# final report

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# Bung cutter online robot trials

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# Abstract

Following successful Offline Bung Cutting Trials all parties involved agreed that to determine whether to proceed with further investment in project P.PSH.0535, Sheep Auto Bung Cutting, Online Robot Trials to ensure any major project risks are alleviated were required.
The results from the Online Trials indicated that:

- The Bung Cutting tool is capable of consistently processing the range of carcasses, both males and females, that are processed at GMP
- The tail manipulator operates effectively providing sufficient access to the bung for all carcasses processed.
- The sensing used provides sufficient data to enable the system to process multiple carcasses successfully
- Cycle time was not fully tested during online trails for safety reasons. Trails, however, did not indicate any problems in achieving the cycle time required for GMP. Offline cycle time trails where completed with simulated sterilisation implemented. Cycle times of approximately 7.6 seconds where recorded with room for improvement making a production rate of 8/min achievable and well within the requirements of GMP who currently run around 6/min.

In conclusion these trials have alleviated the major risks identified in the project, however the developed Bungcutter tool does require further refinements to improve on the design and to optimise it for eventual production.

# Executive Summary

Following successful Offline Bung Cutting Trials all parties involved agreed that to determine whether to proceed with further investment in project P.PSH.0535, Sheep Auto Bung Cutting, Online Robot Trials to ensure any major project risks are alleviated were required.
Online Trials were setup on the kill floor at Gundagai Meat Processors, however following several attempts where the setup was unable to achieve the consistency required, the trails were moved offline again where modifications and refinements were made to the cutting sequence to further improve the results. Additionally modifications were made to the tool itself and the method of stabilization. Once the desired sequence and cycle time were achieved off line, the required stabilisation bars were fabricated and the trials were moved back online, where a range of carcasses were successfully debunged.
In conclusion these trials have alleviated the major risks identified in the project, however the developed Bungcutter tool does require further refinements to improve on the design and to optimise it for eventual production.

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# 1 Background

Following successful offline trials, all parties involved agreed that to determine whether to proceed with further investment in project P.PSH.0535, Sheep Auto Bung Cutting, Online Robot Trials to ensure any major project risks are alleviated were required.

# 2 Project Objectives

The online trials will aim to achieve the following goals and enable continuation of P.PSH.0535;

- Ensure Bungcutter tool operates with consistent quality over a range of carcasses (breed, size and gender)
- Ensure new tail manipulation operates consistently providing sufficient access to bung for cutting and ensuring no “bung skin” remains near tail bone.
- Ensure sensing technology implemented provides sufficient data for operations over multiple carcasses.
- Ensure cycle time can be achieved for operations at Gundagai Meat by performing trials with full cycle functionality
- Ensure any major project risks are alleviated prior to continuation of project and system build for installation.

The proposed trials will provide one of two outcomes:

- Favourable results provide confidence to proceed past Go/NoGo decision of “P.PSH.0535” and move forward to Milestone 6
- Unsatisfactory results may require project scope being re-evaluated and or discontinued

# 3 Methodology

The trials will involve the tool mounted on the robot and will incorporate the following:

- Design & Build of new components, these being
    - an upgrade of the Tail Manipulator such that retraction of the manipulator prior to cutting is automated
    - online carcass stabilisation to eliminate swing and movement of the gambrel/carcass during the cutting process
- Setup and temporary installation of robot system online on the kill floor at Gundagai Meat Processors
- Commission and test temporary robotic bung cutting cell
- Online Robotic Bung Cutting trials

# 4 Results and Discussion

The images below show the Online Trial setup on the kill floor at Gundagai Meat Processors in June 2012. The stabilization bars, the gambrel sensing and height sensing, robot, robot base, tooling and vacuum system used for the trials are all shown.

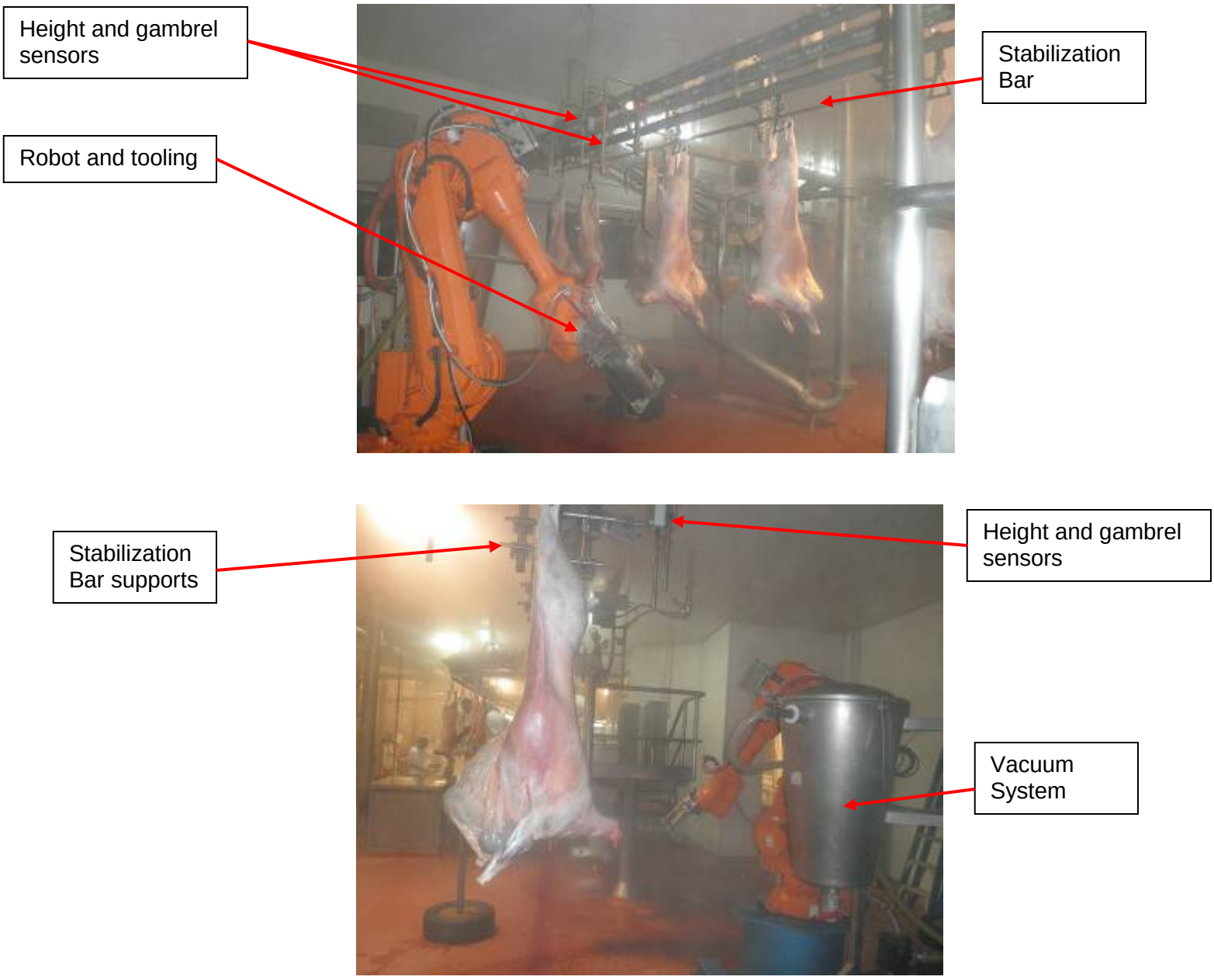


**Fig.1 Online Robot Trial setup at GMP June 2012**

## 4.1 Cutting Tool

Modifications that were made to the tool for the online trials included redesign of the Tail Manipulator. The springs that were used in the Offline trials have replaced with a pneumatic cylinder. This was done to enable more control over the Tail Manipulator and allow this to be retracted when required during the cycle. It was found that when using the springs pressure was being maintained on the tail and surrounding skin during the cutting phase of the cycle inhibiting the skin from being vacuumed into the tool.

## 4.2 Carcass Stabilisation

The gambrel stabilisation system fitted to the rail for the trials is similar to that which has been used for previous installations where the plastic gambrel is guided between two round bars as shown in the image below. The bars serve two purposes:

1) They stop the gambrel from rotating as it passes in front of the robot.

2) They provide friction on the gambrel so that it does not jump ahead of the guide dog.

**Fig.2 Stabilization bars.**

The image below shows the bars installed at GMP.


**Fig.3 Stabilization bars installed at GMP.**

## 4.3 Trials

Following the setup above, trials were conducted in the presence of Daryl Heidke from MLA. The sensing and trigger routines were tested, the robot was cycled and the Bung Location Routine was tested with no carcasses using the Offline Trial program as a starting point. Initial online trials were then conducted. It was found that the programmed cycle was too quick, the cutting tool did not cut for long enough and the tail manipulator sequence was not correct. A number for modifications were made to the sequence including:

- Slowing the cycle down.
- Modifying the tail manipulator sequence.
- Increasing the cutting time.
- Increasing the time for vacuum to be achieved.
- Modifying the amount the tool retracted once vacuum was achieved.

All of these changes had some effect but the results achieved were not consistent and with the carcass online and moving at production speed it was difficult to adequately observe exactly where the process was going wrong. To enable us to obtain a better understanding of the issues it was decided to revert back to an offline setup.
To commence the trials off line the pneumatic cylinder, used to control the tail manipulator, was removed and replaced with springs to return conditions to the state they were in during the initial offline trials. The original offline program was loaded into the robot, trials were conducted and the following changes were made to the cutting sequence to further improve the results:

- Angle of approach
- Speed of cutting
- Speed of retraction before cutting
- Length of time for vacuum to be achieved

The improvements resulted in a cycle time of between 6-7sec's with the results of the cuts being predominately good to very good. For the cuts that were not good it was felt that the addition of sensing to properly detect the height of the carcass would result in an improved outcome. The pneumatic cylinder was reintroduced into the sequence and the fact that there was height detection sensors mounted on the line it was decided that we were at a point where we could reintroduce the system to online trials. The trials achieved good success on all the males processed, however, had issues with the females. The robot has been programed in such a way that on females in the offline trials both the bung and the reproductive organs are captured under vacuum and cut away. What was found during the online trials even with the cycle running at the speed it was off line, the results were inconsistent. The issues encountered were:

- Missing the opening to the vagina and hence all the female reproductive organs.
- Missing the opening to the vagina but cutting away the organs.
- Cutting rump meat or bones in an attempt to capture the female organs.
- Missing the bladder.
- Locating in the vagina rather than the bung.

At this point trials were switched back to offline to enable further refinement of the robot paths/program in an attempt to overcome the issues listed above. In addition it was felt that a larger area for vacuuming up the bung and female organs would be of benefit. Trials were conducted between October 2012 and February 2013 during this time the following occurred:

- A lot of time was spent refining robot sequence, cutting speeds, wait times for vacuum, angles of approach.

- A shroud that was able to slide along the outside of the cutting tool was added. This increased the area capable of vacuuming up the bung and female organs.

- Additions were made to the stabilization of the carcass. A bar was added across the hip area of the carcass to limit the swing of the carcass when the de bunging process is taking place.

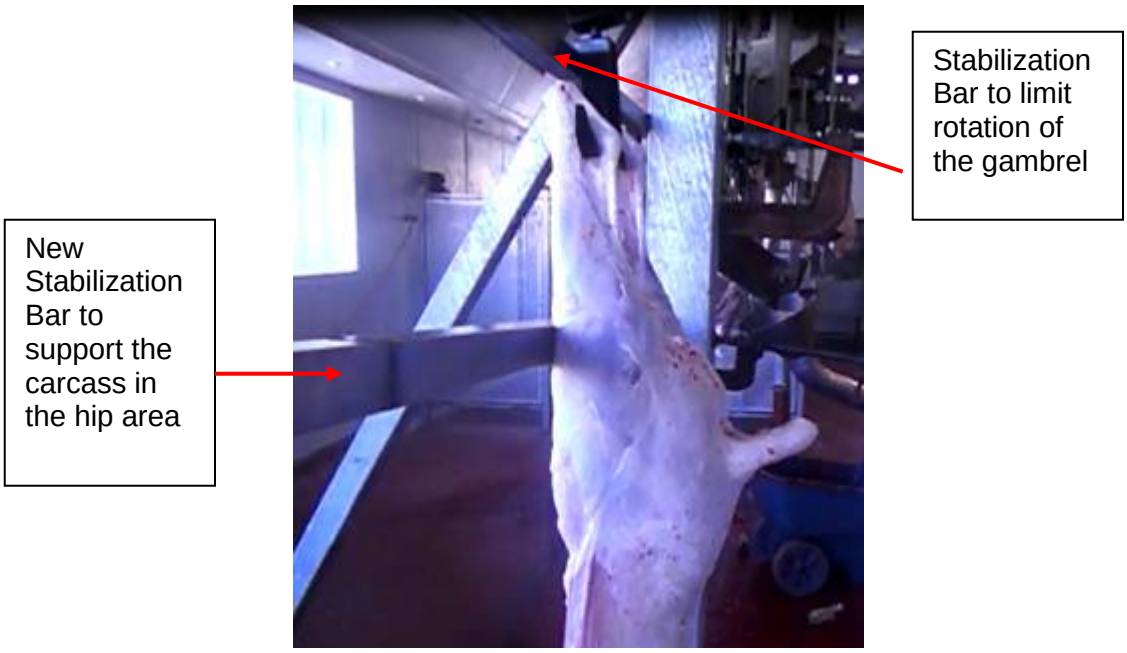


**Fig.7 Stabilization bars**

- Modifications were made to the tail manipulator to improve its robustness and ensure it ran smoothly and did not jam up.

- Finally due to continued issues of not getting enough vacuum at the end of the tool to 'suck' up all required material, and locating in the vagina rather than the bung, trials were conducted with the centring pin removed. This improved the vacuum dramatically and resulted in all females trialled being cut correctly.

With all these modifications in place further refinements were made to the sequence and a cycle time of 7.6 sec was achieved including allowance for a sterilisation routine.

At this point it was decided that the system was ready to be trialled online again. The stabilisation bars simulated during the offline trials were designed, fabricated and installed and shown in the image below. A third bar that cannot be seen in the image below is rubbing against the back of the hook as it runs along the rail to inhibit it 'skipping' ahead of the chain dog while the debunging process is taking place.


**Fig.8 Online stabilization bars**

# 5 Success in Achieving Objectives

The Online trials were conducted on the 27th of March 2013 in the presence of Darryl Heidke from MLA. A total of 15 carcases were trialled and the results are shown in the attached spread sheet and videos on the accompanying DVD (to be sent to Darryl by mail).
As can be seen from the spread sheet and videos all cuts were successful except for Carcass 10 where the H Bone was cut. This has been put down a possible sensor error and carcass swing. The only other issues that were experienced were when the bung was full of pellets (Carcasses 4,12 and 13), where the bung was cut and released but damaged in the process. This would be alleviated if the bung was evacuated. Hence, from the results achieved it can be said that:

- The Bung Cutting tool is capable of consistently processing the range of carcasses, both males and females, that are processed at GMP
- The tail manipulator operates effectively providing sufficient access to the bung for all carcasses processed.
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- Cycle time was not fully tested during online trails for safety reasons. Trails, however, did not indicate any problems in achieving the cycle time required for GMP. Offline cycle time trails where completed with simulated sterilisation implemented. Cycle times of approximately 7.6 seconds where recorded with room for improvement making a production rate of 8/min achievable and well within the requirements of GMP who currently run around 6/min.
- These trials have alleviated the major risks identified in the project and at the completion of the 15 carcasses Darryl indicated that he was satisfied that the system had achieved the required outcomes for the Online Trial Project.

# 6 Conclusions and Recommendations

Following these trials the conclusion is that the current tool design and concept is capable of consistently processing the range of carcasses encountered at GMP.
MAR and GMP agree that the full Bungcutter development project P.PSH.0535 should be re commenced now that major project risks have been alleviated.

The developed Bungcutter tool however does require further refinements to improve on the design and to optimise it for eventual production.

- Shroud design
    - Automation of the shroud around the cutting tool needs to be designed and implemented
    - Longer shroud 10-20mm may assist obtaining quicker vacuum
    - Shroud needs more rigidity and friction to make it harder to push back - need shroud to push back under Vacuum only
- General Tool Improvements:
    - Tool needs to be setup for automated production
    - Tool needs to have through tool sterilisation implemented with necessary controls.

    - Improve linear rail setup on Tail Swiper, improve pneumatic control speed, flow and pressure adjustments
    - Need longer cutting tool and Tail Swiper on final version to promote easier access for Tail Swiper ensuring it is well clear and does not influence cut cycle
    - Need Longer cutting tool and Tail Swiper on final version to prevent gearbox hitting carcass at full depth
- Cutting Tool
    - Cutting tool length needs to be optimised
    - Various size Tools required to fine tune and improve range of cut
    - A range of larger diameters tool and shrouds required (~+5mm increments)
    - Change cutter location Pin directions

With regards to the production process, Evacuation of the colon prior to bung cutting needs to be implemented as part of GMPs' process.
This must be implemented to avoid unnecessary spillage and contamination during the automated process.