final report

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BMC auto sheep evisceration study

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Executive summary

The process of evisceration involves handling, separation and manipulation of soft and non-uniform animal parts requiring skill and dexterity. The current manual operation requires people to perform the task in a harsh and somewhat unfriendly environment, whilst the task itself is demanding and physically stressful to perform.

This study has analysed the current practices and measured the variability in the process and the carcasses in the Ovine range. Aspects of automation have been assessed and although the current practice is considered beyond the capability of the robotics technology a new process has been identified that maps the technology capability to the task enabling development of automation in this application.

The new process proposes the removal of viscera and offal/organs in one pass, with the belly opening also automated and the carcass manipulated and transferred under control. The new process has been evaluated and is considered valid. The study has thus examined approaches and concepts for handling and fixation of carcasses of variable sizes, sensing capability and tools for handling, belly opening and viscera/offal separation from the carcass. The study has proposed an integrated approach, which with some variations to current manual practices before and after evisceration would result in a cost effective solution.

Contents

1 Visits, automation, people saving

The processes of evisceration at several plants have been examined and this section presents the findings, giving an overview of the potential for automation and labour reduction opportunity.

1.1 Visit to plants

Five plants have been visited and in total 7 lines were observed during the period of the project period.

The process of evisceration of lamb carcasses has been observed and there is commonality among all plants as the procedures are the same and so are the steps. Space availability, practices in dealing with stoppages, dealing with veterinary issues in carcass, offal, viscera and carcass inspection, sanitation and in between step cleaning and aspects related to manning levels and OH&S have been examined and there is commonality in all lines observed. There are also no concerns for the introduction of automation to such lines. The observations at each plant are included below.

Plant 1:
At Plant1 2 lines are used for slaughter and evisceration of Lamb. Each line has been observed and photographic and video recordings were made during the visits.

The process is described later in this report, which is common to the other plants visited.

Plant 2
The process of evisceration was observed and although the process is similar to other plants, recordings were not permitted.

Plant 3
The process evisceration was observed and photographic recordings were made. Manning levels and the sequence of the task in the slaughter area were slightly different, however the tasks relevant to this study were observed to be the same.

Plant 4
Video recordings and photos of the process were made. The operation is once again the same, although more labour was employed performing the task compared with other plants observed.

Plant 5
At Plant 5, the process was fully recorded and observed to be the same. Two people are employed for viscera removal, one person for brisket cutting and two people for Offal o removal of organs. The line is operated 2 shifts at 600 carcasses per hour.
In all plants sufficient space is available for installation of equipment; however careful attention needs to be paid to the detailed design allowing manual back up if needed. The practices of carcass re-hanging and clipping and steps to the point of evisceration are common to all plants.

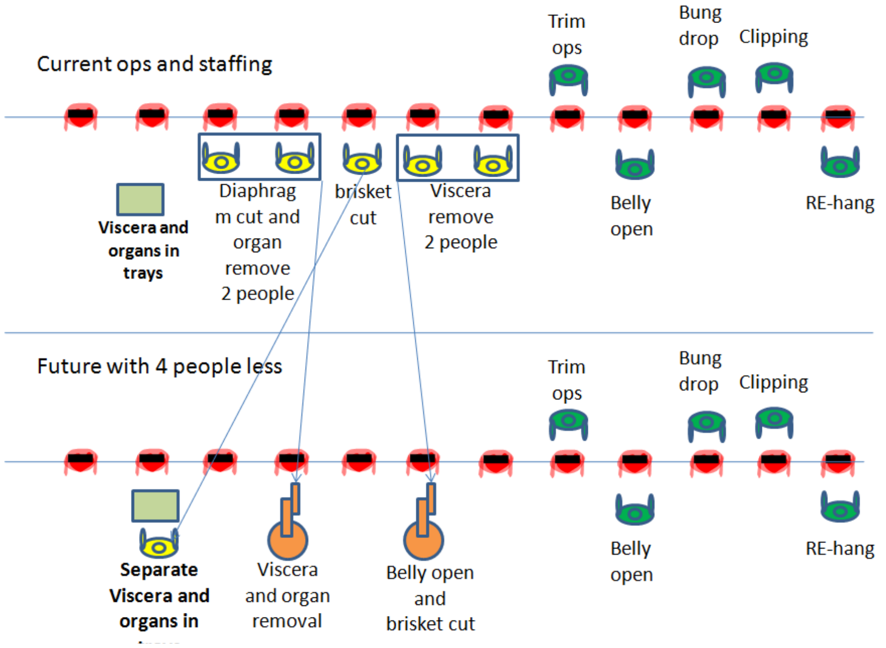
The manning levels considered relevant to the scope of this study were as follows:

1 person performing belly opening and tying
2 persons removing viscera
1 person performing brisket cutting
2 persons performing diaphragm cut and organ/offal removal

1.2 Manning levels and labour saving targets

Figure 1, shows the approach intended in removing 4 units of labour from the line. This has come about after detailed examination of the current process and the devised new process, which is detailed later in this report. The current steps, as indicated in Figure 1 show schematically the manning levels for a 600 carcasses per hour line with and without robotics. The processes of the robotic line require redefinition of some of the manual tasks prior to the point of belly opening. As an example the tasks of re-hanging would be slightly different and the unit of labour performing brisket cutting would not be a saving as the task of organ and viscera separation on trays needs to be performed manually.

Figure 1: Manning levels for current and proposed lines shown to reduce staffing by 4 people



It is important to note that the technology may be specified to deal with the full Ovine species and in some plants calves may also be processed on the same line using the same technology. Such aspects may be fully examined in the proof of concept phase, proposed as a follow up to this study.

1.3 Video and feedback

Discussions with plant management reveal that the automation is high priority; however the solution is not yet available. The requirement is that the following are met as a minimum:

- Automation is kept simple and easy to operate.
- The equipment is compact requiring minimum change to the line.
- The automation eliminates as many steps as possible whilst meeting with hygiene and between cycle sanitisation.
- High degree of reliability at minimum 10 lambs per minute is essential. The line is not to stop for the robots or any automated device.
- The automatic process needs to deal with the carcass variability as well as the variability in the presentation of lambs. Processes before the evisceration steps are observed to

have variability and inconsistency. The proposed automation is required to deal with such aspects also.

On the whole the need for automation was recognised and all consulted were positive, awaiting a solution.
Video recordings have been taken, where this was possible and some experimentation has been conducted during the visit to verify the process and formulate approaches to automating evisceration.

1.4 Approach

Several approaches have been considered for automating evisceration during and after the visits. It is clear that the task as done manually involves a significant degree of handling, judgement and manipulation of the carcass and parts of the carcass, viscera, tools (including knives and power tools) and various organs/offal. It is also observed that the manual process involves significant lifting and moving operations.

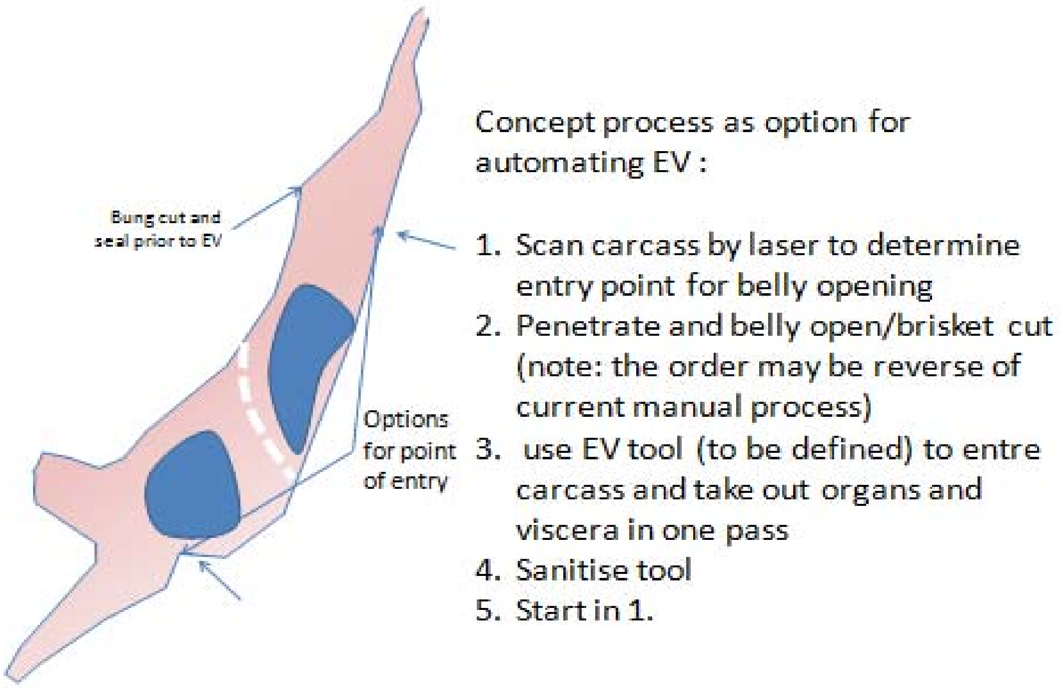
It is considered important that a simple approach is established. It was noted that if the carcasses were to be tilted gravity would aid the process. The current ergonomics of the tasks and processes are set for manual execution and to this ends it is identified that simpler automation would be needed if the orientation of the carcass were belly down. A 45 degree angle to horizontal may be a good start; however, a more optimum angle may be assessed in a proof of concept project.

Figure 2 shows the concept and the expectation is that carcass opening would occur partially avoiding release of viscera, but enabling the tying process. Alternatively the bung capping process could occur earlier as part of the bung separation process.

The steps as currently performed would then follow as they are currently over a twin tray system that catches the viscera and the organs in turn.

As an option a procedure that removes the viscera and the organs in one step may give significant advantage and this will be considered further. It may be the case that in some plants the processes are performed with the carcass180 degrees to the current carcass orientation on the line.

Figure 2: Carcass presentation for Automated EV



2 Current process and variability

The process of evisceration of lamb carcasses has been traditionally manual and to date no cost effective automation solutions has been reached. This study as contracted by the Meat and Livestock Australia (the MLA) aims to assess the possibilities for automation and to draw together the specification and plans for design and build of such a system. The intention is that the proposed solution currently rather conceptual, would achieve 10 carcasses per hour as a minimum.

Visits to companies have shown the range of tasks as performed by people and it is found that the task is the same, though the physical set up and range of handling systems for carcass transfer and viscera handling is different from company to company.

2.1 Process related findings

Preparing carcasses for evisceration starts early in the line. Just after the Y cut, the oesophagus is separated by hand and tied using a plastic clip. Figure 3 shows the step where a hand tool is used to assist with the handling and tying process.

It is shown later that the tied oesophagus is pulled through manually with the rest of the viscera through the opening in the belly. This represents complications for automation during the separation and handling of the viscera from the carcass.

Figure 4 shows the stages:

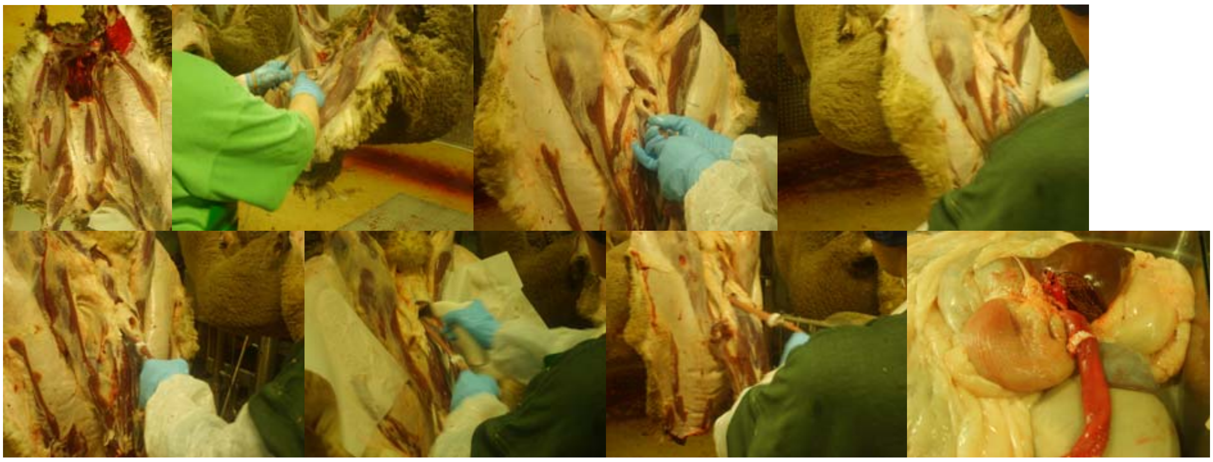
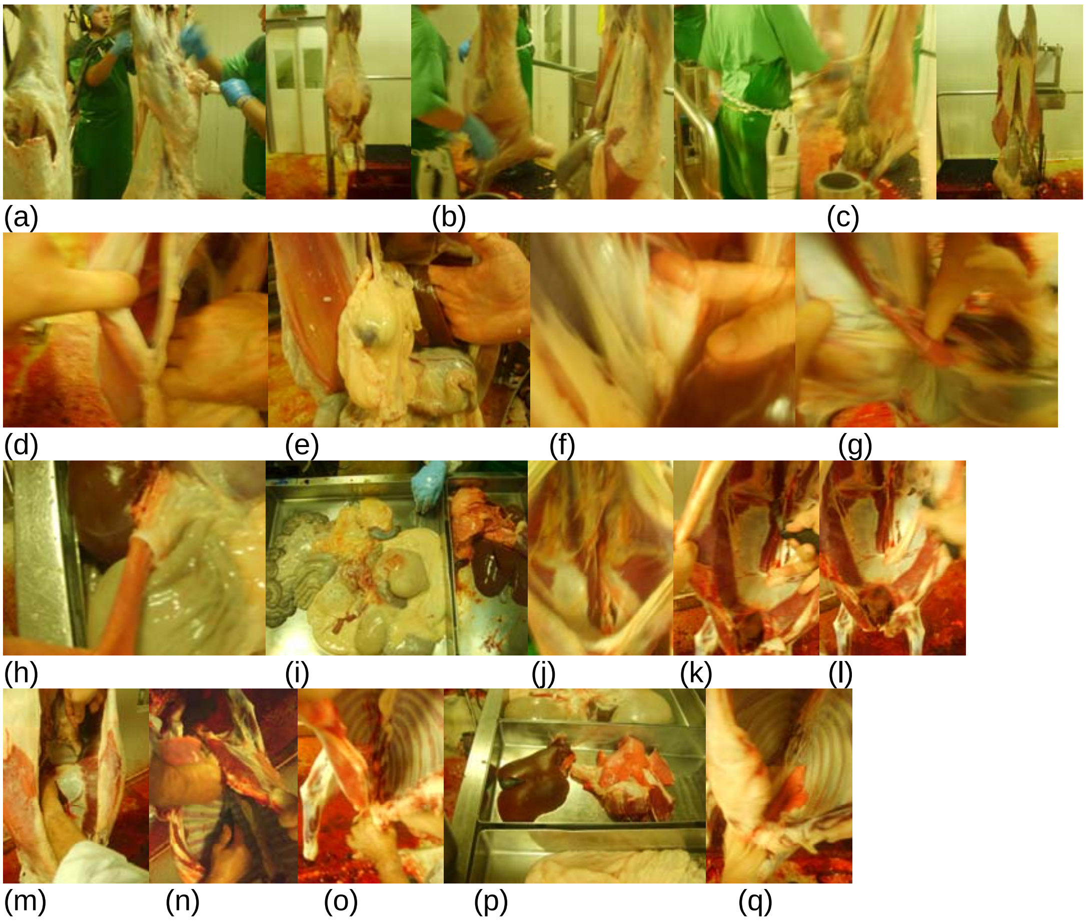


Figure 4: Stages of oesophagus tying using plastic clip shown on the viscera as removed in the extreme right photo

The clipping task provides containment and reduces the risk of contamination. It is thus considered crucial that any automation process is preceded by a 100% clipping operation.

The next stages of the process may be observed in the photos of Figure 5. The bung separation and bung tying (a) is performed followed by belly opening (b) prior to the start of the evisceration process (c).

Figure 5: Current EV process



The oesophagus, which was clipped earlier after the Y cut, is pulled up into the belly area from the rib cage through the diaphragm. The stages are indicated in Figure 5 (d - g). Once this task is reached the viscera is removed Figure 5 (h-i) leaving the carcass ready for its diaphragm to be cut and the organs to be separated from the back and the chest cavity and removed Figure 5 (j-p). Note that pleurisy Figure 5 (q) is a complication that needs specific attention when attempting automation.

In discussions with key personnel in various companies, the initial feedback is that performing the evisceration task as a standalone and automated operation would have a higher degree of success if it were integrated with specific manual steps that reduce the complexity of the process for automation. This however must not add complexity to the manual process. Trials were conducted to assess how the stages of bung separation and tying, belly opening, and viscera and offal removal may be automated.

2.2 Manual trials

Trials have been performed with manual evisceration to assess the variability in task and the complexity associated with handling the types of tissues or organs. An accompanying video illustrates the challenge facing automation technology. The key aspects of the process that need detailed consideration with respect to automation include:

- Physical presentation and handling of each carcass – it is envisages that carcasses will be on the move and the handling system would need to maintain position and orientation of the carcass from the point of bung separation. Tilting of the carcass would allow the viscera to exit under its own weight once the belly is opened. Consideration is to be given to automatic belly opening and brisket cutting as an integrated process as this could ease the processes of handling and viscera and offal removal.
- Any manual procedures that remain may include actions that may be considered too complex for automation. For instance if the oesophagus is manually clipped, it may be it can be left in such a state that it can be handled more easily by automation. Also it is possible that the same approach may be applied to bung separation and tying.
- A radical step may also be to remove the organs in the chest cavity prior to evisceration. This may be possible by performing the same task with carcass upside down to the convention. Further trials and consideration suggest that such undertaking would have technical risks and will be costly.
- Fixation of the carcass should occur early in the process and the technology must accommodate for different hook or gambrel designs. During the visits, several different designs were observed.
- Any tooling that is used must have blunt guards so that during the approach and entry it does not cause undesirable cuts to the carcass, the organs or the viscera. The tooling is thus to be such designed that it performs only programmed cuts.
- The tooling needs to have specific features allowing it to enter the carcass through small openings such as the gap in the carcass after belly opening.
- The process of diaphragm cutting and offal removal from the body of the carcass require alternative handling as well as cutting tools.
- Given the nature of the process it is considered useful that a combined automation stage is considered dealing with viscera removal and diaphragm cut and offal removal as one sequence of automation procedure. The separation of offal and viscera would then be a separate process after removal form carcass.

Manual trails reveal that, once a robotic tool is within the carcass, sensory information has limited use as the task is so unstructured and the tissues being handled are both variable and flexible. With the exception of simple optical sensors and possibly a low cost force sensing solution, the automation technology could not use input from more advanced sensors as they would not offer any greater information for robot guidance that could justify the cost or be capable of performance in speed.

The solution to tooling and sensing need to be simple and the control procedure should use information about the carcass variability and pre-defined models to perform the tasks intended. This is further discussed in the next section of this report.

2.3 Carcass variability

To measure and quantify carcass variability, several approaches may be taken. In the scope of this study, extreme geometric measurements and data that define specific features of the carcass important to the process have been measured. Carcasses have been measured as show in Figure 6 with the selection of the carcasses being in the range from 12Kg – 32 Kg at this stage of the study. (Note that the range for mutton would be added at a later date, but the focus has been kept towards lamb carcasses). The carcass weights indicated are those for dead weight post evisceration as weight information is not readily available on the line at the point of evisceration, nor is it practical to take measurements with carcasses at this point in the process. The measurements are thus made after the slaughter line and also post chill for internal measurements.

Figure 6: Carcasses Measured A-E (carcass F not shown)

Figure 7 shows the measurements taken. These include outside dimensions and internal dimensions referenced to anatomical points:

L1 Edge of the last lumbar vertebrae on the belly side
L2 Edge of the vertebrae at 1st rib on the belly side
L3 Edge of the spine on the belly side between the 4th-5th rib
L4 Edge of the spine on the belly side at the curvature of the neck

The measurements in the vertical dimension x and y are referenced to the centre of the last lumbar vertebrae and are to the upper and lower points of the diaphragm edge on the rib cage respectively.

The positions have been selected as they relate to the requirements of an automated evisceration system. The width, depth and length of carcasses A-F were measures as follows:

Length: From the bottom of the lower horizontal edge of the carcass hook vertically down to the lowest point of the body irrespective on the lowest side of the chest with the carcasses hanging as in Figure 7.

Width: With the carcass hanging and the open belly facing the front, the measurement is taken horizontally from left edge of the carcass to the right edge of the carcass at the point where this measurement is greatest.

Depth: With the carcass hanging and the side facing the front, the measurement is taken horizontally from edge of the carcass on the belly to the edge of the carcass on the back at the point where this measurement is the greatest.

Carcass variability with respect to evisceration

MLA EV PROJECT			All dimensions in mm ±5mm													
Carcass variation data																
Ref	Body/Lot	Body Kg	Length	Width	Depth	L11	L12	L21	L22	L31	L32	L41	L42	X	Y
A	1565/949	31.4	1270	340	270	85	170	70	260	125	350	150	320	240	480
B	1507/948	24.7	1170	300	230	80	150	60	225	100	300	115	300	220	440
C	1548/948	22.9	1130	280	220	70	140	55	230	100	295	130	290	220	400
D	1536/949	18.6	1060	290	210	65	150	55	210	90	295	110	285	180	370
E	1607/950	15.5	1110	300	180	55	140	50	240	90	290	110	295	220	400
F	1638/950	12.8	890	230	140	50	125	40	180	70	240	95	215	175	360

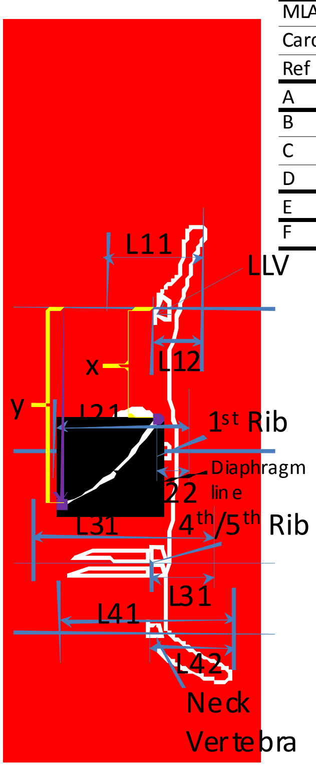


Figure 7: Measurements of carcasses and their variability and range. (Photo does not show carcass F, but the measurements are presented.)

The table below shows the extreme range of carcasses measured and the proposed range for the automated equipment to be designed against. Note that the range for mutton may be added once the measurements are available, however at this stage the results deal with lamb as originally intended.

	Range measured		**Range to design to**	
	Largest	Smallest	Largest	Smallest
Length	1270	890	1400	800
With	340	230	400	200
Depth	270	140	300	120

The use of the additional measurements presented in Figure 7 must be applied in the specification of the tool dimensions and the range of robot movements.

2.4 Sensing

The process of evisceration will require manipulation of a tool or tools from a position outside the carcass into the correct position relative to the spine inside the body. The tool would require manipulation relative to the spine whilst it separates the viscera the diaphragm and the organs from the structure of the carcass. Optical sensing (not necessarily vision) is envisaged to measure and identify geometric features as shown in Figure 8 in order to facilitate the control process to perform tooling manipulation.

A process of fixation is envisaged during automatic evisceration. Carcass shape data would be important when performing adjustments to fixation mechanisms. It is also envisaged that touch/force sensing or passive compliance will be used for path following the spine.

3D scanning technology has been effectively used in pig evisceration and force sensing has been available as a standard load cell attachment between the robot tool mounting bracket and the tool with off the shelf software to perform path following: Example of such tools have been in use for de-burring and finishing for many years.

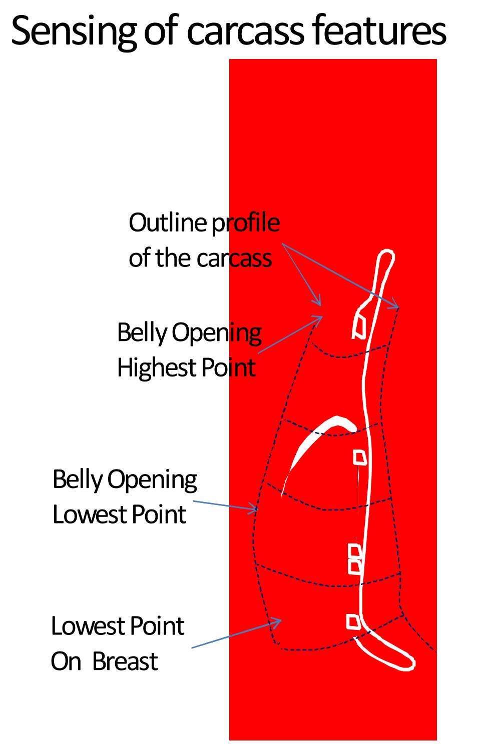


Figure 8: Features to sense

3 The automation process

The processes in slaughter and evisceration have been extensively studied and automated in the pork industry by many institutions internationally. In Europe SFK Systems, BANSS and MPS are among the leading companies providing solutions to the Pork sector. It is considered that the main reasons for such automation not being applied to the Ovine sector are related to the motivation of the industry, the lack of adequate R&D and focused investment. It is the finding of this study that the processes in lamb evisceration have specific variability that making the solutions from pork not directly transferable. In particular, the sticking of pig carcasses after stunning and the consistency of carcass anatomy, especially size variation that is seen with Ovine carcasses as compared to those in the pork industries utilising automation.

The work of this Study has brought about a new approach for evisceration and the work has thus been focused on the practices and automation solutions that would potentially yield to a positive outcome based on this new process. This is presented in the context of technology gap in the next section.

3.1 Technology gap and development

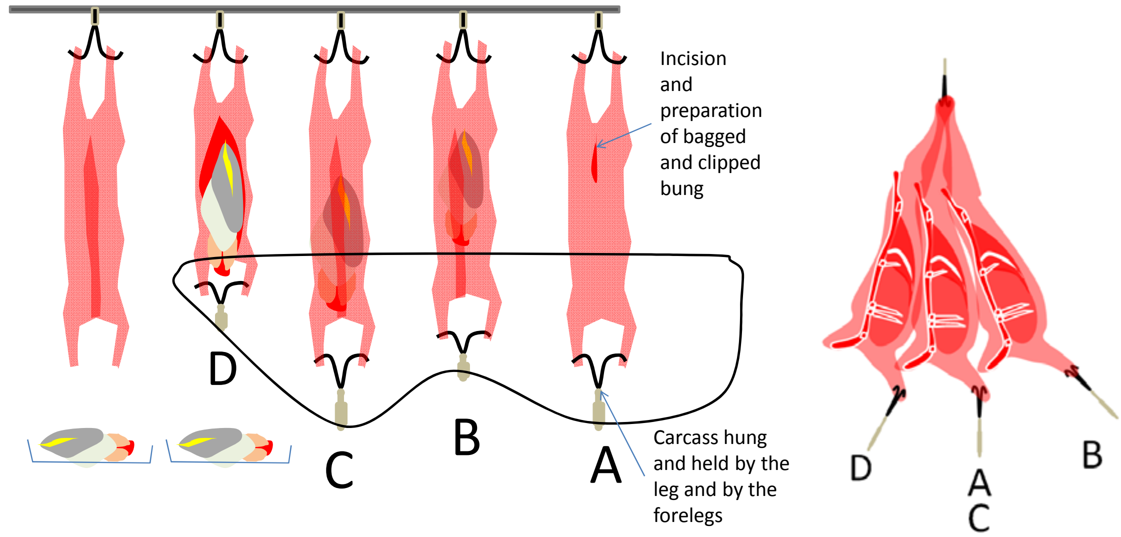
Observations at various companies reveal that that the approach to automate the current processes and practices would be beyond the capabilities of robotics technology given the variability and complexity of handling and separation stages in evisceration. Or at least it can be said that the extent of complexity would require significant resource and several years of development in bridging the technology gap if the process of viscera removal were to be considered for automation exactly as is in the manual process. To automate the process in its current form would lead to automation that would be costly and unaffordable, even if it were to be achievable. To this end, the scope of this study has considered an alternative approach and practical assessments have been conducted to validate the approach, leading to the definition of a new process.

3.1.1 The new process

On examining the process along the slaughter line, it has emerged that a key to the future success in automating evisceration would be to start the process earlier and perform current tasks in a slightly different manner to prepare the carcass for automatic evisceration. This would not imply additional effort or an increase in labour but simply an alternative pre-evisceration task that facilitates the steps in automation for evisceration. Extensive examination of the process and practical trials with several carcasses has resulted in definition of the following steps that bridge the gap form where the industry is to the point where automation of the process is achieved. The following is thus an important contribution to knowledge form this study and is likely to provide the step that allows automation to be developed at an affordable cost both in terms of R&D and the desired commercial system. The proposed process would involve the following (see Figure 9)

a) Use a specific handling attachment to the foreleg of the carcass early in the evisceration process (this is to be developed) such that the carcass is held on the hook from the legs and held in tension by the foreleg. Note that in the EV lines observed the practice is to re-hand the carcass using a manual station and the proposed foreleg attachment operation would be performed at the same manual station without additional effort.
b) Perform bung drop (manually or automatically) but bag and clip to seal the bung before pushing it into the carcass. This would have an added hygiene advantage compared to the current practice.
c) Perform incision to open the belly partially as shown in Figure 9 at step A. The carcass is to remain vertical at this stage and then be tilted by the handling system for the next step. Before tilting it will be necessary to check and ensure that the clipped and bagged bung is well inside the belly.
d) The carcass is then to be opened and brisket cut completely with the viscera and the organs all inside the carcass. This task is proposed to be automated with the carcass tilted belly up as in B, Figure 9.
e) The carcass is then tilted to a vertical position by the handling system and the viscera and the organs separated from the carcass. This is also to be automated, but using a tool and a robotic action, which will be described later. From C to D in Figure 9.

Figure 9: New Process: the stages suitable for automation are shown in concept. The steps have been tested and accepted in practical trials as a new process (a) front view of concept (b) side view of concept showing the orientation of the carcass in positions (A), (B), (C) and (D) as shown.



(a) Carcass has bung dropped, bagged and clipped at stage A. (b) Orientation A, B, C and D

The new process above provides the opportunity for removing 3 manual steps in the process that use 5 people in the current plants, slaughtering 8-10 carcasses per minute, but an additional manual step to separate viscera form offal would be required thus the net saving would be 4 people.

3.1.2 Technology gap

The new process allows the technology currently available from the pork sector to be used and new tools to be developed for removing the viscera from the carcass. The key to the development is the handling system and the tooling system. Figure 9 (a) shows the stages from right to left and (b) the orientation of the carcass corresponding at steps A, B, C and D respectively.

The handling system would be required to hold the carcass in the respective orientation whilst it moves form station to station. It needs to be self-adjusting to accommodate for the carcass variability, specifically in length, and at the same time it needs to comply with the requirements of the process and the processing environment.

The steps prior to A, Figure 9, including bung-drop, bagging and clipping for containment are not a consideration under the scope of this work. The attachment of the foreleg clamps however is to be introduced and in consultation with plants visited it is considered that this task may be integrated into the existing practice of carcass re-hanging earlier in the line and before station A.

At A, Figure 9, the incision at the top of the belly would be manual. With the carcass tilted at B the process of belly opening and brisket cutting would be automatic and this technology already exists as an automated process in the pork sector. Note the carcass is tilted to ensure that the viscera and the organs stay within the carcass. The technology for pork, closest to what would be needed, is developed by BANSS and uses a standard tool (available from several sources) adapted for use with robotics. In the case of lamb it will be necessary to retrain the carcass form moving sideways during the brisket cut for an accurate and centred cut. Most brisket machines do not make an accurate centred cut.

Once the belly is open it is intended that the carcass is brought to vertical position and the tool to be developed automatically engages at the top of the carcass and penetrates the belly whilst opening the belly as it travels vertically down keeping the belly open, separating the viscera and the organs in one sweeping action. The carcass is to undergo a tilt in moving to position D. The tilt would allow viscera and the organs to drop into a tray for separation and veterinary examination.

Note that one unit of labour may be needed to attend to viscera and organ separation and this has been taken into consideration when calculating return on investment.

The tooling required for separation of viscera, diaphragm cut and organ removal may be based on the approaches for tool design developed in the early 90’s under the CEC BRITE-EURAM project 4152 providing the same for pig evisceration. The next section elaborates on the tooling and handling, but it is necessary to state that the new process has been trialled and an accompanying video shows the stages. There is also acceptance of this new process as considered by the veterinarians consulted.

3.2 Definition of tooling and handling devices

The devices for the new process would include:

- Carcass handling at the point of entry such that the carcass maintains its vertical attitude held by both the legs and the foreleg, only changing orientation under control through the stages of belly opening and evisceration (Figures 9 and 10)
- Belly opening and brisket cutting tool (see Figure 11)
- Viscera and organ separator also performing diaphragm cut (see Figure 12)

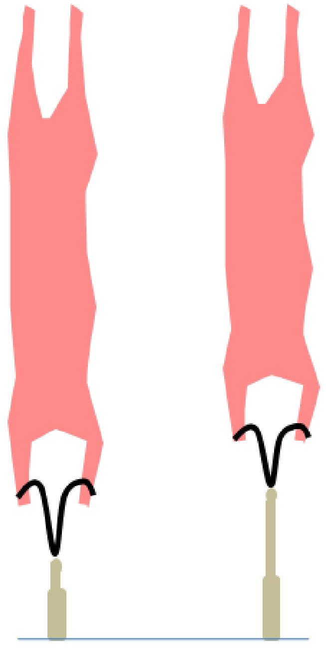
It is possible to consider tools for bung cutting, bagging and clipping, however several commercial units are available and this is also on the periphery of this study, but may be included in the R&D phases that follow.

3.2.1 Carcass handling

Figure 10 shows the concept and the requirement is to develop an attachment device that meets the following needs in order to transfer and manipulate the carcass through the stages of A-D in Figure 9. The device must:

- Be capable of easy and fast attachment at some stage in the line before stage A of Figure 9,
- Keep the carcass under tension whilst accommodate for the variability in length and carcass variations,
- Be capable of hygienic cleaning,
- Be capable of transfer using a simple rail system after attachment.

Figure 10: Handling system to facilitate the new process of evisceration

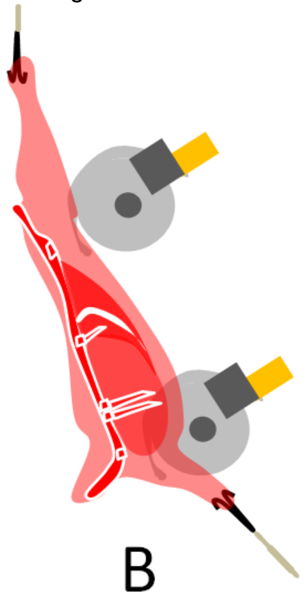


The process of re-hanging would be required to take a different form in the automated approach. The expectation is that carcass would be using the foreleg clamp attachment to be designed as part of the solution for transferring the carcasses form one station to another. The level of complexity will be no greater than what is currently done as the attachment would be a simple process currently used in many plants. The innovation is that the clamp is such designed to put the carcass in tension by virtue of its mechanics and features designed into it and not by any action on the part of the operator. The operator is to simply perform the attachment and the task is no more demanding than attaching a hook to the legs on existing lines. This step would be at the start of the EV line as shown to the right of Figure 1 at station labelled ‘Re-hang’. Clearly the process needs to be implemented and tested in the proposed Proof of Concept phase after this study.

3.2.2 Belly opening

This tool is already available and has been developed and used in pig slaughter lines (see Figure 11). The main requirements are that the tool does not cut into the viscera and that the brisket is cut along the line of the vertical centre.

Figure 11: Belly and brisket cutting



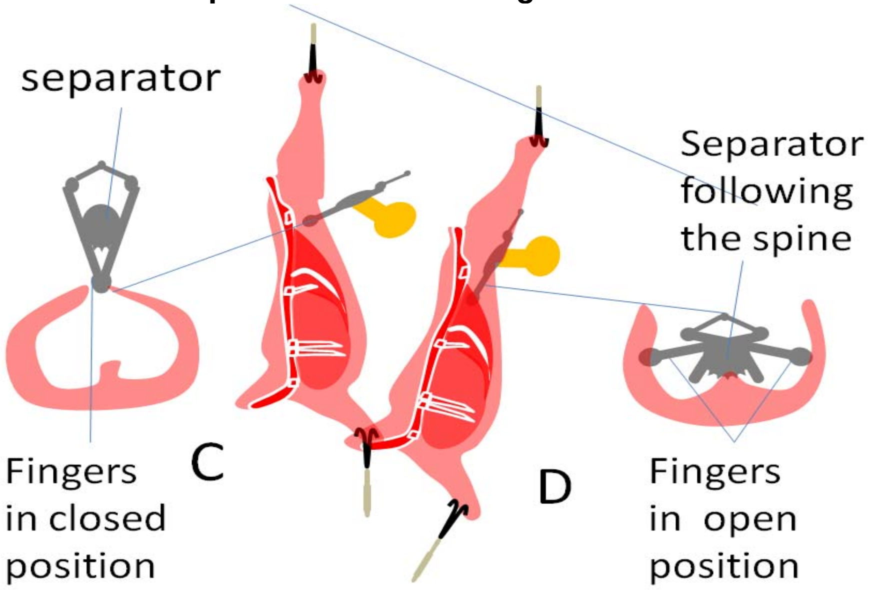
A blunt guard is to engage the carcass at the incision A with the rotating blade opening the belly and separates the brisket as the tool traverses along the length of the carcass. The same guard ensures that the blade does not come into contact with viscera to avoid spillage. Side movements need to be avoided and it is intended that the centring action would be a feature of the cutting tool, guiding the motion and stopping the carcass from side movement. This feature of the robot tool for belly opening and brisket cutting is seen in similar applications. There is no independent clamping intended for side movement control of the carcass during this operation.

The sensing of the incision gap is to be automatic using the same arrangement as the BANSS system for pig slaughter lines, which employ an SICK line-scan laser system to profile the carcass. It is likely that a simple location indicator could also provide the entry point, but the travel distance and potentially the line of the cut would need to be determined.

3.2.2 EV tool

Figure 12 shows the concept of the EV Tool. The tool is to have a compliant separator and a set of opening fingers that are normally closed, but automatically open as the tool enters the carcass widening the belly opening allowing the viscera and the offal/organs to fall out. The separator is to follow the spinal column after entry through the incision at position C. The fingers would move out from the closed position to open the belly as the separator follows the spine downwards with the carcass moving from position C to D.
The viscera and the organs are to fall out on to a tray that follows the carcass along the line (this is already in use in the current process). Note the level of sensing required would be the same as that used for belly opening, but the separating tool needs to have passive compliance in order to allow self-adjustment against the profile of the spine as the tool travels down against the spine.

Figure 12: Concept for viscera and organ removal tool – EV Tool



The key to the success of the project is the EV tool proposed. The tool in the 4152 project was developed in the CEC task on tooling under Koorosh Khodabandehloo and this is in the public domain as the results were published in the early 90s as part of the normal academic activity. It is envisaged that the results of that work provide the background to any activity for the automation project intended for lamb with the MLA.

The tool for viscera removal used would include features for centring the carcass and as in the 4152 project, separating features on the end of these guides would perform the diaphragm cutting. The Automated EV station is intended to take all the offal with viscera out of the carcass. The task of separation of red offal, white offal and viscera in the tray after the robot (see Figure 1 bottom left) is intended to be manual.

The Robot tool requires detailed design, but in concept, it is intended that the tool is normally closed on the tip as in Figure 12 top left as it enters the carcass through the opening of the belly. It opens as it approached the back such that the separator comes in contact with the spine. The fingers open to keep the rib cage open as the tool traverses downwards. The short fingers locating either side of the spine centre the carcass and as the tool approaches the diaphragm separating features on these short fingers break away the diaphragm from the main body of the carcass. The cutting features would perform an incision followed by the natural pulling action as is done manually today, but the pulling will be a task for the longer fingers.

3.2.3 Sanitisation

The operations in evisceration are to be automated using automated tools manipulated by robots and using sensory information of the types proven for pig slaughter lines. Sanitisation between carcasses is a requirement and needs to be automatic also; a feature of the pig lines that may be used in the robot concepts proposed in Figures 11 and 12 for between cycle sanitisation. See also short video of the pork line from BANSS attached.

4 The process of development

A new process for the automation of evisceration of Ovine carcasses has been presented. The steps to reach proof of concept, inline implementation and commercialisation of the automation solution require a focused approach. The following gives an outline of the steps, the starting point and the duration of the tasks with estimated resources in terms of effort and budget. The risks are to be managed by taking a step by step approach with go/no go decisions. Three main stages are proposed each having specific tasks that allow gradual low risk progress to the conclusion of each stage. These are:

- Proof of concept
- Inline implementation
- Commercialisation

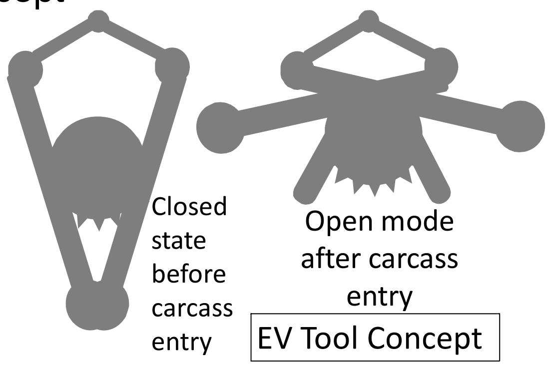
4.1 Proof of concept

The progress beyond the initial trials of the process would be as follows.

4.2 Task 1: Confirmation and tool trials (duration 5 months)

In this task the new process will be trialled further at several plants. Although the principle is accepted by those involved with authority at the plant where the trials were conducted, it would be important to conduct broader trials also involving prototype models of the intended tools in order to obtain broader confirmation and more formal acceptance. The process of trialling at different plants also facilitates early buy-in, which is also important.

Figure 13: Tool development from concept



The intended tool would need to be designed and built for trialling with a standard industrial robot, but off line with carcasses in a single station, but with tilting as required by the process described earlier. The EV tool as in Figure 13 would be built with the trial involving the procedure described in Figure 12 but the carcass remaining in the same position, i.e. without the move from station C to D. The tilting action would need to be included as this is part of the proof of process and function of the tool showing separation and falling of both viscera and the organs. Once this is shown to be functioning adaptation of belly opening tools are to be made using standard tools and the same trials repeated using carcasses in the same station as that used for EV tool trials. This would prove the concept as described in Figure 11 with the tool also proven.

The development of concept to the point of trials with lambs of different sizes but in a fixed station would aim to prove the following:

- Operating characteristics of the tool with proven design
- Cycle time and consistency of process
- Adaptability using sensory information
- Quantification and confirmation of range of cost for a commercial system.

Note that the use of a standard industrial robot is intended.
On completion of task 1 and trials that used manual input to show tool capability for the range of carcasses, the next task is to use sensory input to guide the robot carrying the tool in the same station.

4.3 Task 2: Sensory developments and tooling (duration 3 months)

The processes of robotic belly opening and evisceration as described in Figures 11 and 12 require sensory technology of the type used on the pig lines. The purpose of this task is to ensure that the technology is tested for lamb and that the features that are required can be located and that the data transformation and the calibration procedures work without any technology risk in the intended application. The SICK system is to be used to meet the requirements as follows:

- Profile the carcass after the incision to determine the position of entry and exit for the robot belly opening and brisket cutting tool

- Determine the point of entry and exit for the EV tool

The proposed tasks should deal with interfacing set up and execution of task using sensory data on a trial basis with the carcass at a fixed station. Integration with a robot is also intended as this shows the capability to accommodate for the carcass variability.

4.4 Task 3: Handling, sanitisation, total cycle testing improvements and further testing (duration 4 months in parallel with task 2)

The ancillary equipment that would need to be testes with the system includes:

- Handling system for holding the carcasses in position before, during and after each step
- Sanitisation system for in between cycle cleaning of the tool at each station
- Interfacing modules and software to integrate the devices to achieve cycle testing

It is important to know the task of implementation would take several iterations and tuning, but the focus of tasks 1, 2 and 3 are to prove the concept and the specific tools and devices rather than to implement a robot solution. The use of the robot is incidental to the development as this is a vehicle for testing the tools and sensory devices. The work done in the implementation of the software, however, would be usable in the R&D phase that would continue to reach an inline solution.

It is expected that once 10 carcasses of varying sizes have been trialled successfully one after the other, then the tools and the process may be considered ready for the next stage of R&D implementation.

The process of handling plays an important part; however, the EV tool must be tested before any other work and tested using simple handling set up. Once the tool is considered ready work in developing the handling system can begin. **Please note that Tasks 2 and 3 in the proof of concept are intended to be in parallel as indicated.**

4.5 Inline implementation

Once the proof of concept has been reached, it is envisaged that the system is introduced in line for extensive testing.

The steps include:

- System design to include:
    - Lay out including location of all stations (robotic or manual), handling system for transfer form the last step in the process to the new robotic line, safety system and connection to services
    - 3D visualisation
    - Installation phasing and timing

(Duration 2 months)

- System build and off-line testing including
    - Implementation of the line in an off-site location for functional testing
    - Build and testing
    - Production of engineering documentation
    - Training of engineers on the system off-line

(Duration 4 months)

- Installation on site and operation including
    - Preparation of host site
    - Re-installation of the system on line
    - Initial running at slow speed
    - Ramp up to line speed
    - Training of operators
    - Observation and tuning

(Duration 2 months)

- Line demonstration and consolidation including
    - Consolidation of all design and operations information
    - Preparation of video and training material
    - Demonstrations to invited audience
    - Patenting and licensing considerations
    - Detailed planning and update of commercialisation phase

(Duration 1 months)

4.6 Commercialisation

The steps following the implementation would involve commercialisation tasks including the following:

- Involvement of a second end user who is prepared to invest in a follow up installation. It should be planned that the commercialisations involves the sale and installation of a second set of equipment primarily paid for by the user company
- Agreements on sales and marketing plans
- Documentation of system design for repeat installations
- Presentation at Exhibitions
- Other tasks necessary for the sale, installation and operation of repeat systems

4.7 The project team and the role of parties

The project team is intended to be *Plant1* and BMC initially for the proof of concept with involvement form other parties. The skills development would be part of phase 2 and in particular an important element of Phase 3 when commercialisation is intended.

The basic roles and the responsibility may be presented as follows at this stage, however this may be further enhanced as the project progresses:

BMC - To facilitate and co-ordinate project and to provide detailed technical input in the progress of the project

Plant 1 - To perform implementation trials and provide engineering support for the project in the Proof of Concept phase and to host the first installation

Marand - To provide robotic and integration support for the project with responsibility to engineer the system and support installation and after installation service for the first and subsequent systems

FPE - To take responsibility for sales, marketing and first contact after sales support

BANSS and other organisations - Line integrators and companies to be involved international marketing.

It is important to note that the Proof of concept would motivate several companies to invest in the technology to bring about commercialisations, but many would be reluctant to take the initiative to take the early steps financing studies of this nature or proof of concept projects. The role of the MLA and AMPC is thus a key aspect of this development if the Australian Meat sector is to see the rewards in the short term.

5 User group and networking

The opportunities for networking through FAN and international initiatives such as EUREKA and other CEC networks should be considered. However it is important that a user group is formed in Australia prior to the start of the inline implementation. The companies visited during the study may be considered as the initial members.

The user group would expand as the R&D progresses and it may be likely that members could be offered a package where the layout for their lines would be produced on a cost shared basis involving MLA or AMPC support.

BMC would provide the support and co-ordination of the user group formation and operation.

The formation of the user group and involvement with international networks are considered important and BMC together with FAN can instigate such initiatives based on several years of experience.

6 Concluding remarks

The process evisceration on the slaughter line has been assessed. The tasks and steps currently used in Australian lines have been observed and the study that defines possible automation approaches concluded. Progress has reported on the following:

(a) The process and carcass variability have been assessed and reported,
(b) A new process has been established pointing to a low risk option for automating the EV process,
(c) Trials have shown that the process has high potential for success,
(d) Early viewing by the veterinarians has met with a positive response,
(e) The concept for automating the process from belly opening, brisket cutting and viscera and organ separation have been assessed and documented,
(f) Early concepts for devices for cutting, handling and sensing have been identified and included in this report,
(g) The stages of development form proof of concept through to implementation and commercialisation have been outlined and stages of progress presented,
(h) The team that would be in a suitable position to take the project further have been identified and their roles presented,
(i) Cost of each phase as a maximum budget and an estimate of projected investment and return on a 2 shift basis is given as 2 years
(j) The opportunities for networking and establishing a user group exists and suggested.