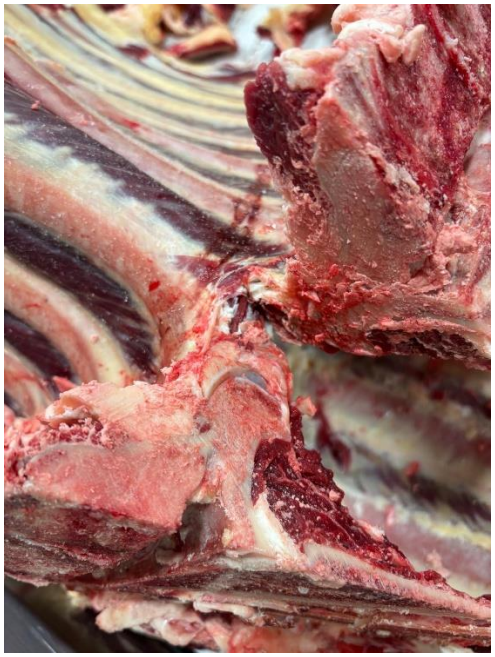
Total Measured	Total Outside Parralel Specification	Total Outside Size Specification	Pass %
100	0	0	100%

5/6 Measurements

Total Measured	Total Outside Specification	Pass %
100	0	100%

- Example images of 5/6 cuts, cutting just on top of the 5th rib:





- Examples of Parallel Rib Cuts



- Training
  - Operator training was performed through a prolonged training regime, as the Principal Operator joined us through the commissioning and ramp-up processes
  - The Maintenance training was carried out by IR Service personnel.
- Documentation
  - Documentation was developed, updated and provided to AMG
  - This documentation was also placed on the HMI, so that it was easily accessible for those that needed it, and it was provided as well in hard copy, inside the IR-Scribe control room.
- Spare parts list
  - Non-critical and recommended spares were listed for AMG in order to allow maintenance to order the spare parts that was necessary
  - Critical spare parts were listed, and items included in the Intelligent Robotics scope of supply were provided
- System Validation through prolonged running
  - The system operation, cut rates, accuracies and reliability was confirmed by running the system 5:30am – 4:30pm each day of operation

Stage 11 – Independent audit conducted by Greenleaf and production of a video for the public domain. Along with this report a Snapshot will also be produced.

- The following is the Executive summary from the Greenleaf audit. Although it is still early days with this project, the results align with the project assumptions when we submitted the project and will only improve as we fine tune the cutting lines to maximise the value from each carcass. The full report is an attachment to this report.

Executive Summary

The Intelligent Robotics (IR) automated scribing system operating at AMG plant was reviewed over several days comparing the manual scribing accuracy to the automated scribing system for all carcases and specifications processed during the period. The cut value prices applied in the modelling are industry averages. The accuracy of the IR automated scribing system has an improved cutting accuracy over manual operators for all cutting lines. As can be seen in Table 1 the IR scribing system provides a payback of between 1.97 and 2.18 years based on the ex-work capital cost and between 3.69 and 3.72 years for the overall AMPC project. The benefits are based on the actual system accuracy of the cutting lines shown in Table 2, with an overall gross benefit of between $5.25 and $5.83/carcase when including the ongoing maintainence costs of the system. Maintenance costs are excluded from the second scenario as they were included in the AMPC project. The cube-strip separation was not validated as this cut is not currently undertaken at AMG.

Table 1: Summary of performance measures

SUMMARY PERFORMANCE MEASURES				
	Automated - Ex-Works		Automated - Overall Project Cost	
Hd / annum	239,892		239,892	
	From	To	From	To
Capital cost (pmt option, upfront)	$2,750,000		$5,020,315	
Gross return Per head	$5.66	$6.23	$5.66	$5.70
Total costs Per head	$0.98		$1.07	
Net Benefit Per head	$4.68	$5.25	$4.58	$4.62
Annual Net Benefit for the plant	$ 1,122,548	$ 1,260,312	$ 1,099,032	$ 1,108,801
Annual Net Benefit for the ex cap	$ 1,260,048	$ 1,397,812	$ 1,350,048	$ 1,359,817
Pay back (years)	2.18	1.97	3.72	3.69
Net Present Value of investment	$11,624,359	$13,083,836	$9,354,044	$9,457,534

Table 2: Overall plant benefit

TOTAL BENEFIT					
		Automated - Ex-Works		Automated - Overall Project Cost	
Benefit summary		$/hd From	$/hd To	$/hd From	$/hd To
Accuracy	Cube-strip separation	$0.00	$0.00	$0.00	$0.00
	Cube-chuck separation	$4.29	$4.65	$4.29	$4.65
	Vertical Scribes	$0.83	$1.05	$0.83	$1.05
Labour benefit		$0.53	$0.53	$0.53	$0.00
Equipment costs	**Maintenance**	-$0.38	-$0.38	$0.00	$0.00
	Operation	-$0.03	-$0.03	-$0.03	-$0.03
	Risk of failure	$0.00	$0.00	$0.00	$0.00
	$ Benefit per head	**$5.25**	**$5.83**	**$5.63**	**$5.67**
$ Annual Benefit overall plant		**$1,260,048**	**$1,260,048**	**$1,350,048**	**$1,350,048**

- The video showing the robots cutting the 1 horizontal and 2 vertical lines on each side is also an attachment to this report.

6.0 Discussion

After a few years of discussions between AMG, IR and AMPC and attempts to find enough space at AMG Dandenong, this project commenced on 15/03/2024.

The Cootamundra plant was being rebuilt and due to previous discussions with IR in anticipation of this project being approved, an area between the chillers and boning room was set aside during construction to allow for the robots to be fitted there. The space required would not normally be available in an existing site and having it on a corner of the building also allowed for construction of a control room with external access.

The project progress is outlined in the stage summary above but what was important was the close working relationship between IR and their suppliers and AMG and their contractors that were building the plant. There were

some delays due to supply or contractor delays, or prioritisation of other parts of the plant, however this was worked through to ensure the delays were minimal and time was able to be made up where required.

The plant is now starting to increase production with a second shift. This will enable the scribing saw to work more consistently than in the past and allow the team to look for other scribing opportunities with the existing robots or in other parts of the plant.

This project is different to the original IR-Scribe project as the variety of carcass categories makes it more challenging with dressing and cutting specifications and the presentation of the sides to the robot. This has all been learned effectively and adjustments are seamless without any delays.

The audit by Greenleaf shows that the project is achieving the results it assumed in the original proposal, but we believe that over the balance of this project the improvements and returns will be even greater.

7.0 Conclusions / recommendations

There are no final conclusions at this stage as the plant still has a lot of upsides to its production capability and therefore the returns from the IR-Scribe project. There are a few years of this project still to run.

The project will continue to the next Milestone as originally planned.