final report

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Meat Quality Science and Technology

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1. Background

Developing innovations that improve the consistency in eating quality of Australian beef and lamb is clearly a strategic imperative for MLA and there has been considerable investment in the Meat Standards Australia (MSA) program for beef and more recently the Sheep Meat Eating Quality (SMEQ) program for sheep. These programs have already achieved significant benefits, and improvements in eating quality and consumer satisfaction have been quantified. MLA is currently facilitating adoption of the outcomes of these innovation programs via initiatives in both the industry systems and marketing areas.

However, while these programs have provided the Australian red meat industry with systems to quantitatively measure meat quality, and management standards to provide optimum conditions for the production of high quality meat, they do not provide interventions to ensure this quality post-slaughter.

As illustrated in Figure 1, research has shown that the single greatest contribution to variability in meat eating quality occurs during processing. Therefore, MLA has undertaken R&D in parallel with the MSA and SMEQ programs to develop processing intervention electronics technologies through the Meat Quality Science and Technology (MQST) program. The first technologies to arise from this program are being commercialised and are delivering quantifiable benefits in terms of further improving eating quality (beef and lamb) and processing efficiency

This paper looks at the development to date, discusses future strategy and provides recommendations on key decisions that are to be made by MLA regarding the adoption of the MQST program outcomes.

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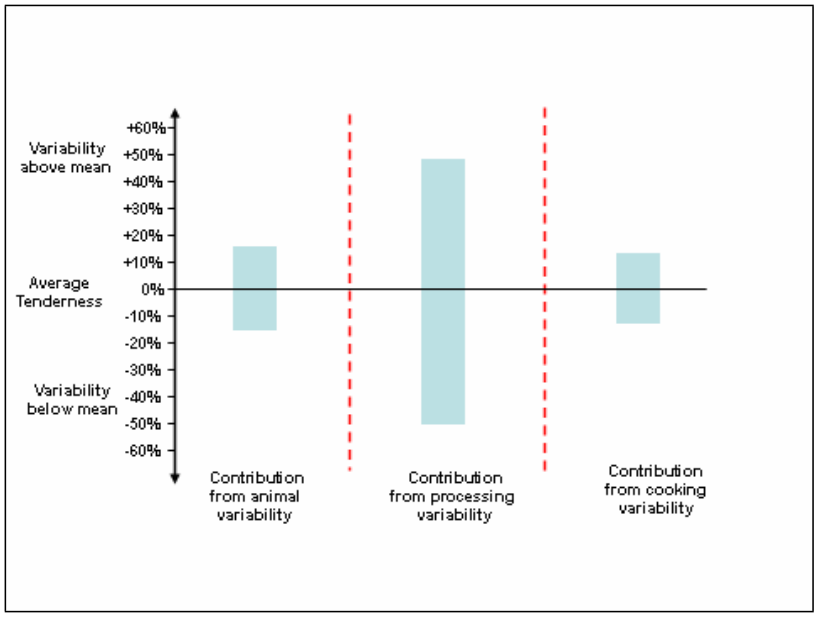

Figure 1: Relative influences on meat quality variability measured by meat tenderness.

2. Technology Overview

The development of the technologies arising from the MQST program can be divided into two stages of development. These two generations are described below.

Generation One

To address the quality variation that occurs during processing, MLA has developed a suite of computer controlled processing intervention technologies. These technologies are based on new forms of electronics that maximise both eating quality and processing efficiency. The initial development of the sheep technologies was completed in 2002 and the beef technologies in 2003. The suite of technologies that comprise the Generation One electronics is summarised below.

Controlled Dose Low Voltage Stimulation (beef and sheep): to control meat tenderness.

Electronic Bleeding (beef): to enhance blood yield, improve meat colour, improve plant hygiene and reduce costs.

Low Frequency Carcase Immobilisation (beef and sheep): to reduce OHS risk. Imparts a small stimulation effect.

High Frequency Carcase Immobilisation (beef and sheep): to reduce OHS risks. No stimulation effect.

Mid Voltage Electrical Stimulation (beef and sheep): to control meat tenderness.

The Generation One electronics are controlled by an overarching management system called the Computer Process Management System (CPMS) which regulates their operation based on operator defined parameters as demonstrated in Figure 2. These parameters are based on the normal characteristics of the type of animals being processed in a batch, taking into account factors such age, sex, and husbandry.

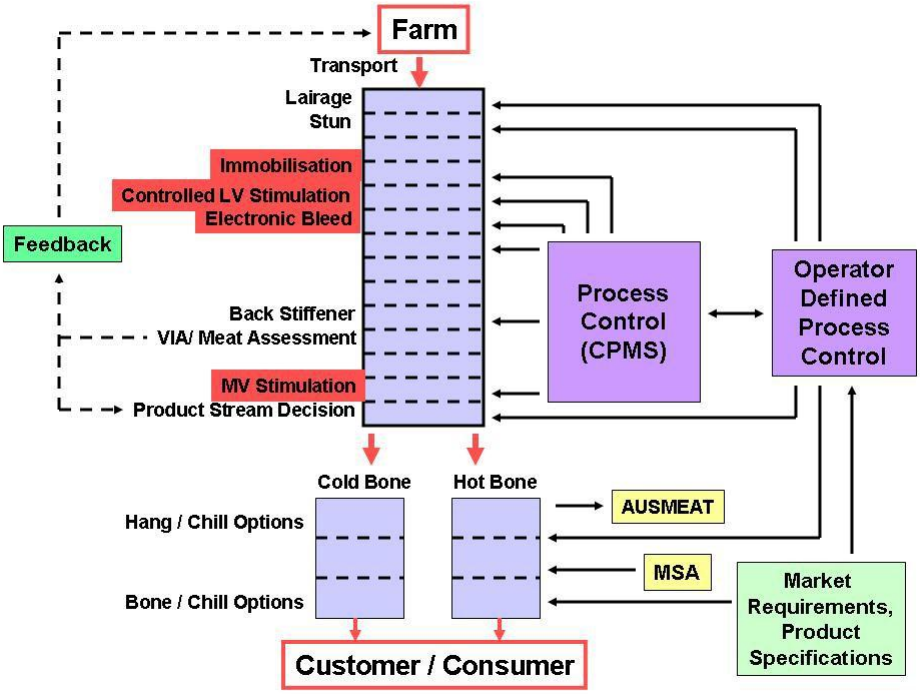

Figure 2: Generation One Technologies (highlighted in red)

Generation Two

The Generation Two technologies will provide more consistent quality through the tailoring of inputs from the intervention technologies based on the analysis of the individual carcase traits as compared to the batch treatment of animals with the Generation One technologies. The development of these technologies was outlined in the 2004-07 MQST R&D Plan which was presented and approved by the MLA Board in April 2004 and includes a combination of industry and MDC funded projects as illustrated in Figure 3.

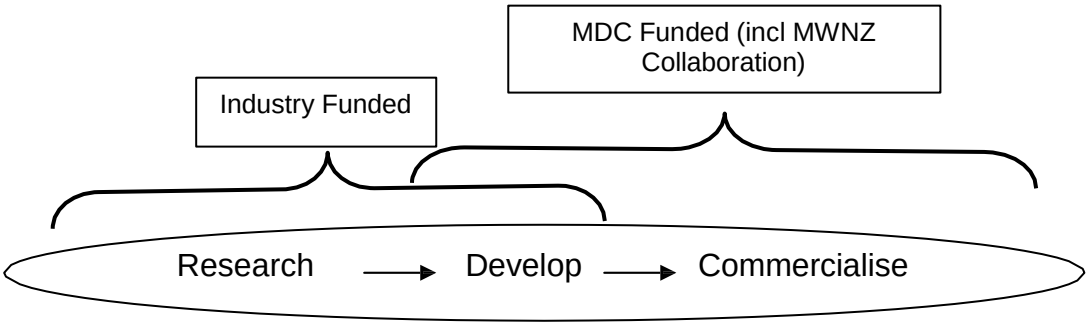

Figure 3: Summary of the combination of industry and MDC R&D funding across the technology development stages for the MQST program.

The first of these technologies that will become available from 2006 is Advanced Stimulation in which the CPMS will calibrate and tailor the inputs of Mid Voltage Stimulation based on the feedback response of each carcase to a reference electrical impulse as indicated in Figure 4.

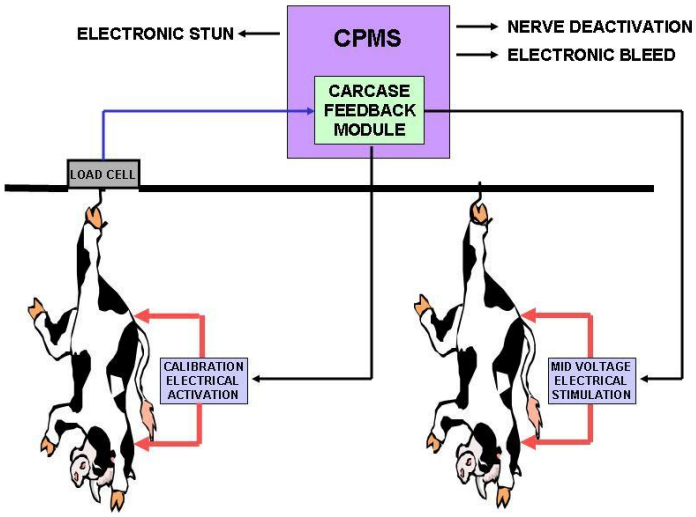

Figure 4: Advanced Stimulation system demonstrating the initial calibration stimulation which feeds back the result to the CPMS (blue arrow), followed by the controlled mid voltage stimulation as the carcase moves from left to right across the chain.

The other Generation Two intervention technologies (see Figure 5) that are currently forecast to become available from 2008 are:

- **Stretching Technology**: (beef and sheep) - stretches pre-rigor meat to maintain tenderness while hot boning.
- **Low Kgf Technology**: (beef and sheep) - identifies the mechanism for "always tender" muscle and allows tender meat from hot boning.
- **Super Tenderisation**: (beef and sheep) - electronic activation of cell mechanisms which produce meat that is tenderer than current limitations.

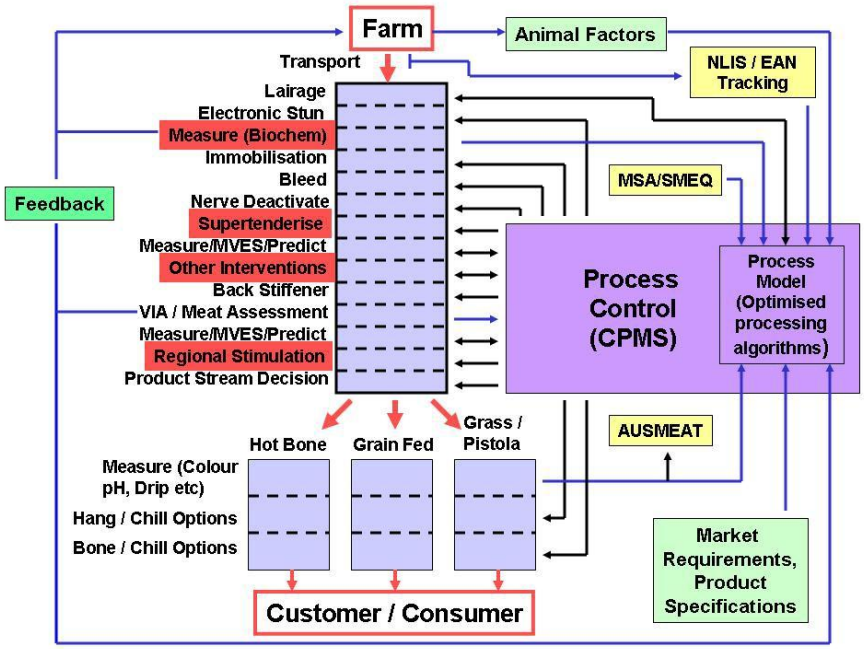

Figure 5: The Generation Two technologies (highlighted in red) and their interaction with the CPMS and Generation One Technologies through the feedback mechanisms to the CPMS (blue arrows back to CPMS)

These intervention technologies will be completely controlled by the CPMS with individual carcase treatments tailored as a result of quantitative feedback from measurement technologies that are also being developed in the MQST program including:

- **Online pH measurement:** (beef and sheep) - continuous logging of pH to allow optimisation of process variables.
- **Visible Spectral Analysis:** (beef and sheep) - prediction of eating quality traits using muscle reflectance data.
- **MQ Lab:** (beef and sheep) - biopsy determination of muscle glycogen and prediction of ultimate pH.
- **NIR Pre-rigour:** (beef and sheep) - non contact determination of key eating quality characteristics (first stage muscle glycogen).

The inputs from the measurement technologies and subsequent outputs will be managed through the CPMS utilising models that are being developed through industry funded research. Those models that are currently in development are:

- **Nitric Oxide:** (beef and sheep) - modelling the stress induced nitric oxide influence on eating quality.
- **Proteolysis:** (beef and sheep) - modelling the cellular conversion of muscle to meat.
- **Stressor Response:** (beef and sheep) - modelling the cellular processes effecting eating quality under high pH high temperature conditions.

3. Intellectual Property Outline

Generation One

All intellectual property relating to the Generation One technologies has arisen from projects undertaken by MLA in collaboration with the technology development partner, Applied Sorting Technologies Limited (AST), through the Partners in Innovation program. The specific projects are:

- PSHIP.061 “Sheep Electronics Project”; and
- PSHIP.094 “Accelerated Process - Beef Electronics”.

Much of the IP surrounding these technologies is formally protected by the patent application titled “Electrical Treatment of Carcases” with a priority date of May 2002. Ian Richards, Manager Technology Development, Client and Innovation Services is the nominated inventor on this patent.

The patent application captures the IP around the electrical stimulation intervention technologies and the business method for the CPMS concept. If the patent application is granted as a full patent it is enforceable until 2022. Depending on the jurisdiction, a patent application can take up to 6-7 years before being granted in each individual country. The patent applications have been lodged in the following jurisdictions:

- Australia;
- New Zealand;
- United States; and
- Europe.

The intellectual property in the Generation One technologies is shared equally between MLA and AST in recognition of the parties’ background IP and funding contributions. The costs of maintaining these patents have been shared with AST until the end of 2003; MLA is now fully funding the patent costs with these being factored in to subsequent royalty returns to AST.

As a result of this ownership arrangement, the parties are required to undertake all use of the IP with agreement from the other.

Generation Two

The intellectual property relating to the individual technologies in Generation Two differs significantly to Generation One. As a result of the collaborative approach taken in the development of these technologies, the ownership of IP in the Generation Two technologies is much more complex than Generation One (see Table 1). As shown, the majority of these technologies are jointly owned by MLA and Meat and Wool New Zealand, with the remainder jointly owned with various research organisations with MLA having freedom to operate with the outcomes. Whilst the IP in the discrete technologies is separate from that in the Generation One IP space, as soon as they interact with each other they are operating within the CPMS business model and are utilising Generation One IP.

Table 1: Ownership of intellectual property in technologies arising from the Meat Quality Science and Technology program.

Technology	MLA Ownership	Other Ownership	Other Party
Generation One			
CPMS and Initial Intervention Technologies	50	50	AST
Generation Two			
Advanced Stimulation	50	50	MWNZ
Stretch	50	50	MWNZ
Low KgF	50	50	MWNZ
Super Tenderisation	100		FSA
NIR	60	40	VIAS
VSA	50	50	MWNZ
pH	50	50	MWNZ
MQ Lab	50	50	MWNZ
Nitric Oxide	60	40	VIAS
Proteolysis	60	40	VIAS
Stressor Responses	100		CSIRO/UNE

IP Issues

In order to proceed with the commercialisation of the MQST technologies, there are two main IP issues regarding the MQST technology that must be resolved. These are whether MLA should:

1. Continue with the joint ownership with AST of the background and project IP in the CPMS technology or to purchase AST's share in the IP
2. Maintain the "Electrical treatment of carcases" patent to protect the IP position

1. Should MLA Purchase AST's share in the Generation One Technologies?

The complexity in IP ownership in Generation Two has important implications for the ongoing development and commercialisation of the outcomes of the MQST program, particularly in relation to the need for MLA to continue to consult with the original partner, AST. The original project agreement with AST for Generation One technology development indicates that:

- The outcomes of the project will be shared;
- The parties must agree on a commercialisation plan; and
- Share any income from commercialisation.

The implications of this original project agreement have been reviewed by MLA's legal counsel, and it has been determined that MLA has no freedom to operate, as authority must be sought from AST for all use of Project and Background IP, including both beef and sheep applications. If MLA breaches this requirement, AST may seek damages from MLA.

This has repercussions in the ability to commercialise Generation One technologies and the full application of the Generation Two technologies. Even if the patent applications are not granted, as the project agreement encompass all project and background IP, these restrictions will still endure.

To date, the relationship between MLA and AST has been positive with the commercialisation of the Generation One technologies providing a direct benefit to AST as joint owner and manufacturer of the intervention technologies. Of particular concern, is that the jointly owned IP provides the CPMS platform that underpins the Generation Two technologies and these technologies have been developed in conjunction with a number of other partners other than AST.

In addition, it is anticipated that some of the Generation Two intervention technologies may, in fact, replace Generation One intervention technologies. This may create tension between MLA's objectives of delivering optimum industry benefit and AST's commercial objectives for their own technologies. It is proposed that this be resolved via the purchase by MLA of AST's interest in the project for an amount to be negotiated in the vicinity of $200k (this amount approximately represents the cash amount that AST have contributed to the project to date). This will provide MLA with the freedom to commercialise the Generation Two technologies unencumbered by AST.

Recommendation:

MLA to purchase AST's share in the Generation One intellectual property for an amount (to be finalised) of 200K. This will enable MLA to have freedom to operate and commercialise MQST technologies.

2. Should MLA Maintain the Patent Application for the "Electrical Treatment of Carcases"?

The patent clearly defines the outcomes of the CPMS technology, and as such provides a unique opportunity for MLA to manage the application and adoption of the technologies and business method. The benefit to the industry that can be derived from the Generation One technologies and the anticipated requirements that Generation Two technologies will have on existing background IP, supports the continued maintenance and support for the patent application. The patent protection of the CPMS business method is required to support the freedom to operate and the commercialisation of both the Generation One and Two outcomes of the MQST program. The estimated cost is approximately $70,000 over the next five years, with funding of this to be shared by industry partners, predominantly being Meat and Wool New Zealand.

The main reason to maintain the patent is the defensive position that formal protection provides for existing applications, as well as those that are yet to be fully developed.

Recommendation:

That MLA maintain the patent application The “Electrical stimulation of carcases” at an expected cost of 70K

4. Industry Benefits

The benefits of the Generation One MQST technologies to the Australian red meat industry have been quantified to enable MLA to:

- Determine the return to industry on MLA's investment in these technologies; and
- Provide the basis to focus technical and commercial efforts into the future.

This evaluation was undertaken using a technology value estimation tool developed specifically for the Australian red meat industry by MLA staff in conjunction with the R&D consultancy company, Innovar Pty Limited

Tables 2 and 3 show the primary quantified benefits for beef and sheepmeat respectively and quantify the maximum possible benefit that can be realised.

Table 2: Quantified maximum industry benefits ($ per tonne ETCW) for beef production.

	Domestic		Export	
	Young	**Old**	**Young**	**Old**
Increased market from improved eating quality	100.00	5.00	100.00	5.00
Electricity savings from hot boning	1.60	1.60	1.60	1.60
Reduced carcase shrinkage	65.00	51.00	65.00	51.00
Reduced labour	60.00	60.00	60.00	60.00
Increased blood recovery	28.00	28.00	28.00	28.00

- **Increased market from improved eating quality** – Hassall & Associates (2004) identified an average premium across the entire carcase of 10c/kg ($100/tonne) for improved meat quality in their review of Meat Standards Australia. The benefit for old beef is nominal given that the majority of this product is utilised in the grinding beef market.
- **Electricity savings from hot boning** - A USDA study, "The Economics and Palatability Attributes of Hot Boned Beef, A Review", identified that hot boning resulted in 20% costs savings in electricity costs which are normally $8/tonne (AUD). This equates to $1.60 per tonne in direct savings across all market sectors.
- **Reduced carcase shrinkage** – The same USDA study found that losses from chiller carcase shrinkage are estimated to be 2% of carcase weight.
- Australian export and domestic production figures from the Department of Agriculture, Fisheries and Forestry and value per kilogram of the different market segments from Meat and Livestock Australia[1] were used to determine the additional value per tonne gained by moving to hot boning, therefore avoiding chiller shrinkage losses.
- **Reduced labour** – The USDA study determined that moving to hot boning resulted in a 25% reduction in the requirement for boning room staff. Assuming labour costs of $80,000 per worker and an industry estimate of 6,000 beef

[1] Meat and Livestock Weekly, 4 March 2005

boning room staff across Australian plants, the total 25% saving was broken down per tonne.

Increased blood recovery – The electronic bleeding technology yields a minimum of one litre of additional blood per beef carcase worth $0.08 in dried blood which correlates to $28 per tonne of beef production.

Table 3: Quantified maximum industry benefits ($ per tonne ETCW) for sheepmeat production.

	Domestic		Export	
	Young	Old	Young	Old
Increased market from improved eating quality	100.00	5.00	100.00	5.00
Electricity savings from hot boning	1.60	1.60	1.60	1.60
Reduced carcase shrinkage	63.00	26.00	63.00	26.00

- **Increased market from improved eating quality** – In the absence of definitive data, it was assumed that similar premiums would be paid for the improved quality and consistency of MQST technology treated sheepmeat as that for beef.
- **Electricity savings from hot boning** – Similar savings per tonne were assumed for sheepmeat as those for beef.
- **Reduced carcase shrinkage** – The 2% chiller losses were assumed for sheepmeat and the returns per tonne adjusted in relation to production levels.

The Generation One technologies were assessed to determine the proportion of the quantifiable benefit each technology delivered. The value estimate model demonstrated that the full value of the Generation One technologies to the Australian red meat industry had a Net Present Value of $383 million over the next 5 years.

The processing efficiency benefit of the technologies was also estimated by removing the meat eating quality benefits from the model. This demonstrated that there was still a NPV of $175 million over 5 years, with 92% of this being direct to the meat processing sector.

Further benefits of the MQST technologies have been identified but have not yet been quantified and for this reason have been excluded from the model. As the development of the technologies progresses and the commercial roll-out continues, MLA will work with the commercialiser and the industry to determine and quantify these benefits. The additional benefits identified are:

- **Carcase immobilisation** – will improve OHS conditions for processing staff and may make the difference between particular types of animal are able to be worked on safely.
- **Electronic back stiffening** – existing systems use a potentially lethal voltage that pose a serious threat to operator safety. In addition, the voltages used in the existing systems have an adverse effect on the quality of grain-fed beef, which the new systems will address.
- **Improved meat colour** – the additional blood extraction improves the meat colour and therefore quality in respect to AusMeat grading specifications. The resulting returns are to be quantified.

- **Improved biological status** – it is anticipated that the enhanced blood recovery will reduce the risk of microbiological contamination of carcases and meat products.
- **Reduced waste BOD** – the enhanced bleeding module results in the majority of the blood collection occurring in a much more controlled and central area which means that less blood ends up in the processing waste water stream.
- **Increased production rate** – the facilitation of hot boning will improve the production efficiency of beef and sheepmeat processors. The extent to which this will occur is still to be quantified.

5. Technology Commercialisation and Industry Adoption

As part of the original R&D program that began in 2000, Generation One electronics technologies were installed in six sheep processing plants, one beef plant and one goat plant with funding support through the Plant Initiated Projects partnership program. The size, configuration, geographic spread and type of animals being processed at these plants provide important data to guide the commercial installation of further modules and development of the parameters required for the operator inputs for CPMS control.

The Generation One meat electronics technologies are now being commercialised by Millers Mechanical under licence from MLA. Millers are a New Zealand engineering design and build company with an extensive background in beef, sheep and deer processing and handling equipment. They were chosen after an extensive tender process because of their strong mechanical, electrical engineering and sales capability.

Adoption was slow up until 2004 due to the need for further commercial development of the technologies. To fast-track adoption, MLA entered into a partnership agreement with Millers to provide support totalling $300,000 (consisting of $150,000 from each party) to facilitate the dissemination and adoption of the CPMS technologies. This strategy was successful, with approximately 25 discrete technologies installed. The commercialisation of the Generation One technologies has continued since then and the number installed in Australian processing plants is summarised in Table 5.

Table 5: Summary of the discrete Generation One technologies installed or agreed by sites to be installed as at February 2005.

		Stimulation		Immobilisation	Bleeding
		Low Volt	Mid Volt		
Sheep	2004	1	4		
	2005	3	5	1	1
	2006	1	1		
	Total	**5**	**10**	**1**	**1**
Beef	2004	10	1	2	3
	2005	4		12	1
	2006			2	1
	Total	**14**	**1**	**16**	**5**

MLA has established a target to deliver the benefits of the Generation One technologies to account for more than 85% of sheepmeat production and it is anticipated that at the current rate of adoption this should be achieved by end of the 2005-06 financial year. When fully integrated with the SMEQ program, it is anticipated that this uptake will increase demand by consumers and provide the pull-through from retail for the remainder of processors to install the technologies. It is anticipated that uptake by beef processors to a similar level will require additional support and effort over a slightly longer timeframe.

All royalties arising from the commercialisation of the Generation One technologies are shared equally between MLA and AST. Whilst the initial installations funded through the Partnership Programs did not attract royalties to MLA, the joint owner of

the IP, Applied Sorting Technologies (AST) still collected their proportion. The current royalty rates are:

- 12.5% for sales in Australia and New Zealand; and
- 20% on all overseas commercial sales.

To date the parties have received a total of $16,206 in royalties: $6,013 to MLA; and $10,193 to AST.

Commercialisation of Generation Two technologies will be more complex and no commitment has been made to the current licensee regarding the rights to any future technology outcomes from the MQST program. In fact, it is likely that a number of specialist commercialisers will be required to support the discrete modules from Generation Two MQST, with overall co-ordination from a lead commercialiser (current licensee a potential candidate for this role). Figure 6 illustrates the relationship between the technologies; the licensees and manufacturers of the discrete technologies; and Millers as a potential lead commercialiser for the combined package of the Generation Two technologies.

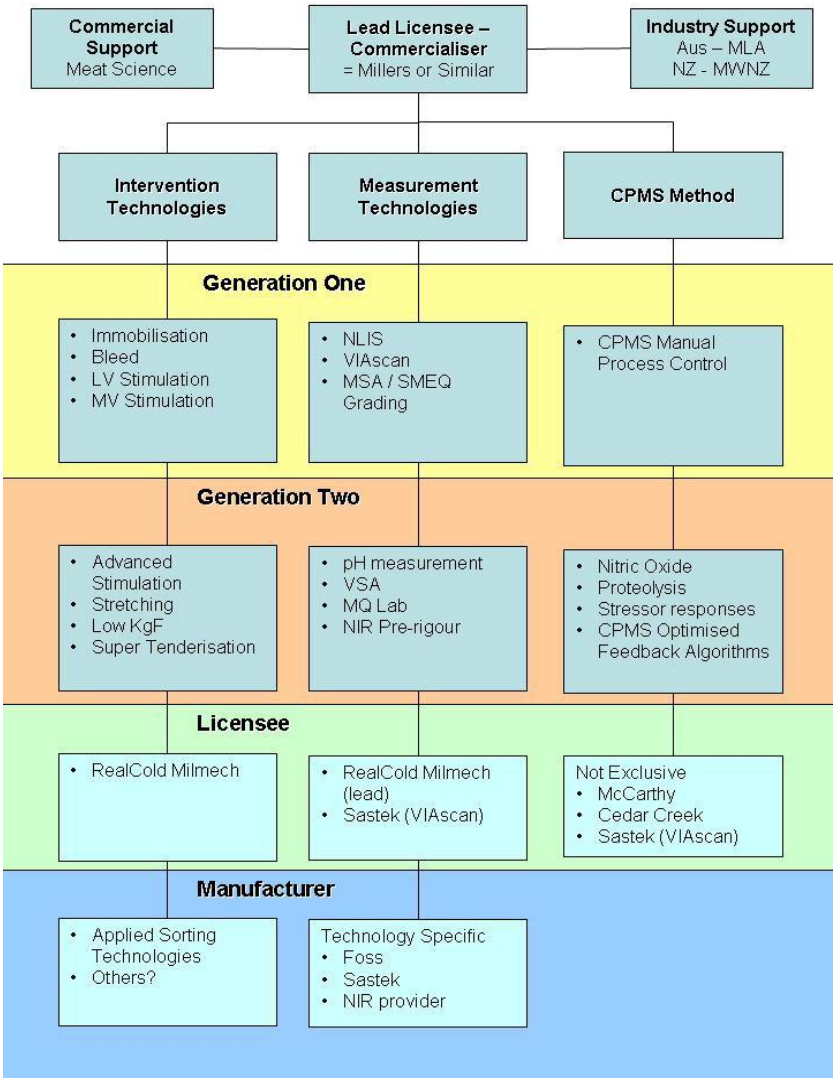

Figure 6: Link between MQST technology components, commercialisers and manufacturers

It is anticipated that ongoing support will be required from MLA (primarily via MDC) to facilitate the technology transfer of outcomes of the MQST program to commercialisers and to disseminate outcomes to industry. This will ensure that maximum adoption is achieved and the full benefit to industry arising from these technologies will be realised.