# milestone report

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# DEXA Lamb Eating Quality and Supply Chain Grading – DEXA Live – Phase 2

## Milestone 5- Final Report

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# Abstract

Meat is one of Australia's biggest exports, and therefore a large part of the economy is supported by the meat value chain. In order to support effective decision making for both the processor and producer in the lamb industry, the grading of meat will benefit from objective rather than subjective assessment.

Stage 1 research used DEXA hardware installed into the JBS Bordertown plant to scan over 600 animals and conduct bone and CT scanning to determine if and what relationship exists for lean meat yield (LMY) analysis in Australian lamb carcases. Results from that work confirmed a relationship and has developed an algorithm that can now be applied to support a commercial system.

This project (DEXA Live phase 2) will put in place a system that enables Lean, Fat and Bone percentage data calculated using the DEXA algorithm implemented in DEXA live phase 1 to be integrated into the JBS Bordertown process chain. This project will involve

a) implementing hardware to enable data-sets to be stored for an extended time
b) hardware to ensure that carcases are presented to the DEXA correctly (and hence the integrity of the LMY data)
c) integrate an RFID scanner onto the DEXA machine to enable data captured to be integrated into the rest-of-plant process and
d) a user interface to enable stored data to be queried in relation to time/batch/flock/run.

Measurements will be captured and stored in real-time and integrated into a database that will have the ability to be interrogated over the corporate network or ultimately with additional work linked into an industry database.

As part of this project an RFID scanner was implemented to read test RFID hooks supplied by JBS for trial and software developed. RFID assists to link/store carcase IDs with captured images and calculated results such that, in future, measurements will have the ability to be related retrospectively to additional measured data within the plant and ultimately to livestock supply and origin. A verification step was undertaken to ensure that measured data is being attributed to the correct animal ID numbers and that the automated primal and middle cutting system are not adversely effected by the use of DEXA hardware.

At the completion of this project the site will have the ability to query a Scott constructed database and extract Lean%, Fat%, Bone% and carcase hook ID (as well as a number of other calculated metrics around cut lines, specifications and production statistics). Results from this project will give JBS the ability to implement a number of business rules and form a structure that can feed data back to industry managed databases and livestock suppliers.

Note that this project is a continuation of and is connected to phase 1 (project V.RDP.2010) and therefore tasks between the projects are linked.

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# 1 Project Information

## 1.1 Milestone descriptions

The aim of the milestones within this project is to:

1) Design of hardware and software to capture and store data and ensure data integrity.
2) Order the RFID hooks
3) Order, Manufacture and ship hardware support components
4) Installation, commission and validation
5) Final Report

## 1.2 Project Outcomes

At the completion of this project it is anticipated that the DEXA system at JBS will be calculating and storing on hard drives the lean meat, fat and bone percentage makeup of a carcass, which is calculated using the algorithm developed from the stage 1 trials.

### 1.2.1 Outcome 1:

Implement hardware/software to enable LMY data to be stored for a period of time and reported on by batches/days/times/runs.

### 1.2.2 Outcome 2:

Design a database to enable LMY data to be extracted with individual carcase identification numbers in a format that can be used to manually populate a JBS internal and/or LDL database.

### 1.2.3 Outcome 3:

Verify data integrity and robustness of system

# 2 Milestone 1

## 2.1 System Design

In order to minimise down time and error on site, initial design on the integration of the DEXA Live system with the site at JBS Bordertown was completed. It was concluded that:

1) A “Double Up” sensor was required to ensure that each hook only contained one lamb carcass
2) A “Rump Detect” sensor was required to ensure that the lamb carcass was oriented correctly on the hook
3) An RFID reader was required in order to read the RDIF code from the hooks and attach the calculated data to a particular carcass ID

These sensors and conditions were taken into account within milestone 1.

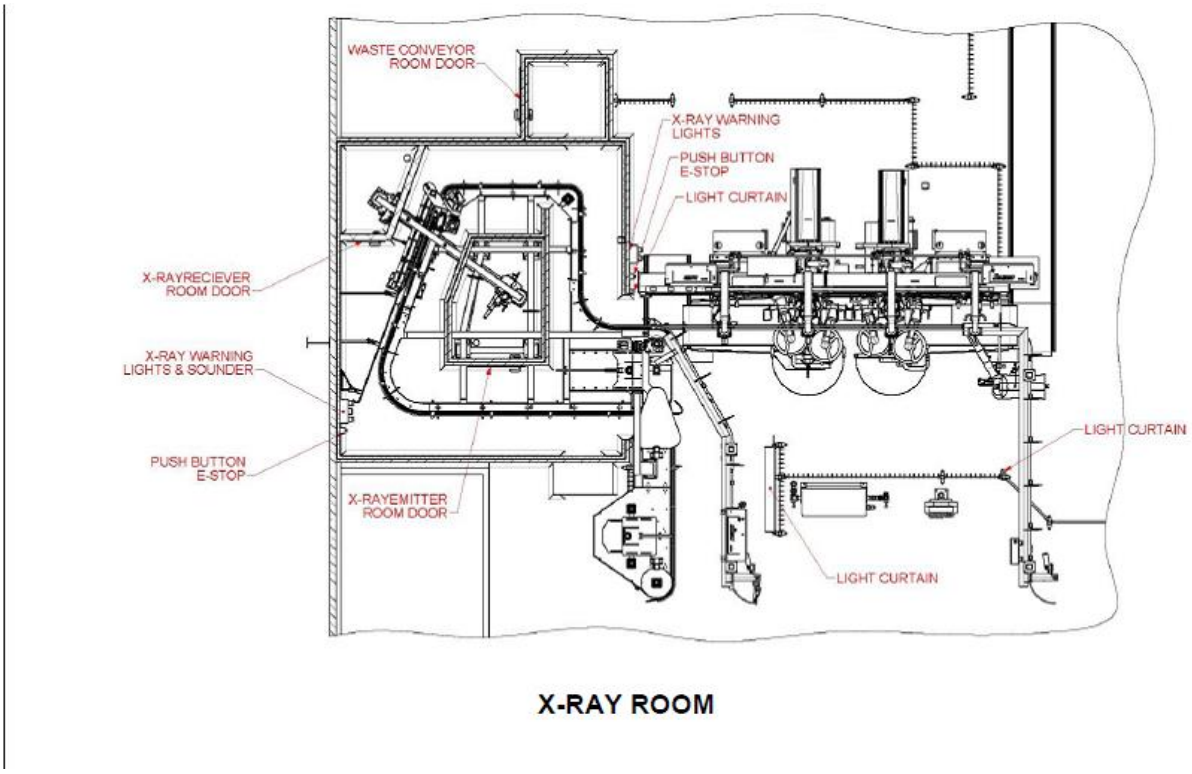


Figure 2-1- System Layout

## 2.2 Hardware Design

### 2.2.1 Sensors

Extra hardware was designed and existing hardware was resituated in order to take into account the error detection deemed necessary within the System Design phase.

For the “Double Up” sensor, a new suitable position was designed, and the existing bracket could be used.

For the “Rump Detect” sensor, the brackets, cable and sensor were researched and designed where necessary.

The final extra sensor required was an RFID reader, so that the RFID tags on the hooks could be read and the calculated data could be attached to a carcass ID.

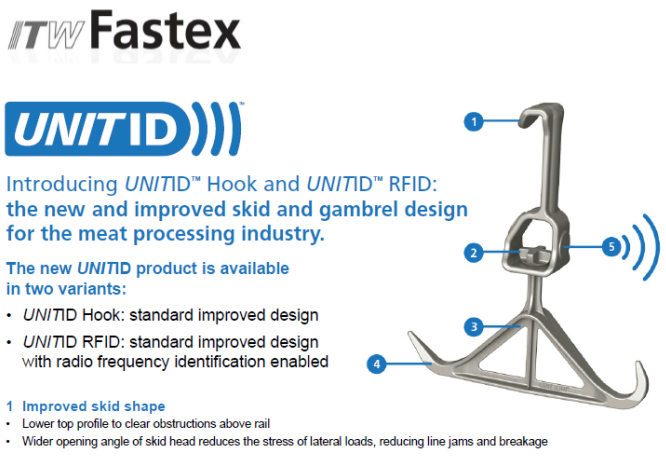


Figure 2-2- Hooks with RFID Tags

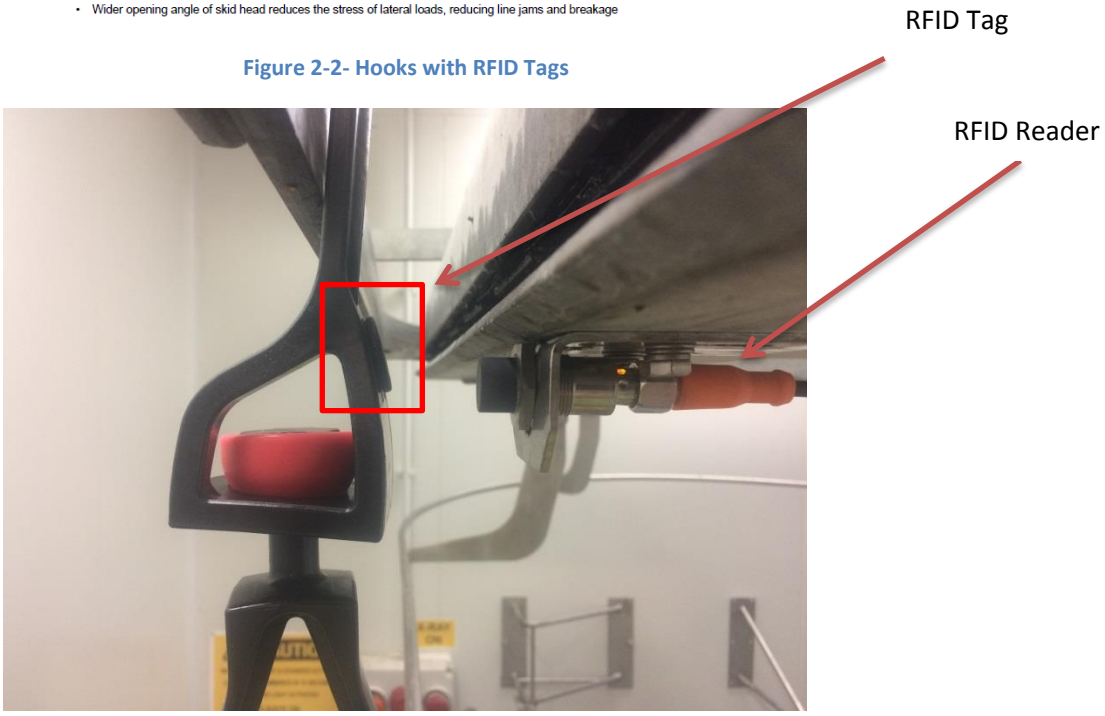


Figure 2-3- RFID Tag and Sensor

### 2.2.2 IT Hardware

For the storage of all of the required data (such that images could be referred to later) there was a range of hardware required. The storage system was designed to store 6 months of X-ray images for later verification and redundancy.

### 2.2.3 Calibration Block

The calibration block is an automated mechanical device controlled by PLC and a HMI unit. It allows an operator to perform a calibration on the system at regular intervals as desired by the processor. The operator will push a button on the HMI in order to initiate the calibration, and it will occur automatically without the need of the operator entering the x-ray room. It is ultimately used in order to account for drift in the x-ray detector values. By periodically referencing the system to known material densities, an accurate and repeatable x-ray scan is enabled.

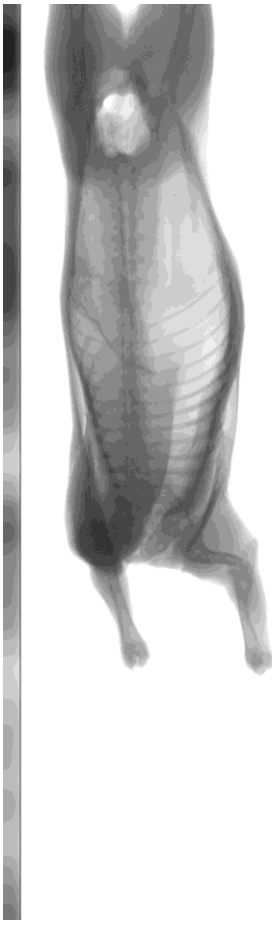

Figure 2-4- Calibration Block Reference next to Lamb Carcass

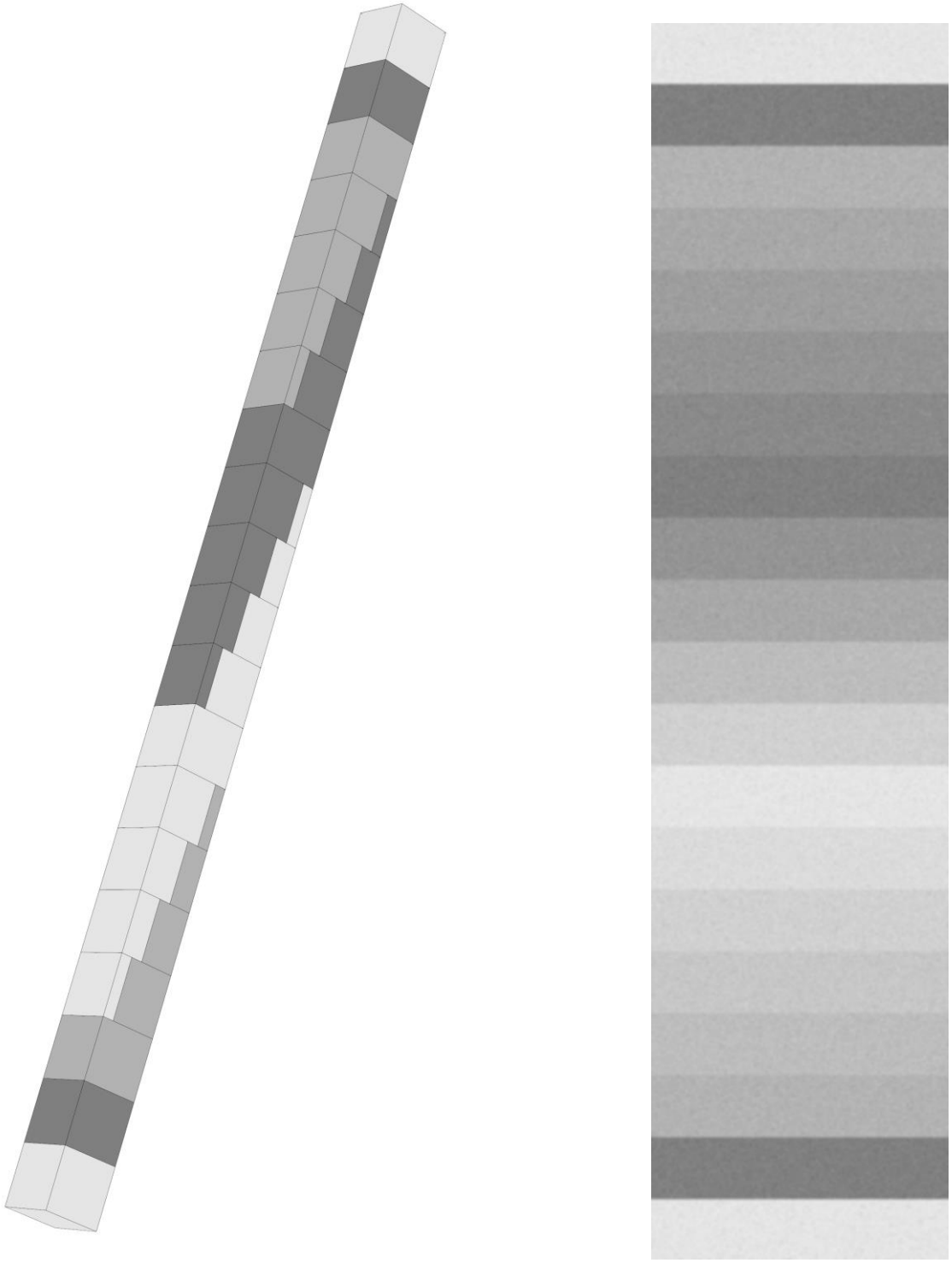

Figure 2-5- Calibration Block

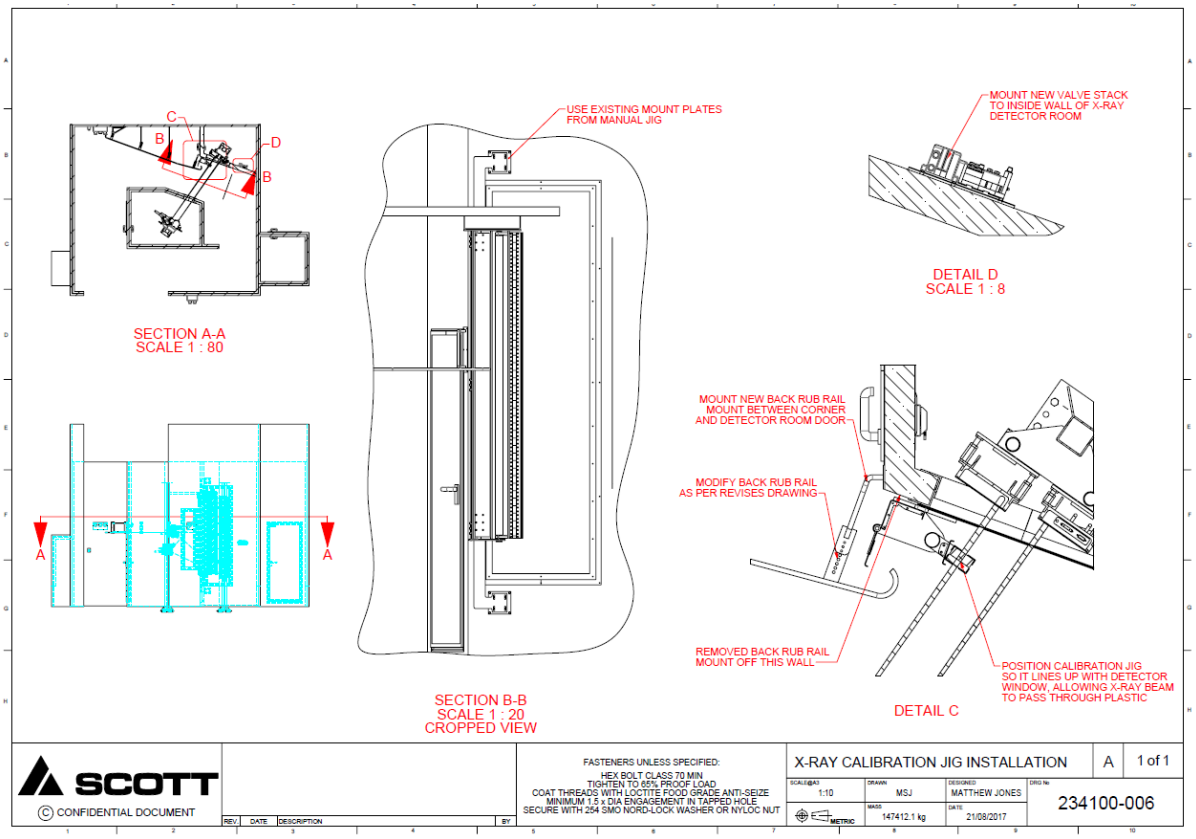


**Figure 2-6- X Ray Calibration Jig Installation after Modifications**

## 2.3 Software Design

In milestone 1, the software design was completed in order to allow the implementation and commissioning on site at Bordertown.

### 2.3.1 Proposed Database Table

| Field | Type | Description | Example |
|---|---|---|---|
| **RFID** | String | The 16 hex digits of the RFID tag in the skid. | ff81237c5e6003c2 |
| **Timestamp** | String | The date and time that the carcass went through the x-ray. | 2017-04-06 15:39:27 |
| **Status** | String | A description of data validity or any errors that occurred. | Good |
| **Weight** | Integer | The weight of the entire carcass in grams. | 23768 |
| **Total carcass lean** | Real | Percentage of total carcass weight that is lean muscle. | 62.4 |
| **Total carcass fat** | Real | Percentage of total carcass weight that is fat. | 21.0 |
| **Total carcass bone** | Real | Percentage of total carcass weight that is bone. | 16.6 |
| **Forequarter weight** | Integer | The weight of the forequarter in grams. | 8715 |
| **Forequarter lean** | Real | Percentage of forequarter weight that is lean muscle. | 60.6 |
| **Forequarter fat** | Real | Percentage of forequarter weight that is fat. | 21.2 |
| **Forequarter bone** | Real | Percentage of forequarter weight that is bone. | 18.2 |
| **Middle weight** | Integer | The weight of the middle in grams. | 7130 |
| **Middle lean** | Real | Percentage of middle weight that is lean muscle. | 59.2 |
| **Middle fat** | Real | Percentage of middle weight that is fat. | 22.5 |
| **Middle bone** | Real | Percentage of middle weight that is bone. | 18.3 |

| | | | |
|---|---|---|---|
| **Hindquarter weight** | Integer | The weight of the hindquarter in grams. | 7923 |
| **Hindquarter lean** | Real | Percentage of hindquarter weight that is lean muscle. | 67.3 |
| **Hindquarter fat** | Real | Percentage of hindquarter weight that is fat. | 19.4 |
| **Hindquarter bone** | Real | Percentage of hindquarter weight that is bone. | 13.3 |

### 2.3.2 PLC Software Modifications

There were PLC software modifications designed so that the x-ray system could communicate with the PLC given the new data structure, including the new RFID data. In addition to this, software was prepared to allow the use of the “Double Up” sensor and the “Rump Detect” sensor.

### 2.3.3 Current File System

Note that the DEXA data is only generated when the images are backed up. This will be at least 5 minutes after the carcass goes through the x-ray room. This time is even longer for carcasses just before a break, and at the end of the day. There is no display on the HMI showing DEXA results. In addition to the files for each carcass, DEXA results are stored in an SQLite database file.

## 2.4 Data Storage

The design of the data storage system is as follows.

- Add NAS (network attached storage) to system, accessible to both SCOTT and JBS.
- SCOTT to copy relevant images and data to NAS.
- Retain the existing main drive and backup drive system (to mitigate any risk of losing data if the NAS is not available).
- The carcass images and data will be saved in the NAS.

# 3 Milestone 2

The objective of Milestone 2 was to order the RFID hooks on behalf of JBS. After a range of research conducted by JBS innovation department, the RFID hooks that were best suited for the job was selected by JBS. Scott team has tried one sample at site for data transferring purposed and worked.

## 3.1 RFID Hook Image

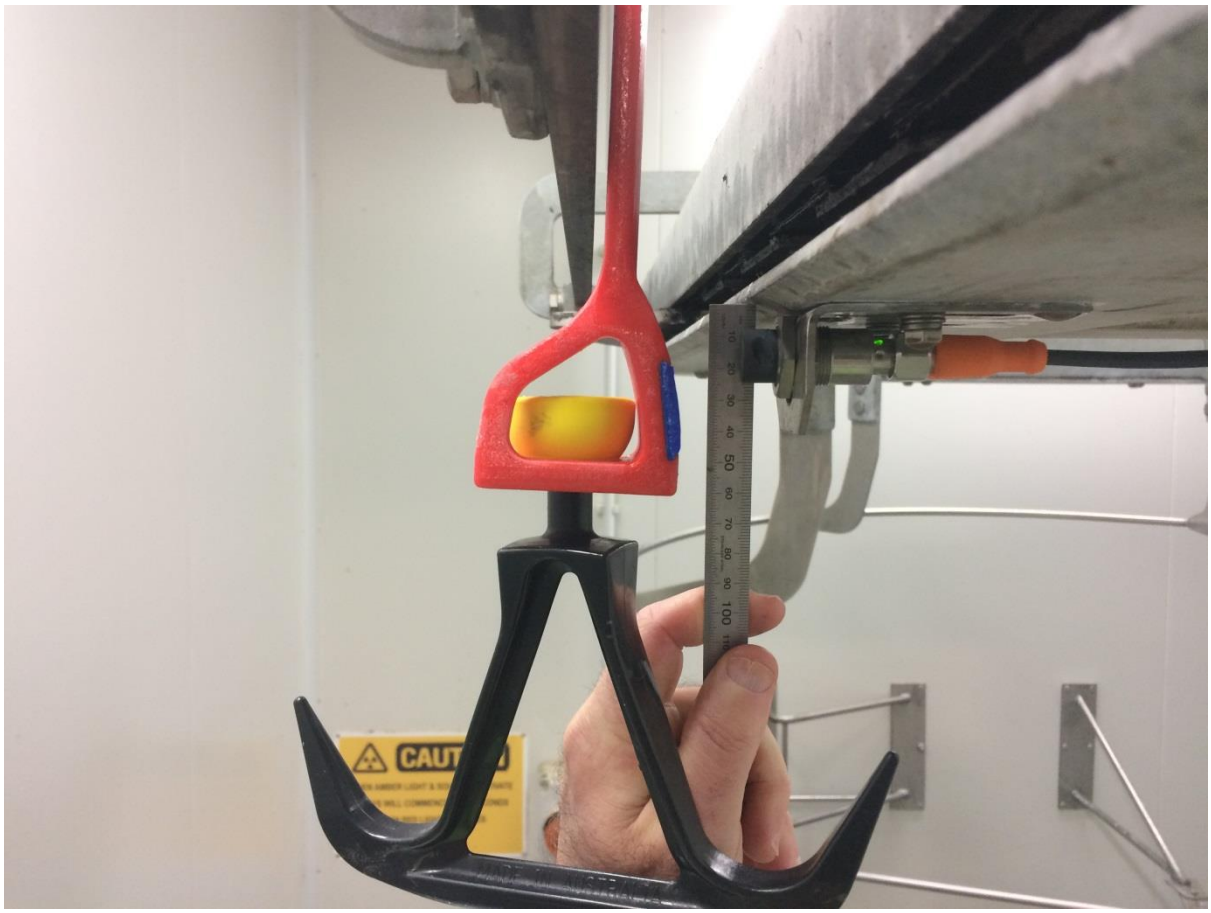

Figure 3-1- RFID Hook after Purchasing

# 4 Milestone 3

## 4.1 Hardware Procurement

### 4.1.1 IT Hardware

As a result of the design of the storage system in Milestone 1, the required IT hardware was ordered.

## 4.2 Hardware Manufacture

### 4.2.1 Calibration Block and Jib

After the design of the calibration Block and jib, it was manufactured and procured by Scott Automation and Robotics, ready to be taken to Bordertown.

### 4.2.2 Rump Detector Sensor

The “Rump Detector” sensors was procured and the brackets that were designed within Milestone 1 where manufactured.

## 4.3 Hardware Shipping

Once all of the hardware was procured and manufactured, it was shipped to JBS Bordertown for the commencement of Milestone 3.

# 5 Milestone 4

## 5.1 Installation

The first part of Milestone 3 was the installation of the hardware such that the commissioning and validation stages could be completed.

### 5.1.1 Installation Bordertown

Each major task involved in the installation is

| Task | Date Beginning | Date End |
|---|---|---|
| Calibration Block Installation | 17/5/2017 | 17/5/2017 |
| Double Up Sensors Installed and Wired | 18/5/2017 | 19/5/2017 |
| RFID Ethernet Communications Installation | 19/5/2017 | 19/5/2017 |
| Uploading of PLC Program to Communicate with X-Ray System | 20/5/2017 | 20/5/2017 |

### 5.1.2 Calibration Block Installation

Figure 5-1- Calibration Block Installed and in Position

### 5.1.3 RFID, Double Up and Rump Sensor Installation

Figure 5-2- Installed Sensors

## 5.2 Commissioning and Validation

### 5.2.1 Commissioning and Validation Bordertown

| Task | Date Beginning | Date End |
|---|---|---|
| **Testing of PLC Program** | 20/5/2017 | 21/5/2017 |
| **Full Testing to Ensure Working System** | 20/5/2017 | 21/5/2017 |
| **Contingency PLC Modifications** | 22/5/2017 | 22/5/2017 |
| **NAS Integration Testing** | 20/5/2107 | 20/5/2017 |
| **Rump Detection Sensor Functionality Programming and Testing** | 23/5/2017 | 23/5/2017 |

### 5.2.2 New HMI after Commissioning

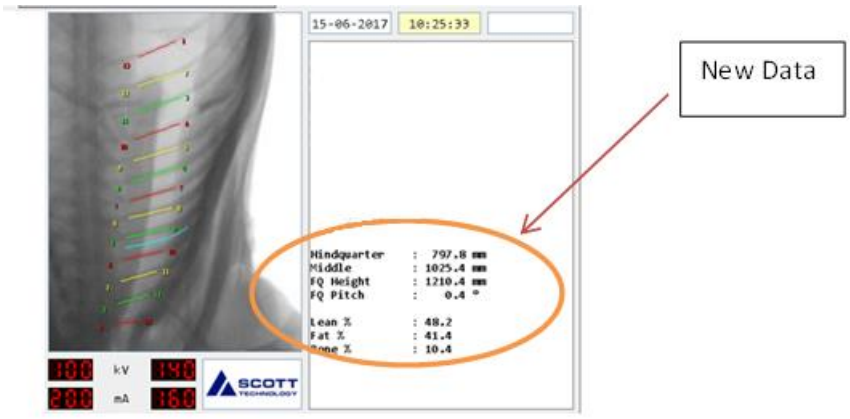


Figure 5-3- New HMI

### 5.2.3 Resulting Database Sample after Commissioning

Below is a sample of the resulting database showing the total lean meat, fat and bone percentages, as is saved within the database from the system.

| RFID ID | Analysis Time | Version | Status | Lean % | Fat % | Bone % |
|---|---|---|---|---|---|---|
| ff81237c5e6003c2 | 20/03/2017 6:07 | 2.2 | Success | 58.2391 | 27.0148 | 14.7709 |
| ff81237c5e6003c3 | 20/03/2017 6:07 | 2.2 | Success | 65.2448 | 16.9518 | 17.7957 |
| ff81237c5e6003c4 | 20/03/2017 6:07 | 2.2 | Success | 67.7611 | 13.3373 | 18.8821 |
| ff81237c5e6003c5 | 20/03/2017 6:08 | 2.2 | Success | 59.9203 | 24.5999 | 15.4968 |
| ff81237c5e6003c6 | 20/03/2017 6:08 | 2.2 | Success | 57.5767 | 27.9662 | 14.485 |
| ff81237c5e6003c7 | 20/03/2017 6:08 | 2.2 | Success | 58.5447 | 26.5758 | 14.9029 |
| ff81237c5e6003c8 | 20/03/2017 6:08 | 2.2 | Success | 54.7314 | 32.0533 | 13.2565 |
| ff81237c5e6003c9 | 20/03/2017 6:08 | 2.2 | Success | 58.8227 | 26.1765 | 15.0229 |
| ff81237c5e6003ca | 20/03/2017 6:08 | 2.2 | Success | 59.2203 | 25.6054 | 15.1946 |
| ff81237c5e6003cb | 20/03/2017 6:08 | 2.2 | Success | 58.5637 | 26.5485 | 14.9111 |
| ff81237c5e6003cc | 20/03/2017 6:08 | 2.2 | Success | 56.3827 | 29.6813 | 13.9694 |
| ff81237c5e6003cd | 20/03/2017 6:09 | 2.2 | Success | 51.8747 | 36.1567 | 12.023 |
| ff81237c5e6003ce | 20/03/2017 6:09 | 2.2 | Success | 56.3998 | 29.6567 | 13.9768 |
| ff81237c5e6003cf | 20/03/2017 6:09 | 2.2 | Success | 55.0413 | 31.6081 | 13.3903 |
| ff81237c5e6003d0 | 20/03/2017 6:09 | 2.2 | Success | 54.8273 | 31.9155 | 13.2979 |
| ff81237c5e6003d1 | 20/03/2017 6:09 | 2.2 | Success | 55.9083 | 30.3627 | 13.7646 |

# 6 Conclusion/Recommendations

At the conclusion of milestone 4, the Dexa system had been designed, installed, commissioned and validated at JBS Bordertown as required by the scope of the project. Within the validation component of milestone 4, all of the objectives that this project was to complete had also been verified.

The hardware and software had been implemented in order to enable the LMY data to be stored for a period of time within the database. This data was then reported on in batches, days, times and runs. On top of this, the data integrity and robustness of the system as a whole was verified and confirmed throughout this stage. This final report satisfies the last milestone, milestone 5 which in turn allows for the completion of the project.