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Analysis of the practices in slaughter, carcase handling and break up, de-boning and end of line operations

Automation opportunities and management of change

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Abstract

Findings and conclusions of a study carried out in a typical Australian medium volume processor of quality beef both for bulk supply, export and retail are presented. The study has considered operations in the slaughter, post slaughter, chilling, break up and de-boning, trim and vac pack, end of line case packing followed by storage and despatch. The process of change management facilitated by industry expert and company senior management team was a fundamental approach to delivering the results and defining strategies over the period of the study. The work done included: (a) consideration of automation opportunities in the slaughter area, where single robot cell with multi-functional capability would give faster return on investment; (b) introduction of grading and carcase evaluation and yield assessment post slaughter for sorting and forward planning; (c) whole carcase rapid-chilling optimising/reducing use of chill space and lead time to start of break up against customer orders; (d) automation for break up, handling and meat bagging including tracking of packs for free flow rapid-chilling and sorting post vac packing to assist with case packing; and finally (e) case packing and end of line automation. An overview is also given of technology supply with investment/return estimation.

Contents

1 Executive summary

Slaughter, carcase break-up, meat cutting and boning, trimming, handling and packaging and post packaging or end of line operations in the meat sector continue to rely on a large population of skilled or semi-skilled tasks, performed by people. It is important to note that in the meat sector, given the degree of product variability as well as the degree of care and attention needed for both safety and hygiene reasons, it would be reasonable to state that there are very few or no 'unskilled' tasks that manual labour could be used for. All tasks, in general, require judgement and dexterity in handling or manipulating products or tools at various stages.

The objective of the study has been to examine the stages of operation in a typical medium size beef plant and to report on the following:

i) Opportunities for improvement by changes of practice or automation
ii) Process of conducting the study and management of change
iii) Process of involving and working with experts in the field to plan and assess returns of investment, whilst developing strategies to meet current and future market needs

In the slaughter area the following findings may be reported:

1- Tasks including: Hock –horn cutting; Belly opening and evisceration; Splitting; Cord removal; Belly opening and other similar tasks, have been the subject for many automation projects, however, in a low speed processing line (60 heads/hour), the configuration of a typical robot cell may be such defined (potentially with tool changing where possible) for a single robot to perform multiple tasks in the time available - 60 seconds. In this manner, tasks performed at two or more stations in a typical line may be performed by one robot including similar tasks with the use of the same tool. In a two shift operation where two stations are automated a typical saving of 4 staff provides a budget in excess of $400k over 2 years for a typical robot cell. This makes the economics of supply more reasonable for technology providers.

2- More accurate post slaughter evaluation of carcase sides, especially in relation to fat, tenderness, primal yield estimation, meat bone ratio estimation, etc., combined with a process for tracking and sorting would have a major impact on planning practices for break up and optimisation of profit. Combining this with rapid-chilling of whole carcases as a strategic implementation was considered to have a major impact on profitability.

In the break up area the main analysis have been related to the practice of pre-cutting carcase sides and using trackable work stations as means of managing the logistics as well as flow of met from the whole carcase side to the point of case packing and despatch. Specific finings or considerations are:

3- Using robotics to perform maximum number of bone scribing or break up operations requiring a powered tool whilst keeping the carcase whole. This was considered important as handling of the pieces from the robot station would be at the lowest cost.
4- Pace boning and muscle separation would follow with carcase side or quarter travelling on hooks and rails until such time that no further cutting or separation operations can be performed without pieces or primal sections needing to be removed from the main body of the carcase half or quarter.

5- The next stage would use work stations for slicing, meat separation, trimming and de-boning in a ‘trackable’ manner. The meat sections, primal pieces or sub primal pieces from the carcase side or quarter, would use manual boning, trimming or slicing actions. The deign of such stations to provide for two subsequent possibilities:
    a. Bagging of main pieces with marking on the bags that allow tracking post vacuum packing
    b. Or, tracking of the main pieces to the point of bagging in such a way that the bagged pieces can be tracked and grouped for easy placement in cases or boxes without the need for sorting. In other words, having a process where the flow is structured and controlled from the point of bagging to the point of placement of the vac packed product in a box.
6- A centralised packing process using robot bag loader as well as a low cost bag loading machine with bag marking equipment integrated at the stations where the main pieces are generated have been considered. The preferred choice is a centralised bag loading with the allied vacuum packing machine where an operator loads the meat at the in-feed, identifying the product. It should be noted that large size and outside the norm pieces would use a conventional approach to packing and this is a small percentage of packs.
7- The process of case packing would rely on the previous stages as in 5 and 6 to give intelligent sorting at low cost using a batch sorting system and a minimum number of people (potentially serving more than one case packing station at a time). The saving when compared with the ‘Lazy Susan’ or a carousel is significant.
8- Super chilling after vac packing would give energy savings and longer shelf life and thus expected to be an important area for the business.
9- Given the level of tracking introduced in stages above, structured storage/retrieval would aid despatch palletising resulting in further labour savings. Justification against a 24 month ROI however is difficult in a one shift operation. A longer term strategic vision needs to be applied in the applications of automation post case packing and despatch.
10- Measurement of fat in trimmings and off cuts and intelligent blending of graded trim using CL measurements were also considered and by balancing the fat meat ratios in a more specific form this can result in reduced ‘give away’ and consistency in meeting customer specifications.

Return on investment (ROI) over a two shift operation give acceptable time scales given the rate of recovery of labour cost, however, in all cases single shift operation extents the ROI period beyond 24 months. Strategies for combining processes and using R&D resource from sources such as an MLA aimed at reduction in equipment cost for the medium size processor is needed, if 24 month return on investment is to be achieved in cases considered.

An important aspect of the work was the process by which the findings were guided by a facilitator external to the company, whilst engaging senior management. Working groups considered the specifics to support strategic planning and defining priorities for automation or improvement with Input from different areas of the business including: operations, engineering, IT planning, finance and sales. Management of the change process and discussions of stages for change brought focus and ownership of the action plan as well as understanding of the benefits.

2 Background

This project was instigated by Rockdale Beef in 2009 with the purpose to analyse practices in operations from the start of slaughter to the end of despatch. The main focus of the project was to identify opportunities and improvement through changes of practice as well as use of technology especially robotics and automation. Improvising 'architecture' for improved process and operation for the plant combined with strategic planning and investment were to be the main deliverables.

3 Project objectives

1. To analyse current operations for beef production using internal and external resource for change management and achieve improvements by avoiding double handling as well as use of technology
2. To cost benefit analyse investment opportunities in automation as applicable
3. To establish working practice in the definition and management of change
4. To involve the supply base in the form of a workshop to assess requirements and technology gap leading to prioritisation and planning of implementation.

4 Methodology - approach

- Background project planning and background desk top research.
- Identification and quantification of issues within plant process, specifically opportunities to the back end of the boning room - load out and pelletising area
- Presentation to senior management
- Workshop with relevant floor employees and area managers to discuss the proposed process changes and undertake change management training to facilitate the identified process change.
- Production of drawings for the operational areas requiring redesign / equipment re positioning as identified
- Identification and quantification of issues within the plant process, specially the slaughter and carcase handling and break up, de-boning.
- Identification of possible solutions and the payback period for each initiative consisting of the implementation and operational costs of each option to support a business case for each option
- Report on findings to plant and production of report appropriate for industry distribution.

5 Results and discussions

The work undertaken has followed a procedure involving planning, discussion and management involvement and execution – facilitation towards priorities.

Areas included for assessment included: the slaughter, chilling, beef break up, de-boning, trimming and packing is considered, leading to end of line operations such as case packing and chilling, case closure and box lidding, followed by palletising and despatch.

Aspects of supply chain parameters, quality and management reporting as well as IT, information tracking and traceability were considered.

5.1 Planning and desk top research

Based on initial observations and evaluation of technologies available or under development the work has been planned and prepared the following as important for the plant to consider. This study has however focused on those aspects that senior plant management have identified as priority.

5.1.1 Slaughter area

There has been considerable technology development in the beef slaughter area, including techniques for killing (such as the use of high power laser), through to robotics for hock/horn cutting, hide opening, head removal, steps in evisceration, splitting, spinal cord removal and carcase sanitisation, inspection/grading and classification. The desk top research was planned to give consideration to:

i) Methods of automatic execution of each step with a series of mechanisms, dedicated machines or semi-automated devices or robots, with the associated cost benefit analysis,
ii) Methods for using cells with multi-step or parallel actions facilitated by simple handling or fixation systems meeting the needs of several cutting or clipping actions at a single work station,
iii) Use of available space for the intended improvements and quantifying the requirements for additional space,
iv) Consideration of processing of offal and other similar products for potential improvement,
v) Consideration of change management issues, skills and resources.
vi) Other matters as may be relevant.

5.1.2 Procedures and steps at the end of the slaughter line

Once beef carcases are ready to leave the slaughter area, there is opportunity to improve on several steps that follow before the carcase is to be taken to the boning area. The work has considered aspects of:

i) Sanitisation and inspection with associated technologies that make use of assessment by artificial vision as well as spray sanitisation processes,
ii) Grading and classification using VIA and other similar technologies and in particular paying attention to features that provide predictive yield and quality information.
iii) Rapid chilling without compromising quality of yield loss.
iv) Information links that facilitate improved planning and optimisation of break up process against customer specification.

5.1.3 Boning area

By far this area presents the greatest opportunity with focus placed the following:

i) Method of break up with recommendations on use of robotic scribing and cost benefits and options for efficient handling, boning and tracking of primal or sub-primal pieces as well as trim and bone.
ii) Commercial (or customised) cutting room designs including those based on readily available equipment and software solutions.
iii) Options for minimum handling and reduced time from boning to vac pack with reduced labour and traceability for internal management of flows and progress monitoring. Super-chilling for reducing time from vacuum packing to despatch, with the added benefits quantified.
iv) Approaches for introducing technology that improves yield and efficiency whilst providing the means for assuring quality and hygiene standards, shelf life and making better use of information and resource, particularly relating to energy, packaging materials, skills, space, etc.
v) Operator information providing performance feed back to each person working at any station.
vi) Handling of trim, off cuts and waste, including consideration of mixing and blending for target CL of bulk packed cases of trim and off cuts.
vii) Other considerations of the work environment, operations, flows and data handling.

5.1.4 Case packing to despatch

The operations from vacuum packing the main products, the processes of packing, chilling, palletising and case packing with specific consideration of the following:

i) Methods for identifying, sorting vacuum packed products that are delivered in a random manner for case packing.
ii) Alternatives for chilling, storage, order picking and palletising as well as despatch.

iii) Efficient handling and case packing by automation with relevant cost benefit analysis.
iv) Options for automatic pack, case and pallet labelling as well as palletising where appropriate with cost benefit calculations
v) Case storage options as well as pallet storage with automated or structured placement and retrieval with cost benefit calculations.
vi) Other relevant aspects that relate to case packing and handling to the point of shipping.

5.1.5 Information handling and exception management

The processes and practices of planning, information reporting and meeting customer deliveries to specification and on time at the expected margin in the business are considered key to sustaining market position as well as revenue and growth. Options, approaches and, where applicable, technologies in the following areas:

i) Operations planning and management of information in the supply process, monitoring of progress against plan.
ii) Exception management reporting where real time flags are raised by using IT and electronic communication technologies.
iii) Presentation of information to staff, supervisors and management using computerised displays.

The next section of this report presents the steps considered priority as a subset of the above and considered in the study.

5.2 Priority Opportunities

This section is aimed at the analysis of the practices in the slaughter, carcase handling and break up, de-boning and end of line operations. The work here has had direct input from:

James Kelly - **Innovations Manager**
Don Blackburn - **Plant Manager**
Will Cowley - **Chief Operating Officer**
Gary Shanley - **Production/Shipping Manager**
Jeff Ticehurst - **Financial Controller**
Craig Light - **Engineering Manager**
Greg Duggan - **ICT Manager**
Phill Britt - **Slaughter Floor Supervisor**
Neil Watson - **Boning Room supervisor**
John Vearing - **Boning Room supervisor**
Brad Chisholm - **Boning Room supervisor**
Jim Frazer - **Load out supervisor**
Tony Pearson - **Quality Manager**

5.2.1 Hock cutting

The main approach, given that the tool for hock cutting is the same pre and post de-hiding, the robot cell as illustrated in Figure 2.1 may perform the task if the conveying of the carcase were designed to give access by the robot to both stages of the process.

The expectation is that there will be in cycle sanitisation after each robot cut.

In a two shift operation the potential is to save 4 people. Given a labour rate of $70k a robot cell costing around $450k would have an ROI of less than 20 months.

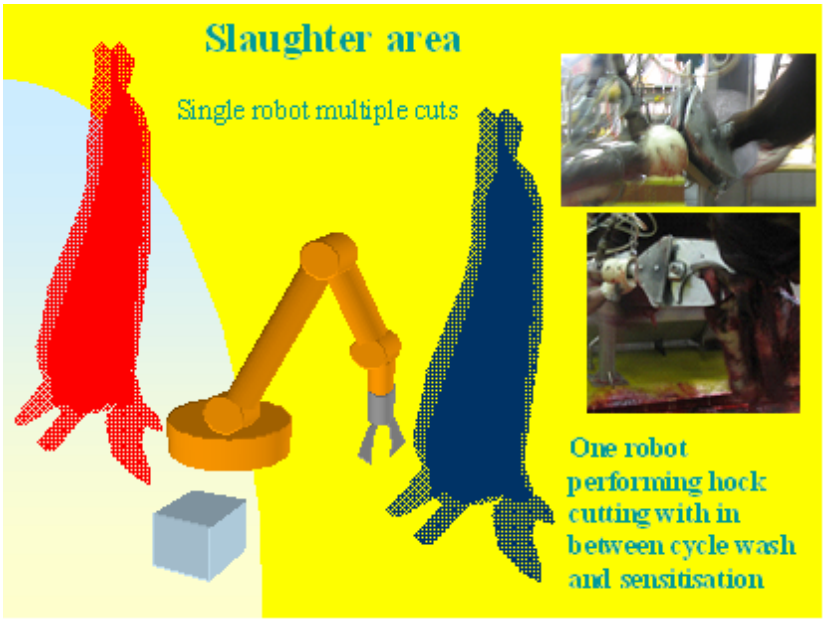

Figure 2.1 Hock cutting – two stages in 1 (applicable to low line Speed operations, say at 60 carcasses per hour).

Clearly, a solution for a single shift operation would need to be delivered close to $280k for a 24 month ROI. This clearly sets the target for equipment suppliers and innovation that go beyond technology development but innovations in cost reduction. It is important to recognise the value of R&D in developing automation solutions at low cost of supply given that high value solutions are available.

5.2.2 Belly opening and viscera separation

The approach would be to use a two headed tool (or tool changing integrated with the cleaning cycle) deigned for belly opening and viscera separation with appropriate carcase handling in place. (Figure 2.2)

The ROI calculation and robot cell pricing is the same as that indicated in 2.1 above.

Figure 2.2: Belly opening and viscera separation

In this consideration it is not difficult to see that equipment suppliers need to consider cost reduction and the MLA may also target initiatives that are aimed at reducing cost for the same or better performance of proven solutions for medium size processors in parallel to those projects that aim at new technologies.

5.2.3 Splitting and cord removal

Although this would be a new development, there are considerable benefits in combining a standard splitting process tool with a cord removal tool (Figure 2.3), whilst improving the carcase handling process that allows better performance especially in relation to soft-siding. Many attempts in dealing with this process using circular saws have been attempted and a few plants worldwide have successes with automation at low throughputs (60 carcases per hour).

Figure 2.3: Combining splitting with cord removal

Again, pricing and ROI calculations from 2.1 and 2.2 apply. However, automation of this combined process would require development funding approaching $700k excluding equipment.

5.2.4 VIA and predictions in achievable yields

Video image analysis of carcases has been in use for many years (Figure 2.4). Automation of this process would give labour saving as well as valuable carcase data for optimisation of planning and cutting room operations.

The returns on investment would relate to labour saving where a probe is in use as well as better assessment of fat grade as well as yield prediction for optimising solution profitability.

Figure 2.4 VIA set up for beef

5.2.5 Rib eye grading

Grading for marbling was considered and technologies such as vision are now available as in Figure 2.5. (Photos from E+V Germany)

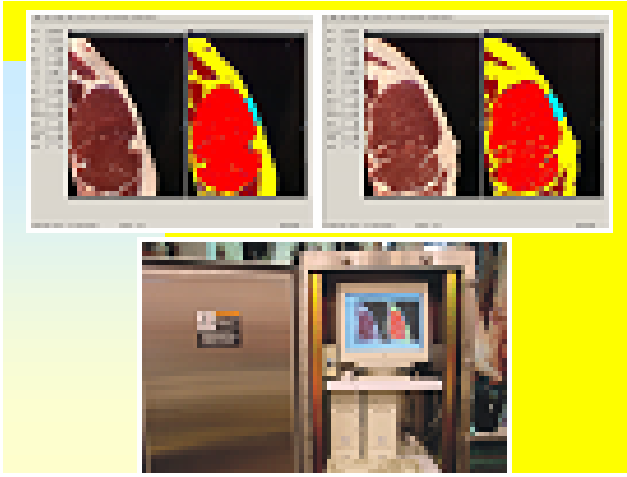

Figure 2.5 Rib-eye camera for marbling grade

Investment in this technology would improve current practice in attributing marbling score to carcases where this is practiced by the plant and achieve improved allocation against customer orders. The solution has been in use in USA for several years now and if combined with a process for online tenderness grading, which is still a subject for research, it would have a significant strategic impact on profitability in high quality meat production.

5.2.6 Scribing beef sides

Robot technology for scribing beef sides is in development and the industry has seen successes in pork and lamb over the past decade. Benefits in labour saving and yield optimisation are important drivers, however, the tasks of scribing require use of power tools and benefits in OH&S feature highly on the priority list. Safety and improvements in work environment were considered key for the management team driving the study.

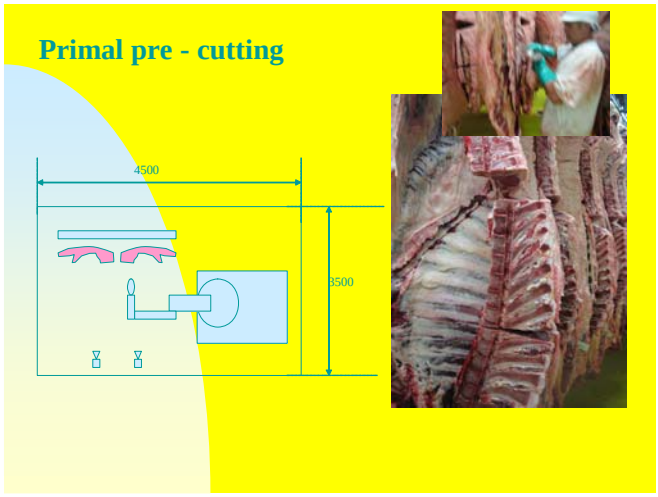

Figure 2.6 Typical pre-cutting on beef

5.2.7 Boning, trimming and vac pack

The study placed significant effort in this aspect of the work and several alternatives for the design of the factory were considered. Input from expert supply company was important to the thinking behind the solutions considered.

The option to adopt solutions such as streamline from Marel as well as others was considered. Alternatives such as placing bagging of meat immediately after boning and trimming stages and using marked bags . For identification at the point of case packing, bag marking was considered. Technologies from Cryovac and other similar companies were reviewed.

Figure 2.7.1: Options in the boning area

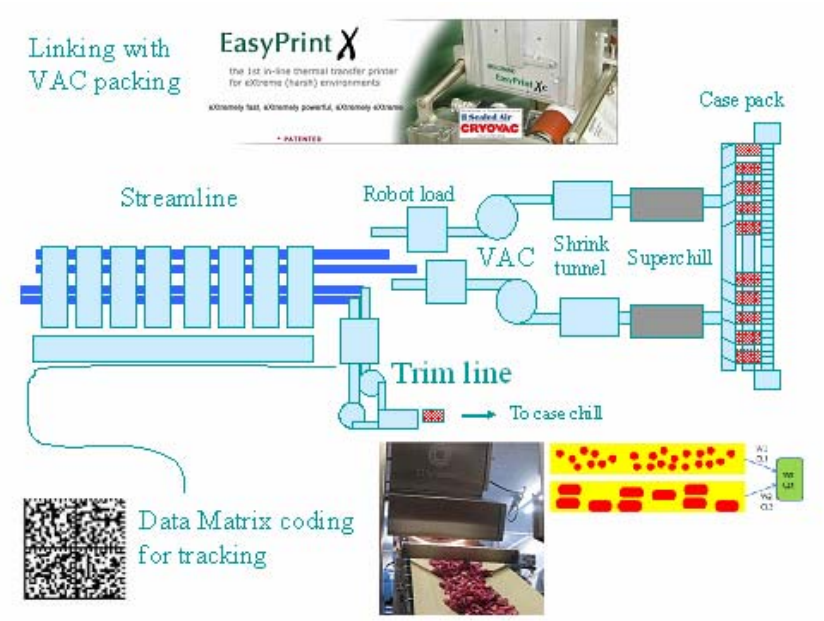

Figure 2.7.2 Overview concept for break up to end of line case packing including packing trim with low cost CL measurement

Figure 2.7.1 gives a representation of a typical Marel installation where primal pieces are tracked to the point of bagging. Figure 2.7.2 illustrates the concept with the option to use EasyPrint to mark bags say with a data matrix code and track the product to the point of case packing in a free flow form. Combining such concepts provides an effective approach for in integrated solution where handling and grading trim for CL allows improved yield and significant cost saving in labour.

In Figure 2.7.3 the overview and approach or the development of the plant has been illustrated. Note that an important consideration is the management of the business and continued production during the period of change. In the case of Rockdale, it is fortunate that space availability provides the opportunity for equipment installation in an area that causes minimum interference with day to day operation in the boning room.

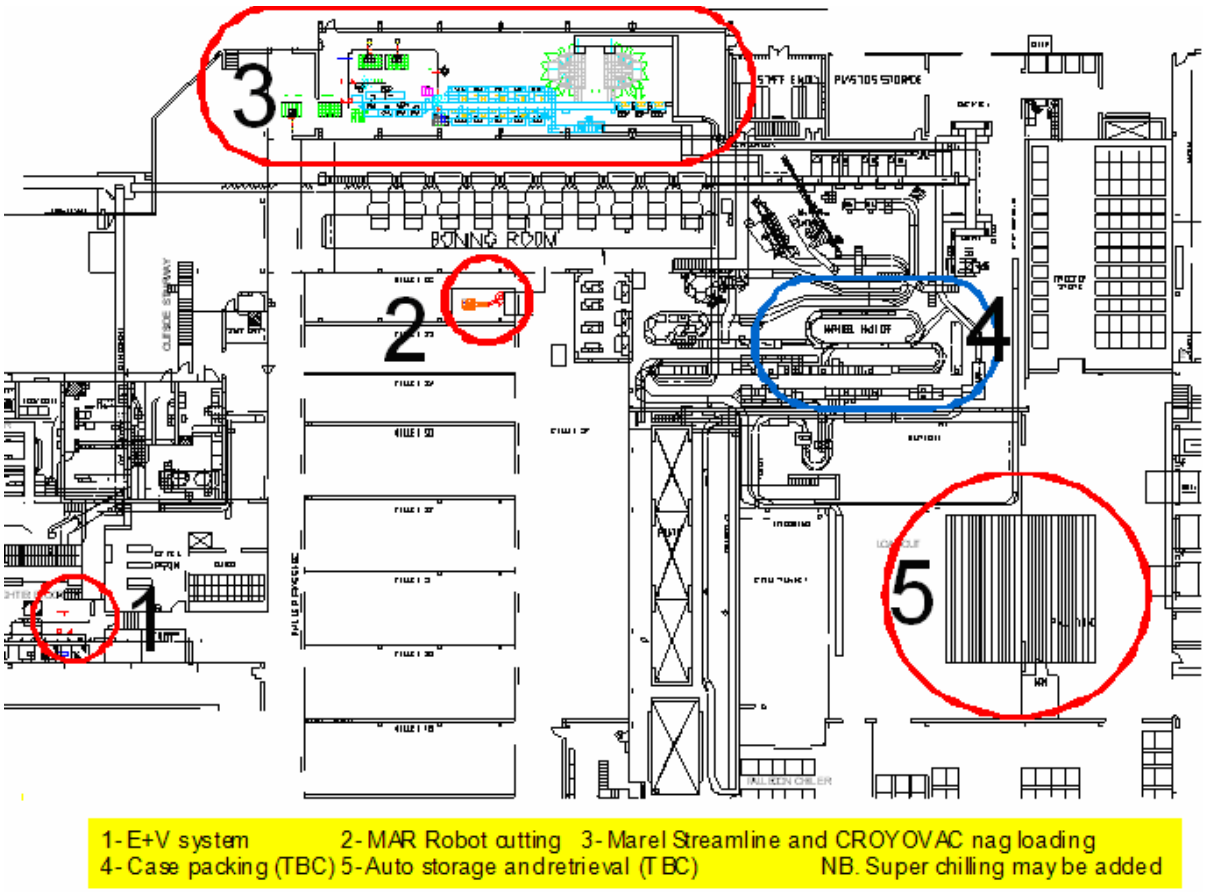

Figure 2.7.3 Overview of the plant development process in respect of break up and packing

Carcase intelligence at the end of the slaughterline (1) in Figure 2.7.3 would give optimisation data to the boning room and also drive the decision for the beef scribing and cutting robot at location (2). This is to be followed by separating main muscles and bones, where this can be done, without removing primal pieces from the main carcase structure, during the carcase travel from (2) to area (3) where tracking is not lost. (3) uses trim stations that

provide for ‘trackable’ de-boning slicing and trimming before bagging through to the end of vac packing. (4) and (5) provide for end of line packing using a sorting system that groups vac pack products before placement in cases at appropriate designated stations avoiding the use of a carousel or ‘Lazy Susan’ tables. The batching of tracked vac packed products avoids significant stock piling of vac pack and avoids double handling.

A specific Workshop was arranged in order to cover the following as part of the change management process:

- Experience of supply companies
- Approach to providing a solution
- Options and risks
- Examples of successes with supporting such implementatiomn
- Meeting expectations and time lines
- Drawings of installations
- Outline of software and hardware in the solution to meet requirements
- Links with current plant processes, IT system, management practices
- Proposed management approach for implementation
- Timescales and novelty that would be classed as development or customisation with innovation rather than standard supply – important when considering the potential input from the MLA.

The Workshop was one of the important steps for senior management to receive the state-of-the-art input from international companies, providing a focused approach in reaching commitment and the path to be followed.

5.2.8 Rapid chilling

Rapid chilling after vac packing was considered an opportunity allowing reduced time to despatch and better shelf life. This was also considered as a potential for whole carcase sides if a solution were to be researched and developed. The savings would be significant; however, the R&D requires a detailed plan, outside the scope of this study. The main benefits are reduction of carcase time in the chill facility and also in respect of vac packed products in cases, a more efficient end of line automation solution for case storage and palletising/despatch process.

5.2.9 Automated storage and retrieval

Figure 2.9 shows approaches for storage of cases, and such solutions are available from many sources.

The issue of investment and returns was considered the main topic in this assessment. Most systems would have a high cost but a long life as installations of this type are concerned. In a single shift operation the savings do not give a return within the normal 24 month period and in many cases this may be true for a 2 shift operation also.

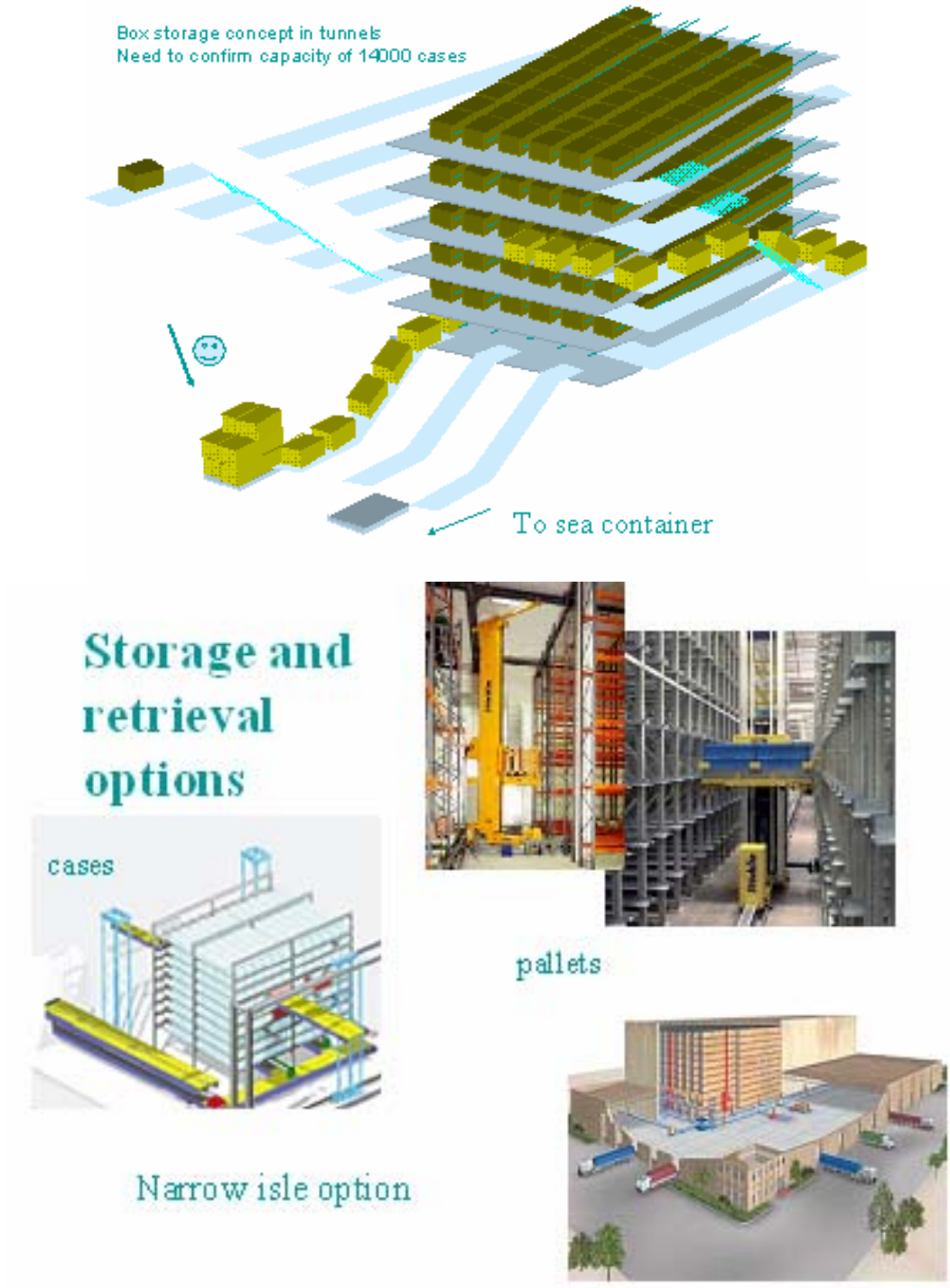

Figure 2.9: Case storage after case packing

The main approach is to track cases from the case packing stations were the information about the case is known to the point of storage and on retrieval allow for the process were mixed cases can be palletised or loaded direct in containers for shipping.

5.3 Review of costs and benefits

A first assessment of investment magnitude against priorities is included in the Table 3.1, where benefits are presented in term of estimated yield gains as well as net labour benefit.

Cost labour in Australian $ is assumed at 70k per person.

Analysis of ROI- overview	Labour/shift/year		70,000		Shift	1.0
State of play over one shift		Staff	1% yield =	350,000		
	Capital	Reduction		Optimising	Total	ROI
item Project	Budget	per Shift	Labour	Yield	Saving	Months
1 Hock cutting	420,000	2	140,000		140,000	36
2 Belly opening and Evisceration	480,000	2	140,000		140,000	41
3 Splitting bone separation and cord removal	750,000	2	140,000		140,000	64
4 Grading and classification	420,000	1	70,000	120,000	190,000	27
5 Rib Eye grading system	450,000	1	70,000	80,000	150,000	36
6 Beef primal scribing	1,200,000	1	70,000	350,000	420,000	34
7 Bone trim and vac pack improved handing	6,000,000	14	980,000	1,050,000	2,030,000	35
8 CL measurement and sorting	1,200,000	1	70,000	350,000	420,000	34
9 Super chilling and case packing	1,300,000	4	280,000	200,000	480,000	33
10 Case storage system with automated retrieval	2,400,000	6	420,000	50,000	470,000	61

Table 3.1: ROI overview based on a single shift operation

The columns in yellow represent savings and the ROI may be seen to be considerably longer than expected based on the estimates in Capital spending needed to achieve the solution.

Table 3.2 however presents the same but against a 2 shift operation.

Analysis of ROI- overview	Labour/shift/year		70,000		Shift	2.0
State of play over one shift		Staff	1% yield =	350,000		
	Capital	Reduction		Optimising	Total	ROI
item Project	Budget	per Shift	Labour	Yield	Saving	Months
1 Hock cutting	420,000	2	280,000		280,000	18
2 Belly opening and Evisceration	480,000	2	280,000		280,000	21
3 Splitting bone separation and cord removal	750,000	2	280,000		280,000	32
4 Grading and classification	420,000	1	140,000	120,000	260,000	19
5 Rib Eye grading system	450,000	1	140,000	80,000	220,000	25
6 Beef primal scribing	1,200,000	1	140,000	350,000	490,000	29
7 Bone trim and vac pack improved handing	6,000,000	14	1,960,000	1,050,000	3,010,000	24
8 CL measurement and sorting	1,200,000	1	140,000	350,000	490,000	29
9 Super chilling and case packing	1,300,000	4	560,000	200,000	760,000	21
10 Case storage system with automated retrieval	2,400,000	6	840,000	50,000	890,000	32

Table 3.2 ROI against 2 shift operation

It may be noted that the ROI is significantly reduced given that yield benefit and labour saving contributions are doubled. Also, note that benefits in indirect savings and OH&s have not been included. These may be offset by costs relating to automation in maintenance and engineering support/skills.

Analysis of ROI- overview - desired		Labour/shift/year		70,000		Shift	1.0
			Staff	1% yield =	350,000		target
		Capital	Reduction		Optimising	Total	ROI
item	Project	Budget	per Shift	Labour	Yield	Saving	Months
1	Hock cutting	280,000	2	140,000		140,000	24
2	Belly opening and Evisceration	280,000	2	140,000		140,000	24
3	Splitting bone separation and cord removal	280,000	2	140,000		140,000	24
4	Grading and classification	380,000	1	70,000	120,000	190,000	24
5	Rib Eye grading system	300,000	1	70,000	80,000	150,000	24
6	Beef primal scribing	850,000	1	70,000	350,000	420,000	24
7	Bone trim and vac pack improved handing	4,000,000	14	980,000	1,050,000	2,030,000	24
8	CL measurement and sorting	850,000	1	70,000	350,000	420,000	24
9	Super chilling and case packing	950,000	4	280,000	200,000	480,000	24
10	Case storage system with automated retrieval	1,200,000	6	420,000	50,000	470,000	31

Figure 3.3: Capital cost to meet 24 month ROI expectation

An important assessment is that presented by Table 3.3, giving a target for the pricing against a single shift operation to reach a 24 month ROI. This is significant as R&D effort needs to provide for the process where high cost automation becomes low cost automation through innovation.

It may be noticeable that in the case of storage and retrieval, the capital could not be expected to be lower as solutions are essentially standard and wide ranging in this application domain. It is therefore important for companies to consider investments in such areas as strategic with reduced expectation accepting a longer ROI period.

5.4 Concluding remarks

This study has been based on a typical medium volume processor in Australia considering improvements and automation opportunities.

Slaughter line processes as well as tasks from start of chilling to despatch have been reviewed and the results presented.

Concept solutions using robots in a multi-tasking function have been presented and the cases where hock cutting (before and after hide pulling); belly opening and viscera separation, and splitting and cord removal may be combined as tasks paired together, higher rates of return would be expected. The opportunity for the dual task option presents itself in each case because a 60 second processing cycle is available.

By using robotics where pre-cutting of carcase sides can be done using vision guided systems, yield optimisation becomes practical. Separating main primal pieces whilst keeping each piece still attached to the body of the carcase reduces handling costs and facilitates a cutting room design with minimum number of cutting, trimming and boning stations. Using flow line concepts and

trackable bagging provides the means for more efficient case packing and end of line operations. At the same time better yields may be expected.

An assessment of returns on investments indicates that single shift operation does not meet 24 month ROI expectations. Strategies to reduce capital cost or make better use of resource in a 2 shift operation present faster returns as would be expected.

For queries or clarification on any matter please email bmcdevon@aol.com.