final report

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Leap IV Saddle Processing – Stage 1 – Proof of Concept

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Summary

The system is complete
The system has successfully demonstrated the automated bone-in Middle processing concept
Some product specification variables became known late in the project and have not been accounted for.
RTL is still awaiting the results of a PPCS-driven market appraisal of cutlets produced using PPCS's Holac portioning machine. The results of this will determine whether or not the Holac machine will be integrated into future systems.

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1 Background

Robotic Technologies Ltd (RTL) was formed in 2003. It is a joint venture between Scott Technology Ltd (an automation company) and PPCS Ltd (a meat processing company). Scott Technology Ltd (Scott) began developing automated lamb boning solutions for PPCS Ltd (PPCS) in 2001. Under the banner of RTL, this development continues, with the ultimate aim of automating the entire lamb boning room. Solutions to-date have included the hindquarter boning machines (to remove the hind legs from the pelvic bone of lamb hindquarters), the primal system (separating the carcass into the three primal sections), and the x-ray system (identifying and measuring key primal cutting locations on the carcass).
The project described here was to develop a pre-production (workshop-model) prototype of a Bone-in Middle processing system, with the intention of separating the rack from the loin, removing the flaps, splitting the vertebrae, and processing chops.

2 Project Objectives

- Development of a process suitable for the automation of the Bone-In Middle cuts of Lamb. These cuts are:
    - Crosscut (between rack and loin)
    - Flap Removal
    - Vertebrae Splitting
    - Cutlets
- Development of a basic Pre-Production Prototype to demonstrate the process. The prototype being aimed at demonstrating the cutting and handling concepts, rather than the details of the final production system. It was to be demonstrated in a workshop environment rather than a food-grade facility, and did not need to be wash-down capable.
- The prototype demonstrated processing of a small number of Middles.
- Project completion was to be when all cutting and handling concepts were demonstrated to a level such that it was clear the required product quality, accuracy and cycle time can be achieved in a subsequent production machine utilizing these concepts. Project completion was scheduled for 1 November 2006.

3 Project Outcomes

3.1 General Outcomes

3.1.1 Feasibility

At the beginning of the feasibility phase of the project, the only known elements were the cut specifications required, and the methods currently used to perform them. Typically we were searching for methods which would be suitable for automation, and methods which would provide a payback benefit to future purchasers of the equipment. The latter item generally involves using a method that does not generate waste in the manner that the bandsaws used in manual production do.

Cutting methods experimented with include:

- **Circular Knives:** serrated edge circular knives were tried on all cuts. As a cutting method, this worked extremely well.

- **Brisket scissor:** a scissor-action device as commonly used to open the brisket of carcasses was tried for cutting the flaps. This worked well on the boneless loin end, and also on the ribs when cutting a 50 to 80mm specification. However, closer to the vertebrae the ribs were found to become thicker and more brittle, and this method resulted in splintering.

Figure 1: Brisket

- **Guillotine:** a guillotine-style device was tried on all cuts with limited success. This generally resulted in splintering

Figure 2: Guillotine

- **Rotary Shear:** a rotary shear as used in portioning machinery such as the Holac Sectomat was tried on the crosscut and on cutlets. Its quality appeared to be reasonable.

Since this early testing, PPCS acquired a Holac Sectomat, and have been conducting their own trials. PPCS has not been entirely happy with the results, but on the basis that their internal standards may be too stringent they sent a sample batch from the machine into the European market to assess the customer attitude. We are still awaiting the result of this trial. We continued development of the crosscut, but put cutlet development on-hold.

Of all the cutting methods tried, the circular knife was by far the most successful. As a result, we adopted this for all cuts (apart from cutlet production, where we are still awaiting the results of the PPCS Holac trial).

A number of handling methods were also experimented with.

3.1.2 Pre-Production Prototype

The pre-production phase involved designing and building a workshop-grade semi-automated proof-of-concept system to test out the combined cutting and handling concepts. The exceptions to this were:

- We avoided doing any further work on the Cutlet production due to the work being undertaken by PPCS.
- We kept the Vertebrae Split station separate from the main system, as we had a greater level of experimentation to continue with here than on the Crosscut and Flap Removal stations.

The Crosscut station consisted of an inverted “U” frame which could travel up and down on a vertical track. It was powered by a pneumatic cylinder. On the ends of the frame were mounted two circular knife blades, powered by air motors. The Middle was manually positioned along the guide bars so that the cut line was below the cutting frame. Following clamping, the air motors were powered up, and the cutting wheels were driven down through the Middle.

The Load Transfer station was developed to take the Loin Saddle and the Rack Saddle from the Crosscut Station and place them onto the Transfer. It consisted of a carriage that ran along a horizontal track and incorporated a pusher finger. The pusher finger could be pneumatically retracted to allow it to pass over the Saddle on its return stroke.

The Transfer consisted of a twin chain-style conveyor with essentially vertical product support plates attached to each chain. The support plates were arranged into a series of carriages, with some higher plates at the back of each carriage to push at the back of the Saddle sections. The carriages were arranged in pairs, such that the first carriage in each pair could support the Loin Saddle, and the second carriage could support the Rack Saddle.

The Remove Flaps station consisted of a carriage suspended from a curved track, supporting a circular knife (powered by an electric motor). On the final production machine, there would be two such carriages – one on each side of the line. There were also twin bars driven down by a pneumatic spring mounted above the Transfer to clamp and centre the product. Below the level of the lowest Flap cut, there was a gripper on each side of the line, mounted to a carriage which was driven back and forth along the line by a pneumatic cylinder. This gripper was used to hold the Flap to ensure it did not ride up during cutting.

As stated earlier, the Vertebrae Split station was kept separate to the main line to allow further experimentation to take place. However, in the final production machine, this station would be mounted at the out-feed end of the Transfer. The main element of the station was a circular knife (powered by an electric motor) protruding vertically through parallel guide bars, with the hub and shaft mounted below the bars. The station had similar clamping bars to the Flap Removal station, and the Saddles were pushed into the blade manually using a carriage-mounted pusher bar. (The guide bars and the pusher carriage would be replaced by the Transfer in the final production machine).

Some testing was done by Scott on the PPCS-owned Holac Portioning Machine. PPCS conducted further trials. While the machine has definite potential to be integrated with the rest of the Middle Processing System, PPCS felt that the cut quality being achieved was not always acceptable, and that the re-formed packaged product was far less attractive to the end customers than the frozen bandsaw-cut equivalent. However, PPCS has sent a sample batch from their trials into the European marketplace (due to arrive in Europe mid-December 2006), and is awaiting feedback. If the Holac-style of machine is found to be inadequate, there is a possibility of a Scott-designed machine.

3.2 Issues Encountered

- Late in the development phase, we were informed by PPCS that the Crosscut specification we have developed our machine around only accounts for about 50% of their production. In the remainder of their production the crosscut is knifed through manually in line with the ribs. To do this, the Crosscut station will need a pitch mechanism, and the two circular blades will need to be able to move to a vee-configuration as per RTL's animal carcass cutter (patent pending) that is currently in use for primal cutting. Developments being undertaken for the primal cutter will be adapted back to this system in the future, and the vee-cut will be offered as an optional extra.

- Vertebrae splitting proved very difficult. We began the development on the understanding that the cut line needed to be through both the spinal cavity and the center of the featherbones, or the cut would be considered soft-sided. A number of different blade configurations were trialed. A variety of guidance devices were trialed to keep the cut line through the centre of the featherbones. Towards the end of our development, it became apparent however, that the specification regarding the featherbones was not clear, and that the moderate success rate we achieved may in fact be more than adequate. What we did achieve reliably was splitting down the centre of the spinal cavity.

A number of methods were trialed for producing cutlets in the early phase of development. Of these, circular knife cutting produced the best quality cut, but traditional circular knife machines are too slow to achieve the required cycle rate. Commercial portioning machines with a rotary-shear style blade offer potentially the most cost-effective method of fast cutting. However, these are typically developed for boneless product, and produce a certain amount of splintering in bone-in product. As the cut quality requirement of cutlets is not well defined, PPCS has sought to develop a better definition by sending a batch of cutlets produced in their Holac Sectomat portioning machine into the marketplace. The issues they are concerned about are the bone splintering and the re-formed vacuum packaging appearance relative to current frozen production. This latter issue will need to be overcome for any fresh-cutting method. If the market evaluation finds the cut quality to be inadequate, RTL is likely to develop its own machine.

3.3 Learning

- Of all the issues detailed above, the most important learning is to ensure that the product specification is fully defined before undertaking any development. While it must be said that in all cases above, every effort was made to establish a full specification from PPCS, it may in fact have been prudent to question other processors also, in order to uncover further variations.
- The cutlet issue has highlighted the fact that even when the processor's cut specification seems to be well known, this is not necessarily the end-point. Ultimately, the consumer decides what is and isn't acceptable; this may be either a higher or a lesser standard than the processor's standard.

4 Future Plan

4.1 Future Project

RTL's next proposed project involves developing a production prototype boning-room front end. As well as integrating and further developing the existing x-ray, primal and hindquarter systems, this will involve developing and integrating a production-prototype version of the bone-in Middle processing system. This project proposal is currently being reviewed by MLA. Please refer to this proposal for the detail of the steps and financial commitment required to develop and evolve the technology to a commercially viable solution. The anticipated savings and payback period for a nominal Australian processing company are also included in this proposal.

4.2 Decisions Required

- A decision needs to be finalized regarding the development of the vee-cut specification for the Crosscut. If this is agreed upon, further decisions need to be made regarding the technical solution to be developed.
- The vertebrae-splitting cut specification needs to be fully defined regarding the importance of cutting down the centre of the featherbones.
- The cutlet cut quality specification needs to be fully defined, which will define the type of machine to be developed/integrated in the production-prototype

5 Future Risks

The key project risks and mitigating strategies for the bone-in Middle phase of the future project are set out below:

Activity	*Risk*	*Consequences*	*Mitigating Strategy*
General Activities	Budget Over-run	o Overall budget exceeded Higher value – hence longer payback – production system	o Costs are to be tightly managed
General Activities	Time delays	o Inability to test system within the funding timeframe	o Time is to be tightly managed
Crosscut	Inability to achieve vee-cut specification	o Lower benefit system	o Use of concepts already developed and being developed for primal cutting
Flap Cutting	Difficulty locating cut position using vision system	o Lack of cut position reliability	o Research into medical techniques o Possible engagement of expert subcontractors Possible manual screen intervention
Vertebrae Split	Inability to position the cut accurately relative to the featherbone	o Product is “soft-sided” o Product is not acceptable to the market	o The need for cutting along the featherbone (processor specification) is to be assessed as part of any future development
Cutlets	Holac machine not suitable for cutlet production	o Holac cannot be integrated with Leap 4	o Design of a suitable machine