Final report

From IoT exploration to strategic impact

Project code: V.DIG.0016

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Date published: 9th April 2021

PUBLISHED BY
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Meat & Livestock Australia acknowledges the matching funds provided by the Australian Government to support the research and development detailed in this publication.

Abstract

This project was undertaken to assess the value of on farm Internet of Things (IoT) solutions to producers (and across the supply chain) and inform strategic planning for future investment. This project included a modelling component using publicly available data as well as workshops to unpack and discover the role of on farm IoT in the red meat supply chain. It was determined that accurate economic analysis of on farm IoT is hampered by the diversity of the red meat industry when trying to understand complex use cases. It is recommended that MLA undertake a series of high rigour commercial projects to further analyse these complex use cases and associated technologies.

In addition, commercial case studies should be undertaken to facilitate peer to peer learning in order to address socio-economic factors of adoption. This project has also been able to provide a high-level analysis of the value of low altitude deployable sensors to the red meat industry as well as provide strategic guidance for future investment into the on farm IoT space.

Executive summary

Background

MLA have made significant investments in on-farm Internet of Things (IoT) solutions in recent years with the commission of demonstration sites and technology trials and development. Looking further out, IoT and AgTech are seeing increasing levels of interest with numerous technology companies from within and outside of ag throwing their hat in the ring to participate in this exciting space. As younger generations learn of new developments and opportunities around how the use of data rich decisions has driven large increases in productivity and profitability in other industries, it is now that IoT devices are seeing increased interest from producers. This project seeks to understand the value propositions of IoT on farm and scope the role MLA can play in supporting technology development and adoption of IoT on farm.

This project was intended to provide information regarding use cases, value propositions, adoption insights for on-farm IoT, and consequently, develop a strategic scope for MLA to engage with and contribute to the development and adoption of on-farm IoT. As a key driver of innovation in the red meat industry, MLA has the ability to lead and guide work in the area both on behalf and with Australian red meat producers.

Objectives

This project sought to build upon previous research and development into IoT on-farm and develop new insights, including:

- Clarify what has been learnt from demonstration farms in terms of costs, benefits, barriers, enablers, and opportunities.
- Understand the flow and types of digital agriculture data on-farm and along the supply chain.
- Determine the relevancy and value of data to support decision making for a range of problems along the chain, not just on farm.
- Learn about how data might help with new business models and commercial relationships. Identify gaps in data sources, data integration, alignment to larger drivers of supply chain value. Identify what else might be required in collaboration with digital and IoT to enable transformation/ value increase.
- Clarify strategic roadmap and options for the greatest impact.
- Connect to customer through data and credentialing of claims.

Additionally, the project also undertook an ex-ante CBA assessment on low altitude deployable aerial sensors.

Methodology

- An ex-ante assessment of low altitude deployable aerial sensors was conducted using publicly available data.
- A workshop was held with KPMG to discuss findings of the adjacent MLA demonstration farm ex-post analysis.

- Data flows for decisions were scoped based on previous industry work and project team experience in order to understand the impact of data and decisions across the supply chain, barriers to adoption, and success limiters.
- Strategic impact was scoped as a result of the findings of earlier milestones, publicly available case studies and findings, and in line with industry and MLA overall strategic objectives as scoped in a workshop.

Results/key findings

Results found that there are limited available quantified value propositions for on farm IoT at current. This is due to the immense diversity across the industry along with socio-economic factors that limit quantification for a far. This project has identified at a high level that there is considerable value to be found through the adoption of IoT such as drones and that third party contractor type models can serve to fill skills gaps and capex barriers to adoption.

Benefits to industry

This project supports a strategic review of on farm IoT as well as the development and scoping of a strategic plan for on farm IoT. Innovations in the on farm IoT space has the ability to catalyse progress and value across other program areas such as sustainability as well as drive value realisation up the supply chain including processing and consumer experience.

Future research and recommendations

There are several recommended areas for further research. It is recommended that MLA undertake further work to quantify the economic impact of IoT devices for complex use cases under high rigour project conditions within commercial operations. It is also recommended that a diverse and extensive number of commercial case studies by undertaken to facilitate peer to peer learning in order to overcome and address socio-economic factors.

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1. Background

The Australian Government's *Precision to Decision* report found that the "implementation of digital agriculture across all Australian production sectors could lift the gross value of agriculture production by 25% - $20.3 billion" (Leonard et al 2017). One of the principal findings of this report was the general digital immaturity and ad hoc nature of strategy, leadership, and implementation across all agricultural sectors. MLA has sought to address this problem with a producer focussed exploration of IoT through demonstration farms. The diagram below shows an example of the type of work being undertaken (Figure 1).

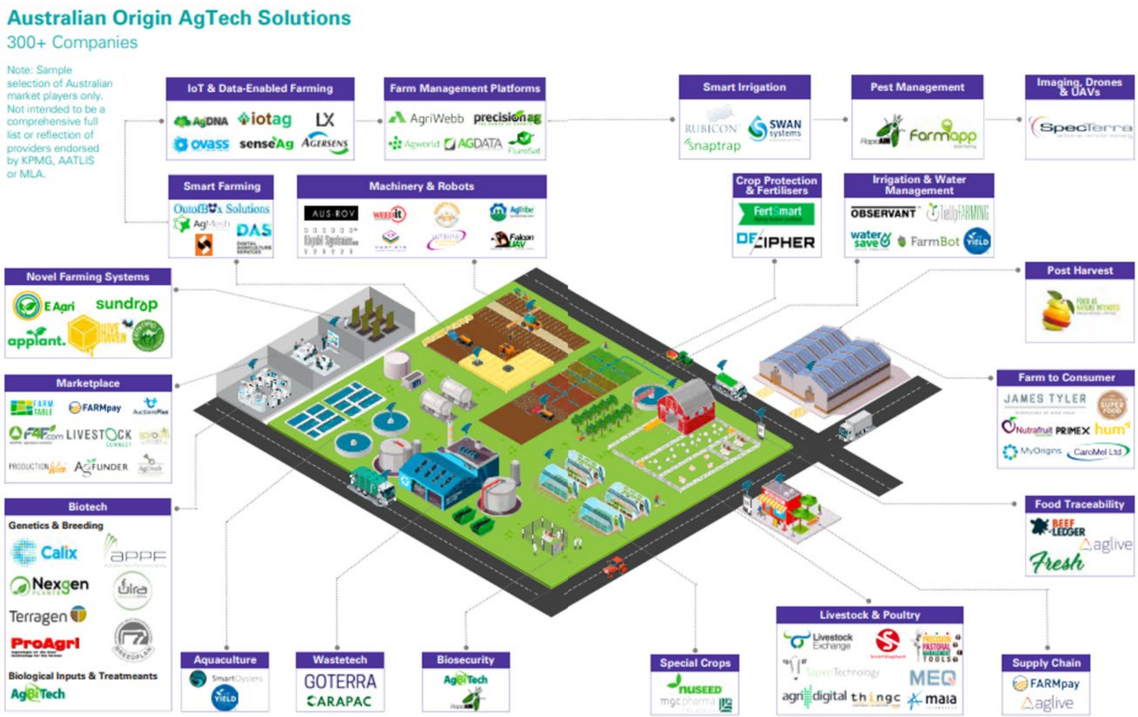

Figure 1. A sample of digital technology companies involved in developing on-farm technologies

The results of this work have uncovered common issues, key benefits, and key advice, including the following examples.

Common issues:

- Costs and benefits of IoT are not clarified, not ready for implementation and the hardware is not commercially robust.
- Producers must use multiple application interfaces to view and run their digital farm.
- Producers are not aware of the options and benefits of different technologies on their business.

Key benefits:

- Remote management of business.
- Potential of new revenue streams.
- Peace of mind.

Key advice:

- Understand what infrastructure is required to deliver a solution.
- Make sure you have ongoing maintenance, support and advice from providers.
- Understand different pricing models.
- Each deployment becomes easier.

Added to the above, is the lack of connectivity, which has been a major reason why the industry has "struggled to innovate and implement technologies quickly and effectively as other leading food producing nations such as the US and the Netherlands" (KPMG, 2019). The MLA demonstration farms have been an important context to learn about the different connectivity options that are available for different geographical areas across Australia.

IoT strategic considerations
The MLA Digital Agriculture (including IoT) strategy to date has focused on exploration through a number of projects, understanding the customer, problem/solution fit, willingness to pay, market size and opportunity. The next phase for the industry will need to focus on validation through fewer but larger and more collaborative initiatives that can have wider industry impact.

Accelerating adoption of Digital Agriculture will require the integration of data for decision support and on-farm profitability rather than the individual benefits of individual technologies. In addition to current IoT on demonstration farms, the integration of data will necessarily involve new forms of testing and learning about technologies that capture and utilise data, including animal health and welfare through to traceability and integrity systems. These technologies must also enable feedback and feedforward processes within networks and supply chains that are informed by consumer expectations. Strategy will need to begin to challenge some of the current thinking and behaviours to stimulate innovative approaches that improve Australia's overall ability to compete.

2. Objectives

This project seeks to build on previous research and development into IoT on-farm and develop new insights, including:

- Clarify what has been learnt from demonstration farms in terms of costs, benefits, barriers, enablers and opportunities.
- Understand the flow and types of digital agriculture data on-farm and along the supply chain.
- Determine the relevancy and value of data to support decision making for a range of problems along the chain, not just on farm.
- Learn about how data might help with new business models and commercial relationships. Identify gaps in data sources, data integration, alignment to larger drivers of supply chain value. Identify what else might be required in collaboration with digital and IoT to enable transformation/ value increase.
- Clarify strategic roadmap and options for the greatest impact.
- Connect to customer through data and credentialing of claims.

All objectives of this project have been met in full as detailed below and in previous milestone reports.

3. Methodology

The ex-ante assessment was modelled using publicly available data from sources including ABARES and technology providers, along with information from producers and others with practical experience in this space. Modelling was completed across the three different ABARES agricultural regions in order to provide categorised examples that allow for the differences in climatic factors, scale of operation and input levels. This is by no means representative of all red meat enterprises but does allow for some variation.

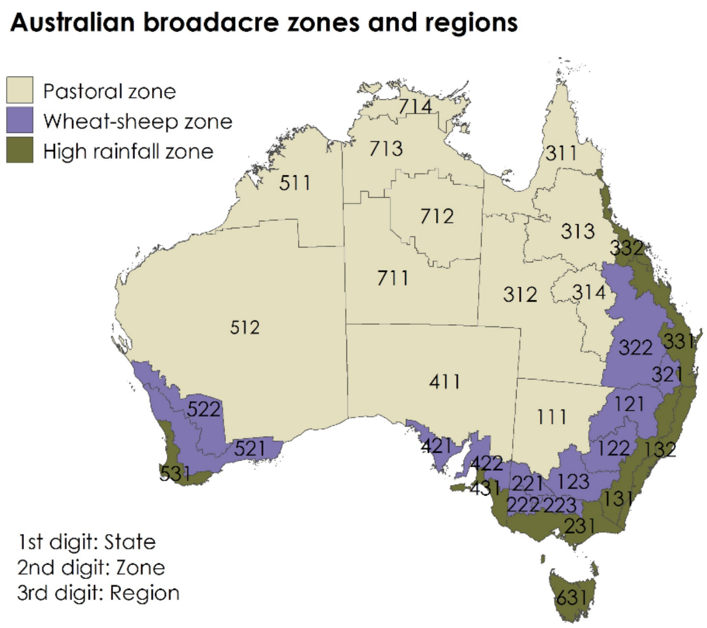

Figure 2. Australian broadacre zones and regions as specified by ABARES. Source: http://apps.agriculture.gov.au/agsurf/regions.html

Data flows were scoped using prior experience of the project team with a background of experience across the supply chain including project experience in IoT within vertical red meat businesses.

The final strategic piece involved a workshop with the MLA project team to unpack the MLA strategic plan and current IoT business plan. The Greenleaf team then drew from learnings from earlier milestones in this project to scope out a strategic impact plan for MLA's program from on-farm IoT.

4. Results

4.1 Low altitude deployable sensors

The Internet of things (IoT) has been hailed a game changer for Australian farm businesses and there are numerous companies both building and researching these technologies. However, the cost-benefit-analysis (CBA) of many of these technologies has not been conducted as yet. This project aims to examine potential use cases and CBA results of some of the technologies tested on MLA demonstration farms. This section of this report focuses on the use of low altitude, deployable imaging sensors and it examines the costs and benefits of a number of on-farm use cases. It was found that there are several potentially valuable uses cases for animal management, feed-base management, and operational efficiency.

The table below summarises the benefits of using low altitude deployable imaging sensors in key use cases modelled in this milestone. The most beneficial use cases identified were fertility and survival rates and biomass management. This is not surprising given these areas as the largest drivers of value in grazing enterprises. Further work should be conducted in the future to evaluate potential of IoT ground based sensors for these identified use cases and how the learnings can be applied in industry.

Table 1. Benefit summary of all possible use cases across the different production regions

TOTAL GROSS BENEFIT			
	Pastoral	High Rainfall	Wheat-Sheep
Benefit summary	$/hd Avg.	$/hd Avg.	$/hd Avg.
1. Improved Feed-Base Management	$14.73	$28.98	$34.81
2. Improved animal production management	$64.72	$29.47	$58.21
3. Improved operational efficiency	$12.16	$54.58	$60.06
$ Benefit per head	**$91.62**	**$113.03**	**$153.09**
$ Annual Benefit overall	**$719,636**	**$84,776**	**$91,853**

In terms of immediate application, it was found that a third-party contract-service model of low-altitude imaging is the most cost-effective. Due to a barrier of skill development, smaller properties would struggle to support a full suite of imaging capability. Due to the cost of adoption, it would be viable to hire a contractor with the capability, though for both small and large operations, the cost would be a barrier to possessing the technology personally.

Numerous opportunities are identified to further explore and exploit the potential of low altitude deployable imaging sensors, such as:

- Address the lack of commercial data currently available to test and model use cases and IoT applications.
- Develop a commercial testing model.
- Creation of cross-functional projects to wider MLA initiatives such as CN30.
- Validate the different capabilities between satellite, low altitude, and manual biomass monitoring.
- Validate capabilities of hyperspectral cameras.
- Creation of training modules for pastoral places.
- Creation of a directory of drones and sensors.

For larger pastoral stations: NPV of low-altitude surveying for the property-owned model is slightly less than the contract-service model. Under the contract-service model, the costs associated with a contractor travelling to the properties could increase the cost per service for the operators. For this reason, it is believed that both contractor and producer owned technologies are viable options for the application of the technologies to Australian agriculture. This will also enable service providers to develop two income streams from contracting and from sales and establishment of the technology into pastural stations.

For smaller properties, Table 2 when compared with Table 3, shows the contractor model should be developed and utilised to maximise the returns of enterprises.

The capital and operating costs associated with the adoption of this technology will vary the overall benefit for producers to adopt the technologies. Similarly, the utilisation of verified satellite technology may enable similar benefits to be achieved by utilising low altitude technologies throughout the year to validate the satellite data as required, reducing the overall costs whilst maintaining some benefits. These assumptions all need validation and will only be applicable to some use cases, others will only be able to be achieved through the utilisation of low altitude deployable sensors.

Table 2: Financial benefits achieved by the case study farms implementing the use of drones through a contractor model for feedbase management.

SUMMARY PERFORMANCE MEASURES			
	Pastoral	High Rainfall	Wheat-Sheep
Hd / annum	7,855	750	600
	Avg.	Avg.	Avg.
Capital cost (pmt option, upfront)	$0	$0	$0
Gross return Per head	$14.73	$28.98	$34.81
Total costs Per head	$7.93	$0.56	$4.80
Net Benefit Per head	$6.80	$28.42	$30.01
Annual Net Benefit	$ 53,419	$ 21,318	$ 18,007
Annual Net Benefit ex cap	$ 53,419	$ 21,318	$ 18,007
Pay back (years)	0.00	0.00	0.00
Net Present Value of investment	$392,020	$73,630	$70,748

Table 3: Financial benefits achieved through the utilisation of a property owned drone model for feedbase management

SUMMARY PERFORMANCE MEASURES			
	Pastoral	High Rainfall	Wheat-Sheep
Hd / annum	7,855	750	600
	Avg.	Avg.	Avg.
Capital cost (pmt option, upfront)	$200,000	$200,000	$200,000
Gross return Per head	$14.73	$28.98	$34.81
Total costs Per head	$7.00	$73.27	$99.85
Net Benefit Per head	$7.74	($44.29)	($65.03)
Annual Net Benefit	$ 60,782	-$ 33,216	-$ 39,020
Annual Net Benefit ex cap	$ 110,782	$ 16,784	$ 10,980
Pay back (years)	1.81	11.92	18.22
Net Present Value of investment	$192,020	($126,370)	($129,252)

4.2 MLA demonstration farm consolidation

The Greenleaf team participated in a workshop with KPMG who were conducting an ex-post assessment of the MLA demonstration farms and IoT ground sensors as part of their development of an on farm IoT Benefit Cost Estimator under a separate MLA project. This workshop and other related work identified insufficient economic data to strongly validate use cases for IoT devices beyond water management.

Itis recommended that MLA undertake high level ex-post assessments of commercial enterprises across Australia that will provide indicative economic analysis, qualitative findings, and cover a significant variation in enterprise types. These should be presented as case studies that allows producers to learn from other producers. In addition to these case studies, high rigour scientific studies should be undertaken within commercial enterprises to conduct economic analysis and verification of use cases.

4.3 Data flows for decision making

Decisions are made constantly across the supply chain with impacts both forwards and backwards in the chain. Data can be collected manually or digitally however correctly collected digital information has the potential to improve data accuracy and efficiency in collection. Digital collection, integration and analysis of this data can provide previously unrealised insights and opportunity as trends allowing the impact to be more easily identified. Missed data leads to missed insights and missed opportunities as portrayed below in Figure 3, thereby limiting value realisation across the supply chain.

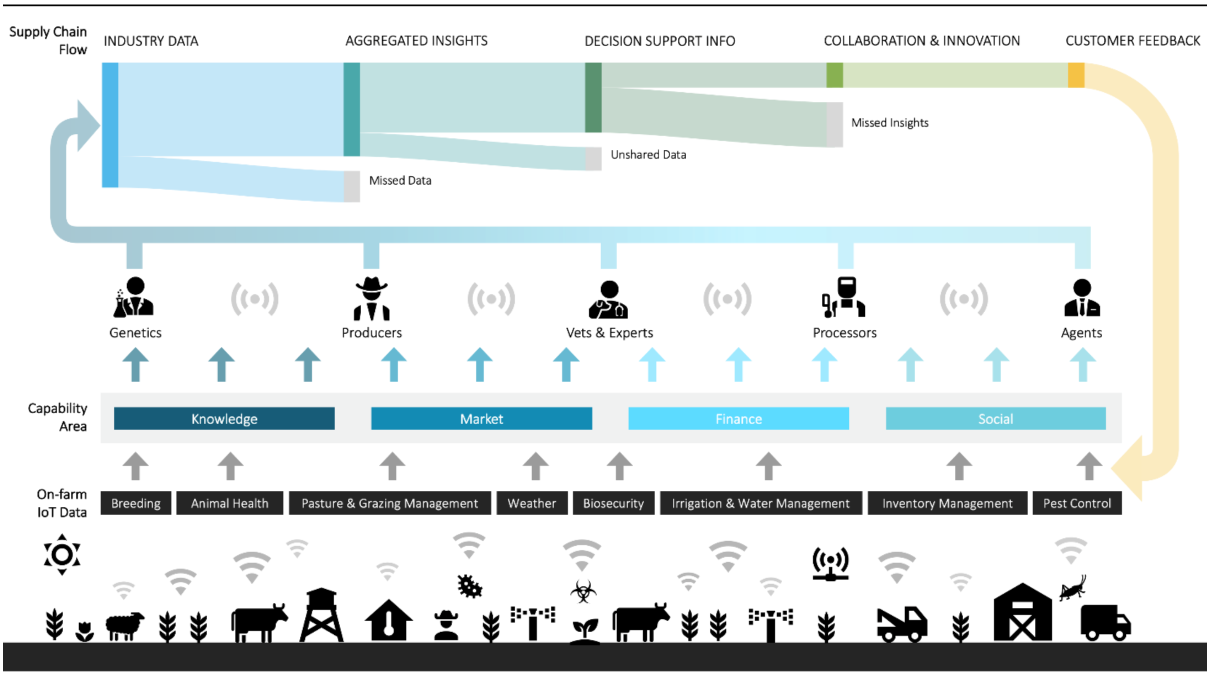

Figure 3. Example of data flows in a value chain

Each part of the supply chain has a role to play in data collection and sharing for decision making.
Producers: Producers can use genetic data to predict animal performance such as predicted yield and marbling score. They can use real time performance data to understand projected performance to establish finishing times. This, combined with data on pasture availability and quality and supplementary feed availability and costs, provides information that will inform management decisions to optimise outcomes on an end market and profitability standpoint. Information on animal history from LPA and NLIS data can inform feedlots and abattoirs on animal eligibility for certain markets. Whilst not often shared at present, historic animal performance and projections can be shared with feedlots and abattoirs to enrich forecasting capabilities.
Feedlots: Feedlots use data to track feed intake and animal performance to monitor health and finishing times to meet compliance specifications.
Abattoirs: Abattoirs collect data to measure yield and predict eating quality. This information, along with feedlot information can be fed back to producers to inform management decisions such as genetics and management interventions to improve performance and compliance.
Consumers: Data as feedback from consumers filters its way back through the supply chain to drive changes in eating quality, cut specification and thus animal specifications, as well as rising trends in raising claims.
End to end: A data feedforward mechanism utilising on farm data, feedlot data, processing data and transport and handling data, provides lifetime traceability and food safety and raising claim verification through to customers and consumers.
Effective data collection and utilisation provides immense opportunity to increase the value at each stage in the supply chain.

There are numerous data flows and inputs into decision making, as displayed below in Figure 4. IoT can contribute to data collection, however it needs to be paired with effective data transfer, processing, and decision support systems. This highlights key limiting factors in the adoption of IoT. MLA must always consider these limiting factors or barriers to adoption when designing programs. It is therefore recommended that MLA address these through capacity building of advisors and producers alike so that comfort and understanding can be gained in the development and installation of an IoT network that aids in decision making.

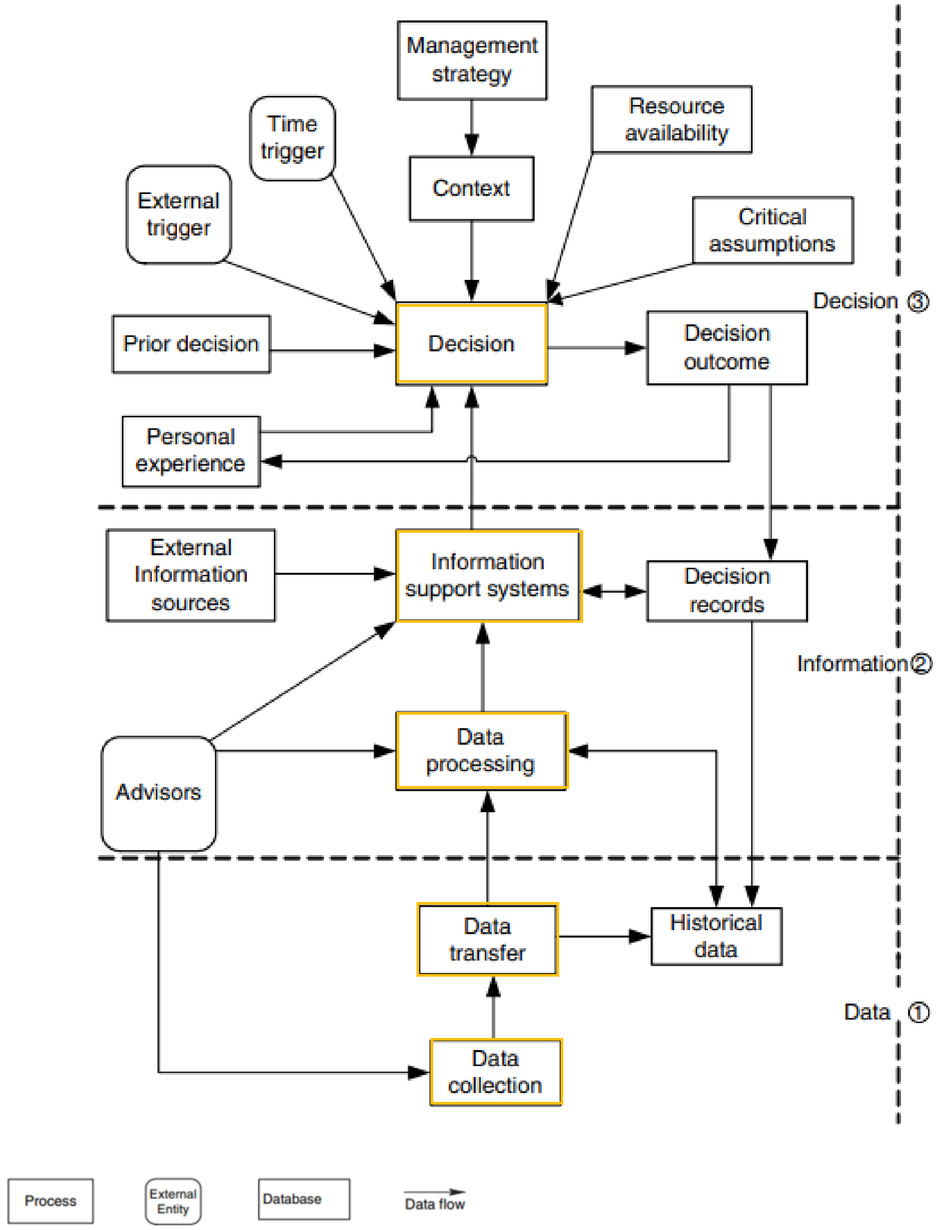

Figure 4. Generic diagram of decision-making information flows in agricultural systems. Source: Fountas et al., 2006

It is therefore recommended that MLA investigate ways to improve accuracy in digital data collection using IoT and invest in projects that highlight the benefits of decision support software for producers both large and small. This will improve the capacity of the industry to increase value and become more efficient and sustainable.

It cannot be overestimated the fragility and uncertainty of the industries trust in data security and privacy. There have been umpteenth examples of data security breaches within agriculture. Along with the scepticism around how a producer's data can be used against them by the likes of banks, regulators, competitors, or service providers. Therefore, it is recommended that data management and security standards be adopted by all technology and data companies and time be spent raising awareness and teaching mitigation measures around data security. Any effort to pool and share producer data must be carefully understood and explained to ensure there is no potential negative consequences of these actions.

4.4 Strategic impact

It has become increasingly clear through the course of this project that on farm IoT can play an important role in the overall red meat industry and MLA strategy. Red Meat 2030, developed by RMAC in consultation with industry stakeholders, serves to provide a vision for the Australian red meat and livestock industry. Red Meat 2030 strives to double the value of Australian red meat sales by 2030 and the trusted source of the highest quality protein. There are several measures of success outside of the doubling of value of red meat sales:

Figure 5. Vision and priorities as outlined by the Red Meat 2030 strategy

Additional detail can be found here: https://www.redmeat2030.com.au/our-priorities/

MLA have also provided MLA Strategic Plan 2025 through which they provide a roadmap and goals with a purpose of guiding and delivering tangible value for Australia's red meat and livestock industries. The two key objectives of this plan align directly with Red Meat 2030:

- To help double the value of Australian red meat sales.
- To become the trusted source of the highest quality protein.

MLA have outlined 6 key areas to focus on which will support the realisation of their objectives:

- Decisions informed through data and insights.
- Targeted investment to address the industry's big, complex challenges.
- Enabling new sources of revenue.
- Developing new, high value products that allow us to maximise the whole carcase.
- Beyond today's farm gate.
- Strengthening our core.

Additional detail can be found here: https://www.mla.com.au/globalassets/mla-corporate/about-mla/documents/planning--reporting/Strategic-Plan-2025.pdf

The use of IoT feeds directly into MLA's first key focus area. As discussed above, much of the data collected on farm now is done so manually and/or subjectively. This creates a level of uncertainty and inaccuracy. The use of IoT will enable the efficient and timely collection of data on farm that will provide more accurate information with which to make decisions. Also as discussed above, it will provide previously unrealised insights into the impacts of management decisions if paired with decision support tools. These elements will combine to provide new value opportunities for producers and the broader industry.

In its second key area, MLA has identified the need to focus on exploring mechanisms to optimise resources and address seasonal and climate variability. On farm IoT lends itself to collecting and monitoring data to support efforts in these areas. IoT paired with decision support tools will increase efficiency in resource usage through targeting stocking rates and pasture performance, identifying high and low performing animals, targeting fertiliser, herbicide, and pesticide use, and ensuring increased compliance of livestock. Likewise, routine data collection on climatic factors will provide more informed and accurate data for green date decisions and more minute stock and pasture management decisions in the face of adverse seasonal conditions. This will become even more vital as the climate continues to change, providing more uncertainty for the Australian red meat industry. IoT provides an opportunity and avenue to support MLA's adjacent work areas in an effort to target investment to address industry's big, complex problems, through improved data collection and accuracy.

Enabling new sources of revenue requires the objective determination of land and livestock productivity to determine the best land use in each business and season. This can include carbon sequestration or crop grazing. New sources of revenue provide opportunities to build resilience into farm businesses, however new business ventures always come with an element of risk. The use of IoT can reduce risk through the assurance of accurate data collection in a less labour-intensive manner to provide a piece of mind and ensure the best management of new ventures. IoT has a potential to overcome some barriers to adoption of new practices required for to credential sustainability efforts.

MLA's Strategic Plan 2025 states:

> *"On-farm productivity performance remains below the productivity improvements being achieved by major international competitors. Growth in chicken and pork production is expected to continue to outpace growth in red meat production. Productivity gains and/or ability to respond to external threats are linked to capability and willingness to adopt new technology".*

On farm IoT has the potential to service the industry to enable realisation of potential productivity gains to not only surpass current benchmarks but ensure the industry is competitive with other proteins in the future.

MLA focus area number 4 can be supported through the use of on farm IoT as it provides opportunities to increase the value of carcases and associated by-products through more regular data capture and performance monitoring. This can ensure early intervention to maximise the quality and yield potential of animals as well as monitor physiological changes associated with animal health and stress. Many of these elements cannot easily be assessed or monitored during the course of an animal's life, and rather producers rely on observational data and retrospective data such as carcase feedback to understand the status of animals. IoT can close data gaps and increase the frequency of data observation, that when combined with decision support tools, can prompt producers to undertake early intervention methods. As a result, the overall value of a carcase and associated by products can be increased.

On farm IoT can support the focus area 'beyond today's farm gate' as it acts to support other program areas including adoption, MSA, ISC and sustainability. It is therefore established that on farm IoT can be a contributing and foundational area of work that serves to provide the tech solutions to support broader industry programs and adoption efforts. It is not a stand-alone piece of work, rather it is a forward looking, future focussed program that aids in the improved efficiency and accuracy of data collection that is essential to the realisation of industry strategies and MLA initiatives.

In a similar vein, on farm IoT can contribute to the strengthening of the core. IoT collects data and hence has the potential to contribute to every program of work in MLA and industry. It is not however a solely data program, rather it is a technology development, change management, process improvement and adoption program. Data alone will not solve all of industry's problems. Instead, it needs to be accompanied by strong use cases, value propositions and supporting infrastructure such as decisions support and extension tools. Data collected through on farm IoT can be fed, along with the appropriate intelligence and context, into the likes of ISC, marketing and trade programs of work. However, IoT devices should not be 'owned' by any one of these programs as it will limit the scope and take away the focus of co-development with producers and true discovery of use cases and value propositions. Rather collaboration between programs of work should be encouraged to ensure maximum value realisation for industry.

Both Red Meat 2030 and MLA Strategic Plan 2025 speak to the need to focus on capability building within the current red meat industry workforce as well as the need to attract new skills to the industry. On farm IoT has the ability to change perceptions of hard, manual, high risk labour, to one of data driven accuracy that is set on increasing sustainability, productivity and innovation. Red meat as an industry is becoming more advanced and is at a point where new skill sets and thinking are required to help execute on exciting new challenges. On farm IoT can play a part in helping to change the image of the red meat industry to one of excitement and innovation where there is a continual momentum to drive new data and insights along the supply chain for innovation.

The MLA Demonstration Farms have proved to be very valuable in enabling producers to see a wide variety of IoT devices in action, touch and feel them, speak to providers, and hear from farm managers their experiences. The next steps from here provide opportunities to learn more about the value propositions of IoT within commercial settings as well as test devices under high rigour conditions. There are six areas of work that will enable the Digital Ag on farm IoT to deliver maximum value to the Australia red meat industry through driving IoT development and adoption:

- <u>Gap analysis of IoT and use cases</u>

The aim of this piece of work is to undertake a global scan of on farm IoT to map which use cases are being considered and how well they are being solved. This will allow MLA to understand the gaps in the market in regard to use cases and identify areas to focus on the development of IoT. The more complex use cases are yet to be solved; however, a global scan could identify novel work in these areas and the potential for further development of existing technologies. A global scan of IoT will simultaneously enable an assessment of where solid value propositions exist for use cases, again allowing MLA to focus in on where they can provide the most value to the industry in supporting R&D and adoption of on farm IoT.

- <u>Commercialisation pathway analysis and technology assessment criteria</u>

This involves categorising current IoT as to its stage in the commercialisation pathway. An example is included below in Figure 6. Understanding where IoT sits along this pathway will help to identify the support MLA can provide. By profiling all known companies in this space, MLA can identify where along the commercialisation pathway IoT devices are, potentially identifying bottlenecks and therefore highlighting where MLA can provide support to improve the number of IoT devices that are being commercialised. MLA can act as the conjugate between producers and technology solution providers. Acting as the advisor and 'translator' between the two to ensure the greatest possible chance of success for on farm IoT.

Figure 6. Commercialisation pathway

It would also be beneficial for MLA to determine the likelihood of adoption of different technologies. This will guide MLA on which technologies they should be partnering with to develop. One such tool is the ADOPT tool developed by CSIRO. This tool works to assist in the understanding of factors that are likely to affect adoptability. It predicts adoption levels using a structured set of questions based on well-known socio-economic factors influencing adoption of agricultural innovations. This tool is not specifically designed for use with IoT but will provide a guiding assessment that can be ground-truthed in case studies and trials.

- <u>Interoperability discovery</u>

IoT devices on their own will not drive practice change. Instead, devices only provide access to data to assist with decision making. As discussed, more complex use cases require several data points and therefore several use cases. To allow the effective use of IoT with these complex use cases, interoperability is essential. Many producers must install connectivity on their properties, whether to establish connectivity or just connect one area of their property. With IoT devices created to serve one or more connectivity types, it is essential that producers not only choose the most cost-effective connectivity solution but also purchase the connectivity type most conducive to future IoT installations. Long term efficiency and decision support optimisation revolves around an ecosystem approach. It is true that data collected in many cases needs to be aggregated and joined up with other data sets in order to provide truly valuable insights. It is therefore essential that interoperability is considered. Likewise, decision support tools and dashboards are required to connect data from different sources and perform analytics over the top of it. By MLA undertaking projects focussed on interoperability and decision support, they will be able to provide learnings and case studies to producers whether they are at the start of their IoT journey and are considering how they can future proof their investments, or whether they already have a handful of IoT devices and are looking to connect these data sets to provide more meaningful insights to themselves and staff. This will provide producers with an objective service and advice to maximise the value realisation potential for producers.

- Producer IoT selection tool

This platform will serve two purposes. One will be an ROI tool, building upon current work by KPMG. This will allow producers to roughly estimate the ROI of investing in IoT devices to service use cases. As discussed, not all use cases will be suitable for an ROI tool however as more data is collected and high rigour projects conducted, the development of ROI tools will improve. The second part of this tool will enable producers to search a directory to discover the IoT devices most suitable for them. For example, they can search using drop down boxes and filters to find the most suitable water sensors for their connectivity and data availability. Or if they are wanting to solve more complex use cases, they can see which companies provide several IoT devices as suitable for the particular use case, along with the most appropriate decision support and dashboarding tools, all with appropriate streamlined support services.

- Commercial case studies

It is well known that producers learn best off one another. As there are many producers already using or trialling on farm IoT, MLA can undertake commercial case studies to profile IoT in the field and the experience of producers. Quantitative data can be collected through the undertaking of crude ex-post analysis to determine the ROI and value proposition of the IoT device/s in question as well as collect qualitative data on choosing devices, effective installation and maintenance, staff training and the use of data insights. Standardised case studies will allow producers to hear from each other on IoT use on farm. A goal of this work should be to gather use cases from a wide of a spread of enterprises as possible. MLA should try to capture as much diversity as possible to provide producers with case studies similar to theirs to learn off. This will also allow understanding of the variation of the value propositions of IoT between different production systems. In addition, the ADOPT tool can be used to ensure that as many barriers to adoption are being addressed in the case studies. More information on the ADOPT tool can be found here: https://www.csiro.au/en/research/technology-space/it/adopt

- High rigour IoT R&D projects

As discovered in this project and adjacent projects, value propositions are not available for all use cases as there are a considerable number of variables and some use cases are complex enough that producers to date have not been able to account for all financial and social impacts of IoT devices. MLA should undertake high rigour projects to establish a baseline financial situation for commercial businesses and then monitor the impact of the IoT devices in question. These projects should measure the quantitative and qualitative impacts on the business. To ensure accuracy, only one IoT device or suite of IoT devices that serve to support one use case should be tested at once. This will allow true measurement of the impact of the IoT device/s in question. Learnings and ROI from these projects will provide learnings that supports technology development and adoption activities of on farm IoT. These high rigour projects provide opportunities for MLA to ground truth different technologies to determine suitability. One such use case is pasture monitoring. It is yet underdetermined whether satellite, cameras mounted on drones or other IoT devices are the most appropriate technologies for pasture monitoring. Depending on the purpose of this data and the type of enterprise in question, the trade-off between accuracy, cost and accessibility will differ. When designing these trials, it is essential that producers be included in the design process to ensure maximum buy in through a participatory process.

5. Conclusion

This project has produced several findings informing future strategic direction in areas of digital agriculture development. This project has also served to increase understanding of the current value propositions of low altitude deployable sensors within red meat businesses. Findings demonstrated that the diversity and complexity of the red meat industry must be accounted for in order to drive adoption by the greatest proportion of Australian producers. Given the impact of data and decisions made on farm to the rest of the supply chain, it is essential that MLA undertake several strategic initiatives to better understand how they can support the development of IoT devices and support the adoption of IoT across the broad range of red meat enterprises in Australia. Details on some of these can be found below.

5.1 Key findings

- IoT can provide significant value to the Australian red meat industry and has the potential to increase the accuracy, frequency, and efficiency of data collection on farm. When combined with data integration and decision support, IoT can contribute to implementation of best management practices and an increase in productivity and profitability of red meat enterprises.
- Solid value propositions for use cases of on-farm IoT are few and far between due to the immense diversity of the Australian red meat industry that results in minimal controlled variables to model, thereby reducing accuracy of modelling outputs.
- Climate, enterprise business components, technology literacy, current management practices and desired input levels of a particular enterprise must be understood to effectively begin understanding the value propositions of on farm IoT for a business.
- Low financial and operational data literacy rates in Australian red meat farming enterprises limits effective economic analysis of the ex-post and ex-ante impact of IoT.
- Technology, data literacy and connectivity are key limiting factors of on farm IoT adoption in conjunction with social factors.
- Data security and privacy are also key concerns of producers when examining the role of IoT in their businesses. Effort must be made to educate technology providers and producers on how to secure their data effectively.
- The use of a tool such as the ADOPT model can aid in understanding the adoption potential for different IoT innovations.
- Skills training and decision support tools must be provided to ensure red meat enterprises have the capability to realise full value potential.

- Third party contractor models provide an opportunity to overcome some capability gaps and bridge capex barriers to adoption.
- Data collected using IoT devices has the potential for increased value realisation across the value chain. Given the breadth of this impact, it is essential to ensure accurate and timely data collection be prioritised in the use of IoT.
- On farm IoT will play an important part in the realisation of Red Meat 2030 and MLA's Strategic Plan 2025 through the provision of new insights that will drive productivity across the supply chain and promote adoption and innovation.

5.2 Benefits to industry

This project has provided an in-depth analysis of the current state of low altitude aerial deployable sensors within the red meat industry including assessment of the potential use cases. It has discussed the options of different business models to support the adoption of these more capital intensive IoT ventures. In addition, this project has been able to highlight some reasons for low rates of producer adoption of IoT and a strategic plan to demonstrate economic impact of IoT devices on farm and drive the adoption of on farm IoT across the broader Australian red meat industry. In order to meet the industry's goals of doubling the value of red meat by 2030 and achieving zero carbon emissions by 2030, more data driven decisions will need to be made at the on-farm level of the industry. This will drive productivity and profitability and as a result, innovation. Improvements in management and more accurate insights into trends and forecasts will in turn drive increased value along the supply, resulting in a healthier, more sustainable industry.

6. Future research and recommendations

There are several areas that have been identified for future work in the on farm IoT space that will serve to support the strategic direction of the Australian red meat industry. Many are discussed above. The areas of work below identify the highest value activities that will serve to drive the development and adoption of on farm IoT to allow value realisation on farm and across the rest of the supply chain.

- High rigour projects that assess pre and post implementation on-farm IoT device value proposition and ROI:
  - Focus on one use case and IoT device at a time.
  - Collect extensive financial and operation data prior to implementation, monitor periodically throughout the course of the project and conduct an ex-post assessment at the conclusion of the project.
  - Needs to be conducted within commercial enterprises to understand qualitative impacts as well as quantitative impacts.
  - Projects should follow participatory design principles to ensure producer buy in and greatest chance of success.
- Conduct commercial case studies of on-farm IoT devices:
  - Use MLA and livestock advisor network to contact commercial livestock producers who are using IoT on farm to conduct a high level or 'back of envelop' ex-post analysis of devices.
  - Quantitative and qualitative learnings will prove to be examples for other producers.

    - An extensive cross section of the industry needs to be profiled to allow for the immense variation in red meat enterprises and to allow producers to find example of IoT in production systems similar to theirs.
    - Case studies to be shared broadly across MLA communication pathways, adoption program activities and livestock advisor network.
    - Case studies should follow a standard process to allow for comparison between each case study.
- Cross-functional projects:
    - IoT has the ability to contribute to and enhance the value of other MLA initiatives.
    - IoT can assist with demonstrating animal health and welfare outcomes.
    - Data collection and analysis can be done with IoT in order to support the RD&A of the Sheep and Beef Sustainability Frameworks and CN30 program.
    - IoT will improve the accessibility of the utilisation of data and evidence to inform production led environmental outcomes.
    - With further research to ground truth technologies, data and satellite imaging technologies can be used to verify environmental best practice.
    - IoT can provide new opportunities to collect, verify and manage data for integrity, food safety and biosecurity to enhance and secure the value of the red meat industry.
    - Cross-functional projects should draw upon producer and livestock advisors at each stage to ensure the participatory design and highest potential for adoption.

7. References

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