final report

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Sensing development project

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Contents

1 Milestone

Integrate 3D stereo Vision sensor sensing technology within a Red Meat development project conducted by MAR

- Upon successful completion of workshop trials at MAR the 3D stereo Vision sensor will be integrated within the design of a development project being conducted by MAR to enhance the capabilities of this system.
    - The proposed project that the 3D stereo Vision sensor will be integrated within is the Beef Hock Cutter system currently being developed for JBS Swift in Dinmore QLD.
    - The 3D stereo Vision sensor will be used to find the location of the hocks in 3D space. Knowing the location of each hock in 3D space will allow us to guide the robot in to cut at the optimal angle to the hock and decrease the cycle time of the automated hock cutter.
    - This system if successful will be used in conjunction with the Thermal Vision system to increase accuracy and speed of operations giving the project increased probability of overall success for the industry and future commercial projects.
- Produce sensing technology implementation report identifying:
    - areas of use in future automation
    - areas of use for current development projects
    - performance indication and comparison with relation to existing sensing
    - cost comparison vs current technologies
    - Implementation report showing the sensor being used in the Beef Hock Cutter system and identifying the positive impact this sensor has introduced.
- MAR Objective:
    - Our exposure to 3D stereo vision sensing has indicated that their lies potential practical areas of use however these are largely untested and effort must be made to ensure this sensing technology is trialled to ensure our overall objectives for sensing technologies used in red meat is achievable. If trails prove successful these systems may be used for current and future developments to:
        - reduce cost
        - increase accuracy
        - reduce cycle time
        - reduce floor space
        - reduce complexity

2 Abstract

Following successful trials of the TYZX Deepsea V2 Development System, 3D camera in MAR's workshops the system was installed as part of the Beef Hock Cutting Project at JBS Swift Dinmore and proved to be very successful, so much so that the project would not have succeeded with out it.

3 Project objectives

- To perform case studies & trials on 2 sensing technologies applicable for automation in the red meat industry
- Produce reports showing the progress of research and trials being conducted
- Overall objective of this project is to find and test sensors for use in red meat automation that satisfy the following criteria:

- Provide the best ROI that will assists or enable developed solutions to become commercially viable.
    - Many sensors that have been trialled by MAR, FSA and others in the industry to date for measurement of processing features are not cost effective for the long term. MAR must ensure each system developed can be provided with a commercial outcome and to do this sensors used must provide sufficient functionality at minimal cost.

- Provide sufficient processing speed and communications protocols that will allow data to be analysed at the accuracy required.
    - Effective use of sensing technologies is often hindered by their ability to transfer sufficient data in a timely manner so as to allow an automated process to be completed at the rates required.

- Provide proof that the sensor can operate with influential environmental conditions such as steam, blood and water mist.
    - Many sensors do not operate as specified or expected under the harsh conditions seen in the red meat industry, this creates a gap between trials completed to date and the real life production conditions and commercial practicality

- Offer sufficient environmental protection against wash down and processing practices (chemical, high pressure water, etc)
    - Commercial practicality for automated systems within the industry relies upon sensors that will withstand long term exposure to a wash down environment, in some cases this may require sensors be fitted with additional protection.

- Provide sufficient accuracy for automated processing requirements
    - In some cases better accuracy is required, however the use of sensors that provide sufficient accuracy for a process rather than using the most accurate sensor available not only reduces the overall cost of a development but will also reduce the complexity of an integrated system making it easier to install, maintain and adjust.

- Reduce footprint of automated systems
    - For many of the systems being developed by MAR one major criteria that will enable a system to be installed in a plant is to ensure minimum footprint. The use of sensors that can minimise guarding and maximise the use of available space to sense and process data is paramount.

4 Success in achieving milestone

Milestone 1 of this project saw the selection of the TYZX Deepsea V2 Development System as the 3D camera system to be trailed. Testing of the TYZX system was conducted at MAR's workshop's in NSW, Queensland and onsite at JBS Swift Dinmore.
The aim of the testing is to prove the suitability of using the TYZX system in automated process tasks in the red meat industry.
Results and images for the various processes trialled during this testing procedure are detailed below. Each process is given three rankings each out of ten.

Ranking 1 – Suitability to task
Here we rank the suitability of the TYZX camera at performing the required detection in comparison to existing technologies such as laser and photo eye.

Ranking 2 – Cost Benefit
The TYZX camera is ranked from a cost benefit point of view in comparison to existing technologies.

Ranking 3 – Perceived Acceptance
Taking into account above two rankings the TYZX system is ranked from the point of view of how customers will accept the system.

4.1 Bung location

Process - Bung Location	
Ranking description	**Ranking**
Suitability to task	9
Cost Benefit	9
Perceived Benefit	9

To locate the Bung, the lamb carcass was hung by its hind legs from the fork lift tines with the back of the carcass facing the camera as shown in Fig. 1 below.


Fig.1

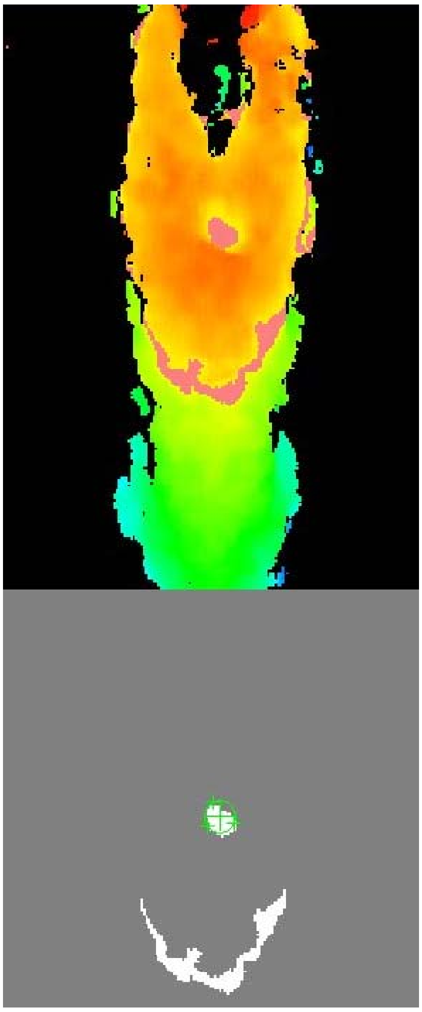
Fig.2

As can be seen in Fig. 2 the Visual Basic program, developed to analyse the data supplied from the camera, successfully created a colour image based on distances measured from the camera. The Vision Tools from the Vision Pro Software were then applied to this image and successfully located the Bung Hole as shown in the lower half of Fig.2.

Comparison of this method of sensing can be made with other systems that are currently in operation, namely the Brisket Cutter and Sani Vac Systems. These systems currently use proximity sensors to detect the gambrel position on the rail and a laser sensor to measure the crotch height. The robot then uses these measurements to determine its starting position. While this is sufficient for these tasks, identifying specific features such as a bung hole requires greater accuracy in determining actual position. This could be achieved with the use of the TYZX System which would allow depth and profile information to be gathered allowing more accurate robot positioning.

4.2 Hock Cutting

Process – Hock Cutting	
Ranking description	**Ranking**
Suitability to task	9
Cost Benefit	9
Perceived Benefit	9

The setup for the Hock Cutting trials in NSW is shown in Fig.3 below

Fig.3

It was found that to accurately locate the Hock cutting position a combination of both a TZYX camera and a thermal camera is required. The TYZX is essential in this operation as it locates the Hock in 3D space (other vision systems are only capable of 2D images) while the thermal camera identifies the location of the Dew Claw allowing an accurate cut to be made. The exception to this is when the carcasses are cold. In this case the thermal camera is not able to effectively locate the Dew Claw and the data from the TYZX camera is used to identify the Hocks 3D location and the leg length and angle to estimate a cut position.
The images obtained are shown in Fig.4 below.

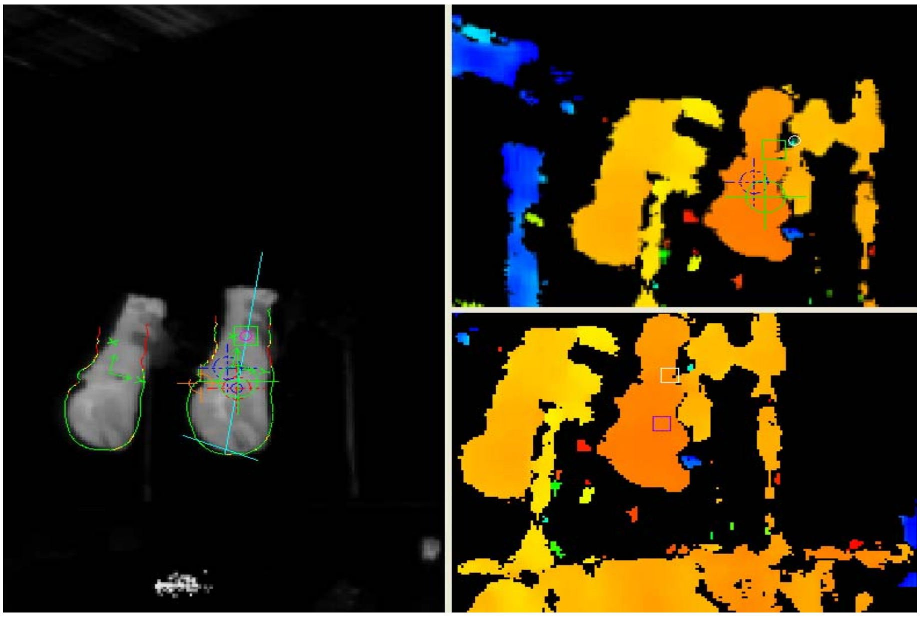

Fig. 4

The image on the left is the thermal image while the two images on the right are produced by the TYZX camera. As can be seen the Dew Claw position is easily found using the thermal image, the top TYZX image is used verify features in case the carcass is cold and the third image is used to illustrate a the location of the Hock in 3D space.

4.3 Profiling of Lamb for Location of Foreleg and Brisket and Belly Opening

Process – Fore leg location, brisket and belly opening	
Ranking description	**Ranking**
Suitability to task	7
Cost Benefit	5
Perceived Benefit	5

To locate the forelegs and centre line, the lamb carcass was hung by its fore legs from the fork lift tines with the belly of the carcass facing the camera as shown in Fig.5 below.

Fig.5

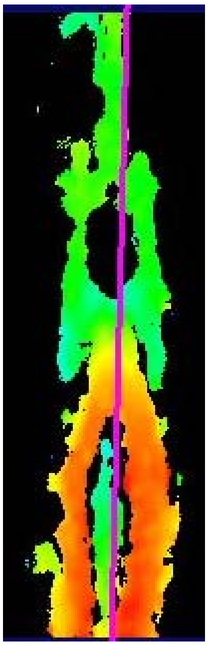

Fig.6

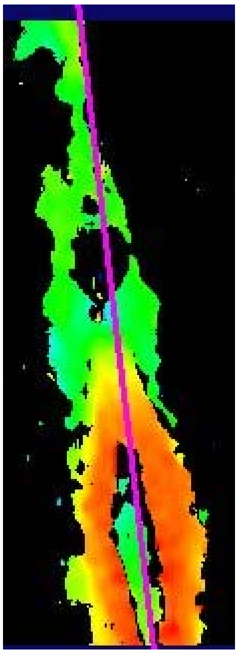

Fig.7

Again as can be seen from Figs. 6 and 7 colour images have been successfully created and vision tools used to determine the carcass centre line. Fig. 7 shows the carcass hanging at an angle and the centre line still being located. The accuracy of the centre line location could be improved with further vision programming.

Current brisket cutting operations use the sensors mentioned above in section 4.2.3.1, proximity sensors to detect gambrel position and a laser sensor to detect the height of the brisket. The depth of cut is varied using a selector switch which enables the operators to select between smaller and larger animals. This works for producers that process similar sized animals in batches, but is not as useful for those producers that process mixed sized animals. The TYZX System could eliminate the use of this selector switch, reduce operator intervention, increase the accuracy of the cut and automate for a larger range of animal sizes by allowing the depth and profile of the brisket cut to be determined on an animal by animal basis. The downside here would be the cost of the TYZX unit and whether the producers that process animals in similar size batches would see the value in moving away from the current selector switch selection method.

From the results obtained in the images above it is felt that automation of belly opening and evisceration processes would also benefit from profiling information obtained from TYZX system.

4.4 Centre Cut Line (Hung from Rear Legs, Hung from Fore Legs)

Process – Centre cut line	
Ranking description	**Ranking**
Suitability to task	8
Cost Benefit	8
Perceived Benefit	8

To locate the centre cut line, the lamb carcass was hung by its hind/fore legs with the back of the carcass facing the camera as shown in Fig. 8 (Hind Legs) below.


Fig.8 (Hind)

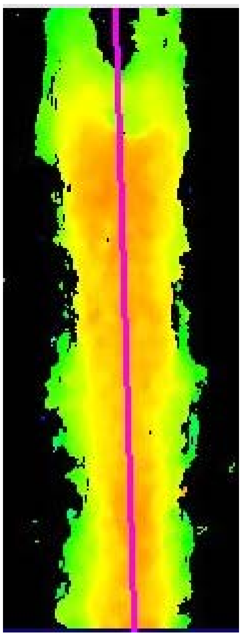
Fig.9 (Hind)

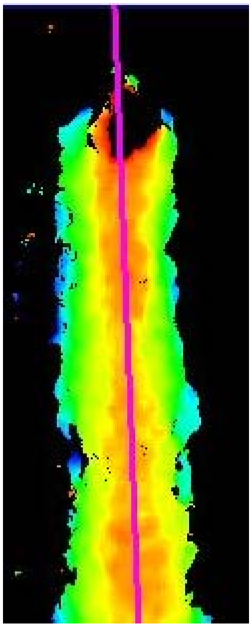
Fig.10 (Fore)

The images produced are shown in Figs. 9 and 10 and once again it can be seen that the centre line is easily found.
The potential uses for the images produced above are in the automation of the following processes, Carcass Splitting, Six Way Cut, Carcass Branding and Full body Vac San

4.5 Neck Tipping

Process – Neck Tipping	
Ranking description	**Ranking**
Suitability to task	9
Cost Benefit	9
Perceived Benefit	9

To locate the Neck Tip, the lamb carcass was hung by its fore legs with the back of the carcass facing and the neck 'hanging' towards the camera as shown in Fig. 11 below.


Fig. 11

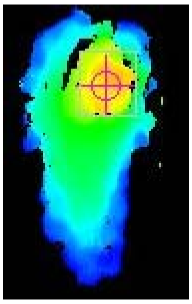
Fig. 12

The image produced and the vision tools used are shown in Fig.12, and it can be seen that the neck has been successfully located. Previous trials conducted have been completed using standard vision systems which provide a 2D image enabling the cut position to be identified but not a 3D position or angle of the neck in space and therefore the possibility of an inaccurate cut. Currently MAR have no systems installed where neck tipping is being performed, however it is felt that the neck tipping project for Peel Valley Exporters in Tamworth would benefit greatly from the use of a TYZX camera to locate the neck in 3D space.

4.6 Primal Cuts

Process – Primal Cuts	
Ranking description	**Ranking**
Suitability to task	7
Cost Benefit	5
Perceived Benefit	5

No specific images of the carcass were made for the Primal Cuts. However referencing cuts 1, 2 and 3 in Fig.13 as the required primal cuts or a six way cut where the carcass is cut into six equal portions, and from the images shown in the previous sections it would fair to say that the TYZX camera would have no issues providing data so that positions for these cuts could be determined. However if specific carcass features such as shoulders, hips etc needed to be located then it is felt that other methods of vision analysis may be needed.

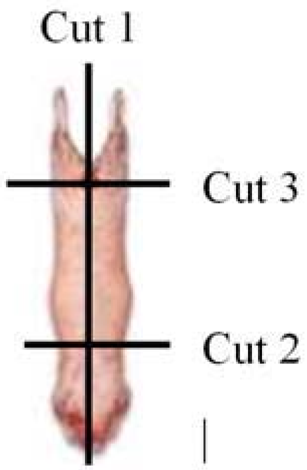

Fig.13

4.7 Profiling for Y Cutting and Sani Vac

Process – Y Cutting	
Ranking description	**Ranking**
Suitability to task	8
Cost Benefit	7
Perceived Benefit	7

Process – Sani Vac	
Ranking description	**Ranking**
Suitability to task	7
Cost Benefit	4
Perceived Benefit	4

For these trials images were only able to be taken of carcasses with the pelt the off and hung from a gambrel that has the forelegs close together. This would obviously not be the case for the Y cutter where the pelt would still be intact and the legs spread further apart, however from the images produced and shown below in Fig 14 it can be seen that the image tools can be used to indentify the leg position and top centre of the chest area, features that a robot could use to perform the Y cutting operation. Similar images could be used for Sani Vac operations but the benefit in this case is not perceived to be as great.

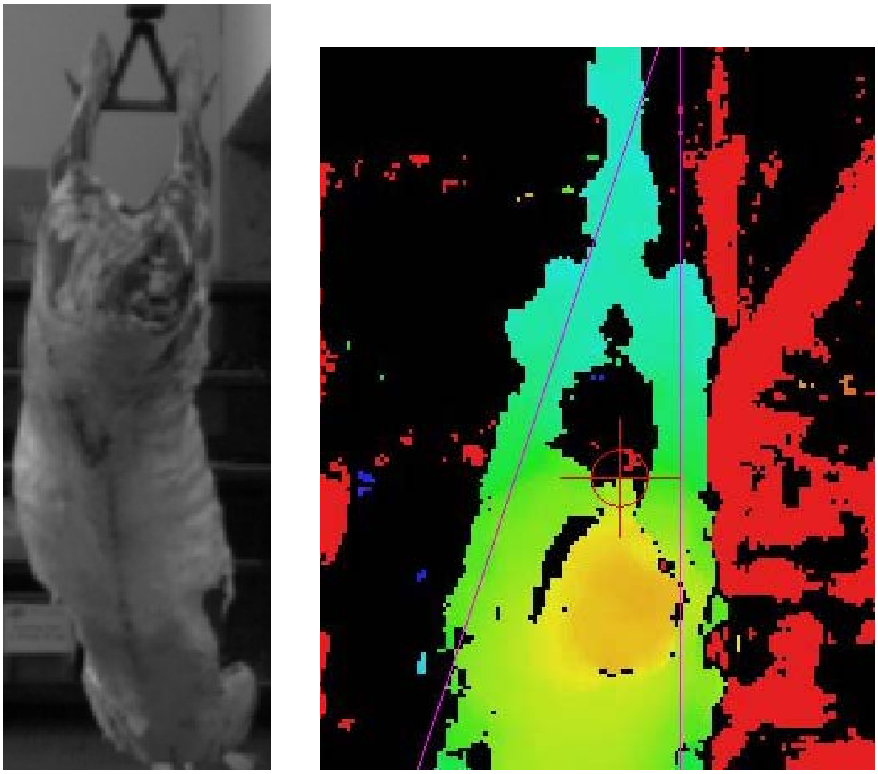

Fig 14

It is recommended that further trials be conducted on carcasses hung in the correct manner and with the pelt on.

4.8 Further trials for Profiling for Y Cutting with Pelt on

Process – Y Cutting	
Ranking description	**Ranking**
Suitability to task	8
Cost Benefit	7
Perceived Benefit	7

At the request of MLA further trials were conducted at Gundagai Meat Processors to determine the suitability of using the TYZX camera for Y Cutting with the pelt still on the carcass. The images of these trials are shown below. As can be seen the image tools can be used to indentify the leg and neck position features that a robot could use to perform the Y cutting operation. Figure 14b shows a carcass that is presented with its neck to one side at the moment the image was taken. It can be seen that once again the image tools locate the leg and neck position. It should be noted however that this carcass was swinging due to teeth inspection on the line and this would have to be avoided for correct Y cutting to occur

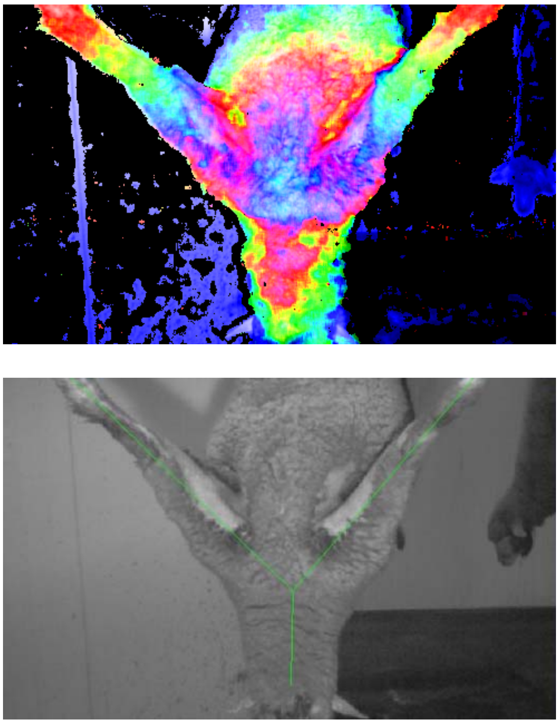

Fig14a

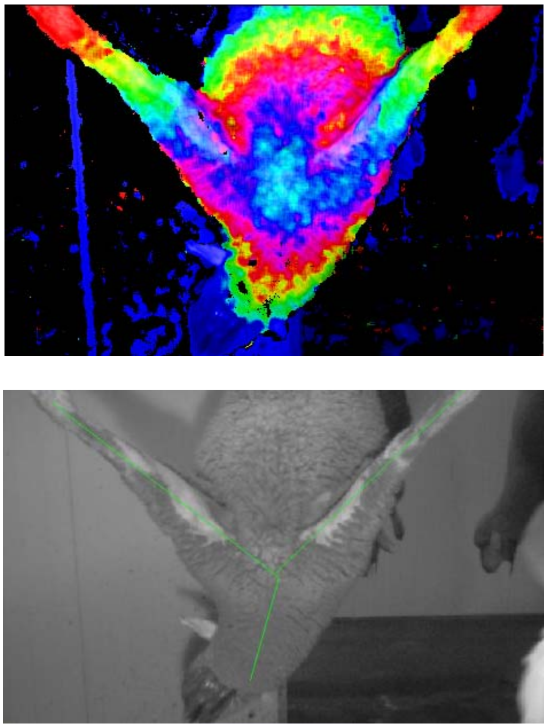

Fig 14b

4.9 Installation at JBS Swift Dinmore

Following the success of the trials conducted above the TYZX system was installed at JBS Swift at Dinmore, the results of this are detailed below:

The TYZX camera system has been used successfully at JBS Swift Dinmore in conjunction with a thermal camera to accurately locate the Hock cutting position. The TYZX system is essential in this operation as it locates the Hock in 3D space (other vision systems are only capable of 2D images) while the thermal camera identifies the location of the Dew Claw allowing an accurate cut to be made. The exception to this is when the carcasses are cold. In this case the thermal camera is not able to effectively locate the Dew Claw and the data from the TYZX camera is used to identify the Hocks 3D location and the leg length and angle to estimate a cut position.
Following the installation of the robot and cameras it was found that for the camera systems to operate correctly a number of modifications to the Hock Cutting cell were required.

4.9.1 Carcass stabilisation

Initial review of the system highlighted that as the carcasses travelled along the rail the meat hooks and hence the carcasses rotated. This was identified as an issue in that once the cameras had taken images of the hocks they needed to remain in a stable ‘rotary’ position to enable the robot to cut them accurately. A stainless steel sheet was added to the existing guide rail in an attempt to stop this rotation. This proved successful but introduced excessive drag and sway issues to the carcass movement again causing issues for the robot when attempting to make cuts. This was overcome by installing a belt conveyor which was synchronized to chain speed and supported the carcass as it travelled through the Hock cutting cell inhibiting carcass rotation, drag and sway.

4.9.2 Camera positions and images

It was initially envisaged that a single image of both Hocks would be sufficient to provide the required information to enable the robot to make the desired cut. It was found, however, that greater accuracy and consistency were obtained by taking a second set of images of the carcass once the first hock had been removed. To do this the cameras are rotated by pneumatic cylinder essentially following the carcass down the line.

Fig 15 below shows, in the fore ground the initial position of the stainless steel enclosure that houses the cameras. In this location it was found that large errors were being introduced in the TYZX system due to the angle at which the second image was being taken. The cameras were moved to a higher location where they had a better view, essentially looking down on the hock and producing much better results, this position is shown in Fig 16.

Fig. 15

Fig. 16

4.9.3 Perspex Panels for Thermal imaging camera

It was found that Perspex panels were required to shield the Thermal camera from thermal reflections and to suppress glare. These panels are also shown in Fig 17 below.

4.9.4 Additional Lighting

Additional lighting was required to that originally installed, the final lighting consisted of two double tube fluorescent lights and four 500w extra white flood lights, this additional lighting was required to allow TYZX system a greater chance of identifying the required features on the carcass and hence producing better result and increased accuracy of cut.

5 Results and Discussion

The impact of the TYZX system on the Beef Hock Cutting installation at JBS Swift has been a very positive one, basically to the point that the project would not have succeeded with out this camera. With this in mind the TYZX system will be used to locate the neck in the up coming Hock Cutting and Hock and Neck tipping project at Peel Valley Exporters.

6 Overall progress of the project

Submission of this report Completes Milestone 2 for this project. Milestones 1 and 3 have already been completed with a NO GO resulting from Milestone 3 meaning that Milestone 4 will not be completed. A variation to the original project has been contracted to conduct further testing of the TYZX system with a view to obtaining further results on the Y Cutting process. This will occur at PVE prior to the installation of the Hock Cutting and Hock and Neck tipping project.

7 Recommendations

Due to the success of the TYZX system in the trials conducted and on the Hock Cutting Project at JBS Swift Dinmore MAR would recommend further use of the system in subsequent projects.