final report

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Understanding the Value of Farm Specific Sensors with LoRaWAN

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Executive summary

Telecommunications coverage remains a challenge across Australian agriculture from both a coverage and price perspective. This project sought to prove that adoption of reliable Internet of Things (IoT) networks could provide value to the livestock industry. A further outcome of the project was to determine the most desirable business model and price point through which to drive up IoT solution adoption.

It is proposed that further investment is needed in the development of appropriate IoT solutions and deployment of appropriate telecommunications infrastructure to be able realise these benefits more globally across the entire livestock industry rather than on specific farms.

Whilst producers appear to be comfortable paying a moderate amount for installation of telecommunications networks on their properties, this remains a stop-gap solution to the overall requirement for broad telecommunications coverage.

This project suggest cattle and sheep producers have a very clear appetite to adopt IoT solutions that assist in removal of labour intensive low-skilled tasks examples of which include ensuring sufficient water availability across a property and location of livestock. Despite significant investment in development, currently available solutions are not necessarily mature or robust enough for full commercial deployment as stands.

There remains a clear need for ongoing technical support of solutions once deployed across a farm. This requirement complicates traditional IoT business models and introduces a requirement for ongoing annual fees to support this desire.

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1. Background

Telecommunications coverage remains a challenge across Australian agriculture from both a coverage and price perspective.

In 2016, the Commonwealth Department of Agriculture and Water Resources funded a Rural R&D for Profit research project, Accelerating precision agriculture to decision agriculture project (P2D). The project was led by the Cotton Research and Development Corporation (CRDC). One of the key findings of the project found that:

> *"A lack of access to mobile and internet **telecommunications infrastructure is a major impediment to the adoption of digital agriculture systems**. 55% of producers reported that they relied on the mobile phone network for internet, yet 43% had patchy or no mobile reception across their property."*

Automation and data collection efficiencies being introduced through sensors has had limited impact pre-farm gate due to these communication network issues.

P2D found that a total potential of $2.2B worth of GVP improvement could be realised from automation and labour savings in the red-meat production sector, a large proportion of which is dependent on improvement of telecommunications services to underpin adoption of new technologies generally grouped together as Internet-of-things (IoT) technologies. Telecommunication service requirements for IoT sensors to underpin productivity improvements are quite separate, and far cheaper, than those required for other more data intensive applications.

This project seeks to understand the tangible value of LoRaWAN IoT solutions in livestock farming systems, the most appropriate business model through which to extend that network connectivity and associated pricing sensitivities to solve these fundamental impediments to technological adoption on farm. The LoRaWAN® specification is a Low Power, Wide Area (LPWA) networking protocol designed to wirelessly connect battery operated 'things' to the internet in regional, national or global networks, and targets key Internet of Things (IoT) requirements such as bi-directional communication, end-to-end security, mobility and localization services.

2. Project objectives

2.1. Purpose and description

Telecommunications coverage remains a challenge across Australian agriculture from both a coverage and price perspective. Automation and data collection efficiencies being introduced through sensors has had limited impact pre-farm gate due to these communication network issues. In an attempt to "plug the gap", current sensor providers include capital costs for network installation and management as part of their solution, rendering the price point too high for most applications.

This project is focused on solving a key bottleneck which relates to enabling a reliable, fit for purpose, low cost solution for in-situ sensor deployment and data creation. A dedicated low bandwidth data network with appropriate coverage and a low connectivity price point could fundamentally underpin productivity and efficiency gains across the industry by reducing costs to access sensors and their associated automatic procedures. This assertion is supported by the NSW DPI LoRaWAN (Long Range Wide-Area Network) Farm Decision Technologies (FDT) project whose findings have shown IoT data and automation have significantly reduced operating costs and increased efficiencies in initial trials.

2.1.1. Objectives

This project seeks to establish 8 demonstration properties across different livestock enterprise types to install LoRaWAN (Long Range Wide-Area Network) network coverage, different LoRaWAN enabled sensors and undertake a pricing sensitivity assessment in order to assess appropriate business models through which to deliver connectivity options.

These initial demonstration sites will include a range of production systems and geographies in order to test the robustness and applicability in a range of Australian red meat production segments. This will include both improved pasture/high rainfall, “rangeland”/low rainfall and intensive feedlot systems.

3. Methodology

There were a number of crucial steps involved with the execution of this project including identification of participating farmers, planning for the network rollout, network and sensor installation, network and solution performance monitoring, ongoing engagement and support for producers as well as final analysis of value of solutions across the life of the project. The methodology for each of these steps is detailed below.

3.1. Identifying participants

The initial task of identifying and negotiating access to 8 demonstration properties representing different livestock enterprise types proved harder than initially expected. Professional and existing commercial relationships were leveraged through the process.

3.2. LoRaWAN network

3.2.1. Planning

The network planning process involved assessment of the topography of each farm to identify the most appropriate location for a LoRaWAN network base station to be installed to provide maximum coverage both spatially and in terms of signal strength.

A 20m digital elevation model of each property was combined with LiDAR imagery showing tree height, density and building dimensions as well as telecommunications coverage maps (3G, 4G and satellite) to create an anticipated coverage map known as an RF plan.

The outcome of the network planning process was a “coverage map”, also known as an RF plan, which shows anticipated coverage of the LoRaWAN network from the identified installation point.

3.2.2. Installation

With the site identified for best network coverage, the next step was to determine the most appropriate design and installation method for each LoRaWAN network base station depending on the structure the base station will be installed upon (ie shed, hill, silo, etc).

General components of a base station include a solar panel, an enclosure with the network hardware and battery array and an external antenna – all up weighing around 70kg.

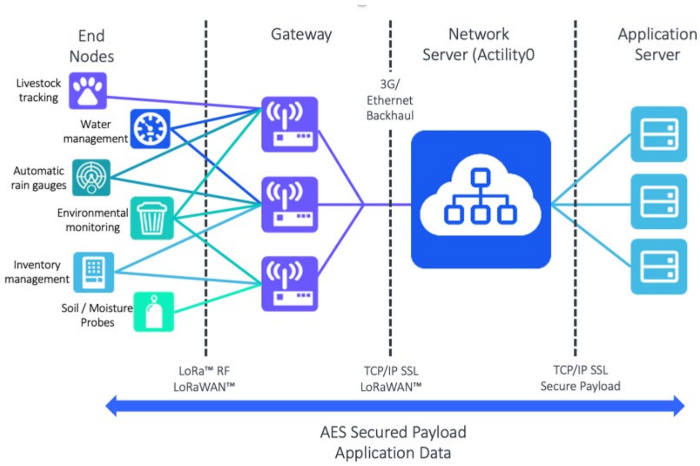
In addition to the general componentry described above, there are a number of site-specific install requirements meaning that each base station installation is as a custom build depending on site specification.

The final step in the process required coordination with each individual farm for installation. Site specific inductions were undertaken including training in WHS & bio-security processes.

3.2.3. Performance Monitoring

Each sensor transmits data using LoRaWAN payloads to listening gateways. The LoRaWAN gateways uses 3G / 4G as the backhaul – the connectivity component to transport data from the gateway to a central server in the cloud. Our central server runs Actility – a telecommunications grade Internet-of-things connectivity management platform for low power wide area networks. A diagrammatic overview of how our LoRaWAN network operates is displayed below.

Image 1: Discovery Ag LoRaWAN architecture



Actility is responsible for monitoring each gateway's availability, also known as up-time performance. It is also responsible for the collation of sensor data transmitted from the gateway and ensuring it gets transmitted through to the relevant user application for use.

Whilst a gateway is "always on", it is not always transmitting data. To ensure that a gateway is "alive" it is programmed to transmit an "pulse" through to Actility every minute. If there are 2 consecutive minutes where a pulse has not been received by Actility, the base station is recognised as being disconnected and alarms are triggered for the Discovery team to investigate.

We are able to run reports on a base station "up-time" over any time period to profile its total availability and performance.

3.3. Sensor Solutions

3.3.1. Solution identification and installation

Given the objective of the project was to ascertain the value of IoT sensors to livestock farming, no pre-determined list of solutions was provided to participants for consideration. Instead, an initial discussion with each farm manager was undertaken to identify base use cases that they believe would add value across their livestock enterprise. Most sensors considered were point of measure sensors – those that exist in an environment to report on the metrics at the point that the sensor was installed. More complex sensor types, including automation products (remote pump management) were not in a sufficiently mature state from any provider for consideration at the start of the project. These solutions became more mature over the 2-year lifecycle of the project.

Solutions were listed by priority for each property. We then determined the number of each type of sensor to be sourced for each solution for each site. All but 3 of the sensor solutions requested by participants focused on management of water across their property in the form of:

- Rain gauges;
- Weather stations;
- Soil moisture monitors;
- Water tank sensors;
- Trough sensors;
- River height / flood alert sensors; and
- Dam monitors.

The 3 solutions that were requested that did not purely focus on water were fuel tank sensors, temperature sensors to monitor for frost events and an asset tracker.
Asset tracking was not a tangible solution at the start of the project but did however become commercially available towards the end with two of these devices being trialled now. Participant appetite for more complex solutions grew during the project to include livestock tracking, oil / water mixture automation for trough and food supplies and irrigation automation.

3.3.2. Performance Monitoring

Each sensor type is programmed to transmit data on a pre-defined time period based on the end-use requirement. A list of reporting timeframes is provided below for the sensor types used across this project:

Table 1: Sensor type data reporting frequency

Sensor type	Reporting frequency (mins)
Air temp & humidity sensor	15
Fuel tank	60
Rain gauge	10 (when raining)
Soil moisture probe	60
Trough monitor	60
Water tank	60
Weather station	10

A single instance of data not being received is not representative of a serious issue. Intelligent programming has been used at the sensor level to transmit data in a way to interpret holes in data transmission. For example, with the rain gauge, a year-to-date accumulation of rain received as well as rain in that period is transmitted. If there has been a dropped packet during the day, we can calculate the missing value.

Prolonged data transmission issues are however significant and need to be resolved, be it due to sensor hardware issues or weak network connectivity at the sensor location.

Each morning an internal report is run to assess the previous day’s sensor performance to alert us to any issues that have been experienced that need rectifying.

3.4. Producer Engagement and Support

No predefined schedule or process for engagement and support of participants was stipulated from the outset of the project. Targeted discussions were had between the Discovery Field Team and Participants when either a technical issue arose or when Participants indicated interest in exploring additional sensor solutions.

3.5. Final Analysis

An end of project survey was provided to all participating farmers to assess value realised from the project. Feedback was also sought on preferred business and pricing models for network and IoT solutions in general discussion as well.

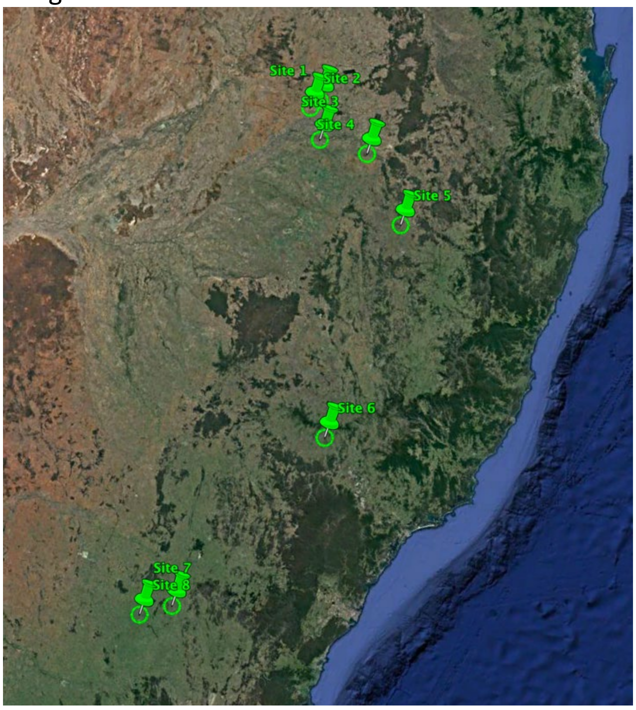
The sample size of 8 participants was not sufficient enough to undertake a full pricing analysis. Additional data has therefore been garnered from other Discovery Ag commercial business transactions to underpin conclusions on pricing and business models for this project.

4. Results

4.1. Network

The 8 participating farms in the project were finalised by the end of July 2018 and were spread across New South Wales and Queensland as follows:

Image 2: Site locations.



After some initial delays in sourcing network componentry, all gateways were installed successfully in the back end of 2018. The installation process extended between mid-August and the end of October 2018.

A photo of the network gateway installation at Site 7 and a separate installation at Site 3 are shown below to demonstrate the differences in physical design and installation.

Site 7 was a ground mount install – the location was chosen as it was one of the highest points on the property. By contrast, the Site 3 installation was installed on the top of a grain elevator to gain as much elevation as possible, providing far stronger signal coverage than a ground mount could have achieved.

Image 3: Site 7 gateway installation

Image 4: Site 3 gateway installation

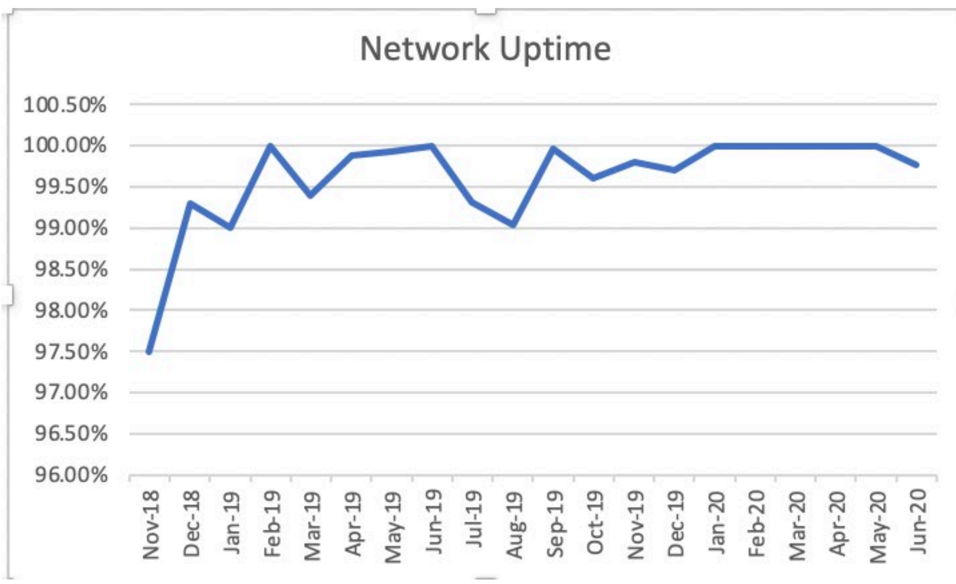
Given distance between properties, detail of all RF plans on a single map view was lost. An example of one of the RF plans for Site 3 has been shown as an example. RF Plans for all sites were contained in Milestone Report 1.

Image 5: Site 3 network RF plan

Whilst there were a few technical issues with gateway operation immediately post installation, specifically at Sites 6 and 7, the network of 8 gateways operated relatively seamlessly throughout the life of the project, with limited servicing from our field technicians.

Analysis across the 20-months of operation of the project shows that the network operated on average at 99.61% availability as shown in the graph below. This is a highly successful result given that network infrastructure had been deployed utilising battery and solar panels as power sources and relied on high-gain antennas accessing the 3G / 4G telecommunications network as backhaul.

Chart 1: Total network performance over full project life



4.2. Sensor solutions

Overall the sensors that were deployed performed quite well, albeit with a few teething issues along the way. There was one clear device that had continual issues – the trough sensor and specifically the variant which measured the level of troughs.

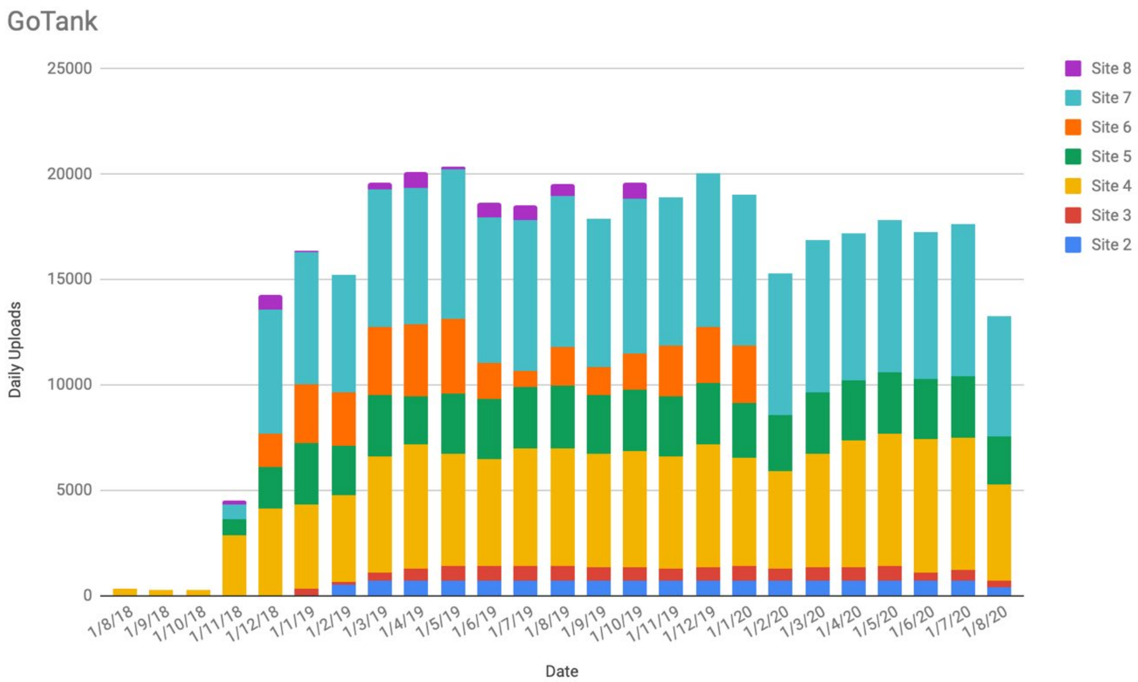
The following subsections provide monthly reporting statistics of devices deployed on each property. A larger number of reports per month for one property is an indication of more than one device being installed.

4.2.1. Tanks

Tank installations generally performed consistently across all deployments. There were some initial teething issues with those installed at Site 7 largely created by topography impacting network signal strength in lower points on the property.

Feedback from participants showed that this was seen as one of the most valuable of all deployed solutions in the project.

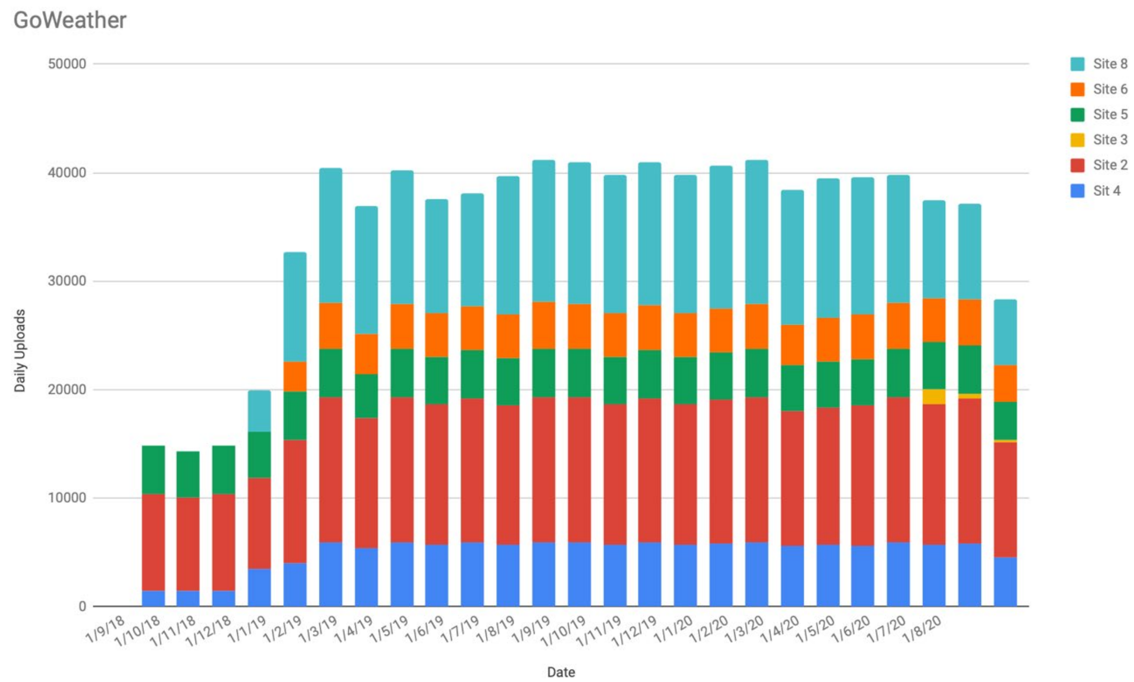
Chart 2: Tank sensor performance across all sites



4.2.2. Weather Stations

At a statistics level, the weather stations used during the course of the project were the most reliable devices deployed. Site 3 pursued installation of a new station in August of this year which is represented in Orange below.

Chart 3: Weather station performance across all sites

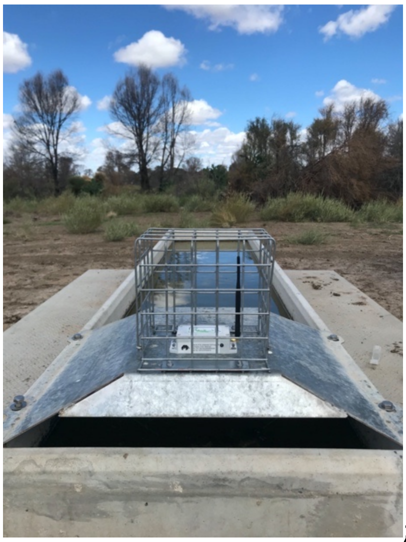


4.2.3. Troughs

Two alternate designs were configured at the Discovery warehouse at the request of participants after an alternative supplier could not be sourced:

i) An ultrasonic device positioned over the trough to detect the presence and height of water in a trough (level trough sensor)

Image 6: Ultrasonic trough level sensor at Site 7



; and

a. A flow device installed into the feeder pipe to the trough which monitored the water flow into the device.

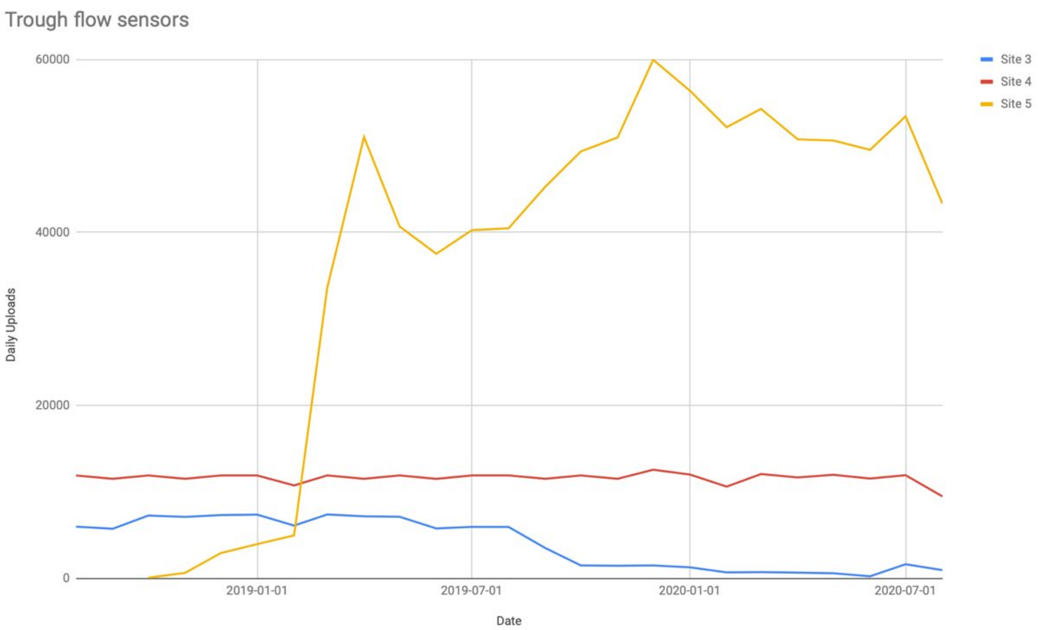
Image 7: Flow trough sensors deployed at Site 5

Whilst the flow devices performed seamlessly and have been rated highly by their respective farm managers, the trough level sensors were undoubtedly the most problematic devices deployed during the course of this project. Continued research did not result in a more robust design or an alternative device from another supplier.

4.2.3.1. Trough flow sensors

The Flow trough sensors proved to be highly useful – particularly to Site 5 who are looking to use the devices as part of the automation of nutrient delivery to their livestock through water. The positioning of the device in the supply line rather than in the paddock provided a level of protection for the device, ensuring they were not interfered with by any beast.

Chart 4: Trough flow sensor performance



4.2.3.2. Trough level sensors

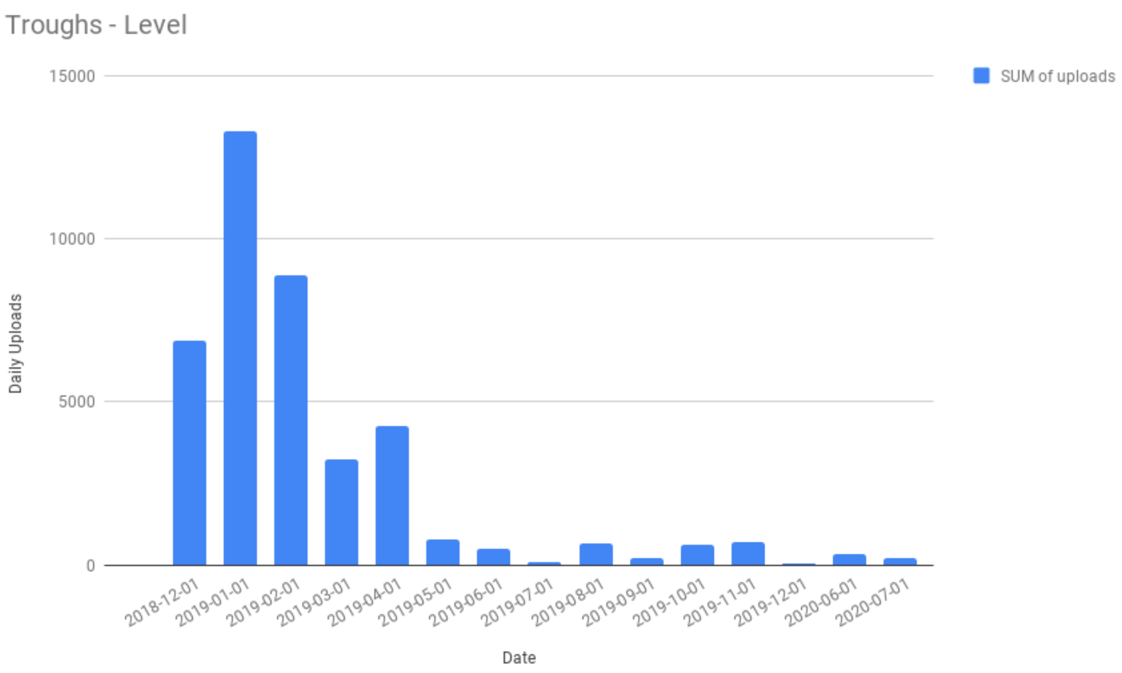
As stated earlier, the Trough level sensor was the most problematic device deployed in the project.

Issues incurred included:

- Installation over the top of the trough brought the sensors within range of livestock. Suitable encasing and installation could not be determined to prevent damage or interference with operations of the device;
- A singular design of this sensor would not suit all of the varying shapes and sizes of troughs across the different properties, thereby proving problematic for a standardised design;
- Sensitivity of the ultrasonic sensor itself was not suited to the distance from water measurement which introduced errors. A higher calibre sensor would have increased the cost of each unit too significantly to consider deployment at a trough; and
- Interference of both the concrete casing of troughs and water with the LoRaWAN signal strength meant that readings were often dropped. This meant the device continually reported information awaiting a confirmation of receipt, resulting in fast drainage of the batteries, impacting reliability and shelf life of the devices.

The reporting statistics below shows the continual decline in performance of the trough level sensor devices, despite a number of in-field visits for servicing of the devices.

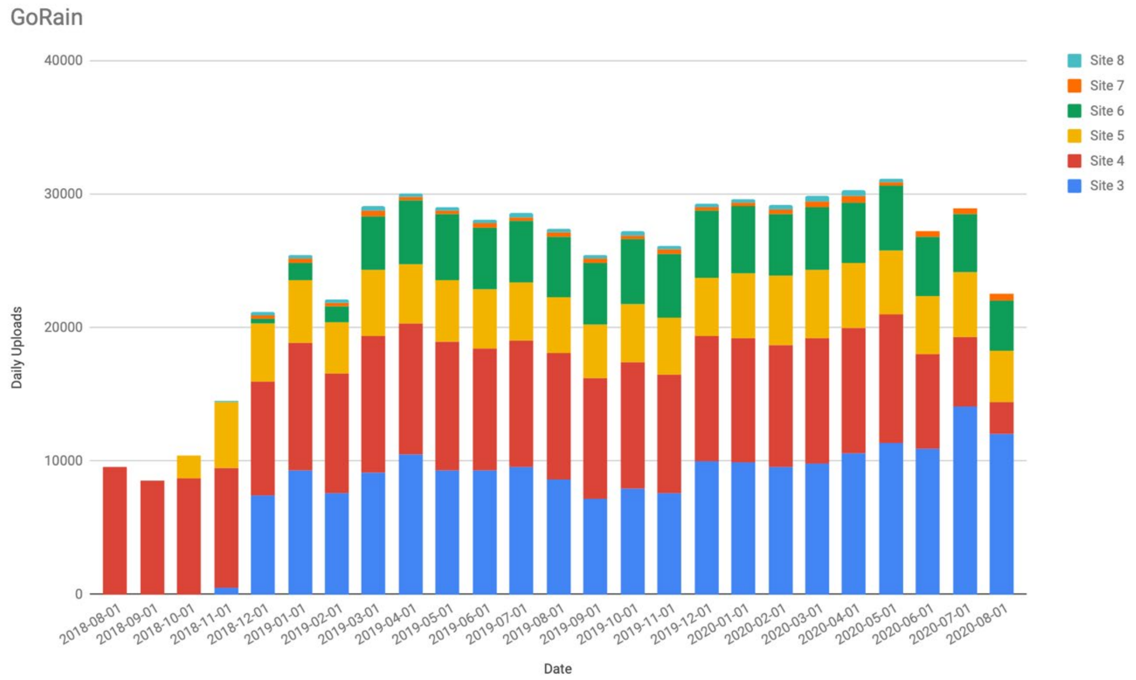
Chart 5: Trough level sensor performance



4.2.4. Rain Gauges

The rain gauges deployed were extremely reliable with very few services required during the project. Further value could be delivered to end users if the data was used to feed pasture growth models or directly into farm management software, removing further data entry duplication efforts of customers – an avenue which may be explored in the coming months.

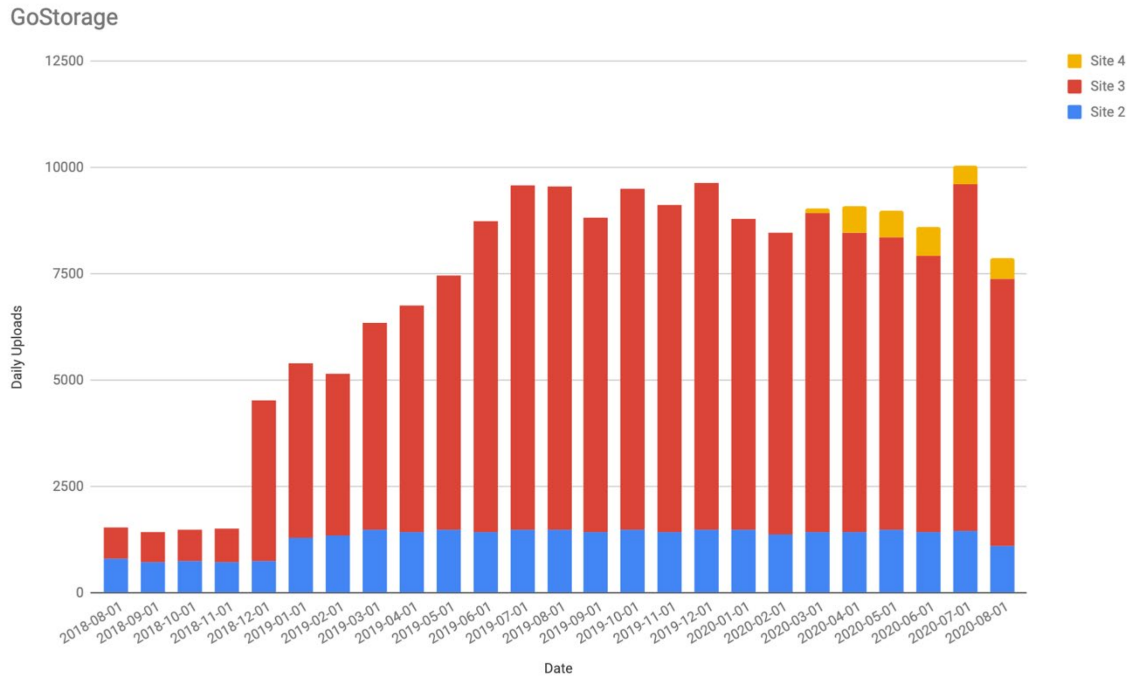
Chart 6: Rain gauge sensor performance



4.2.5. Storage Monitors

Storage monitors installed across the 3 properties were extremely reliable as well, however the value that these devices provided for livestock management is questionable.

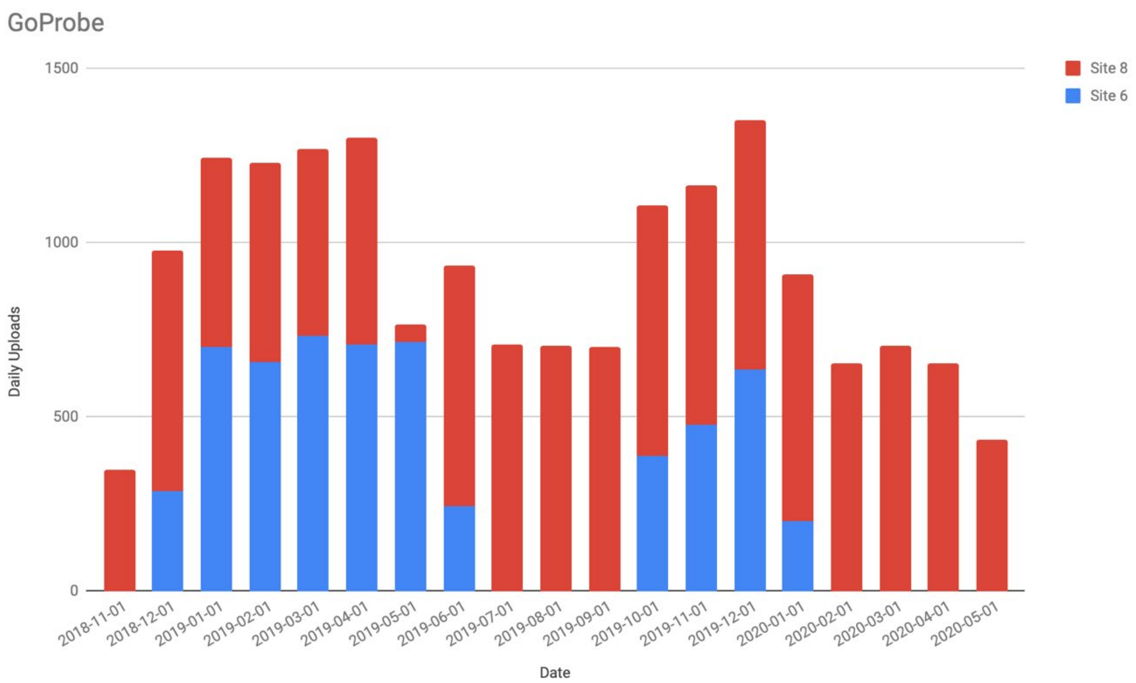
Chart 7: Storage monitor performance



4.2.6. Soil Moisture Probes

The two soil moisture probes deployed as part of the project fared well once fencing was installed to protect the devices – livestock impact was the reason for the decline in performance of the Site 6 device in quarter 3 2019.

Chart 8: Soil moisture probe performance



4.3. Grower Survey

The final grower survey was sent around to participants at the start of June 2020. Four participants answered within the first week. One participant answered the questionnaire by phone and an additional participant answered the questionnaire manually at the start of August. Despite multiple discussions, the final two participants never provided feedback.

Full survey responses have been provided as separate attachments to this final report.

Overall there were a few consistent points of feedback:

- Preparedness for individual farming businesses to pay for the installation of farm specific connectivity networks
- Desire to purchase sensor solutions directly from the provider rather than through a 3rd party. We believe that this desire is closely linked to the requirement for a high level of support in an operational environment.
- There was a level of frustration in the level of support offered through the project
- Acceptance that sensor technology was not as mature as the businesses would have liked
- Preference for upfront purchase of devices/solutions rather than a Software as a service (SaaS) model

- Solutions that are perceived as being the most desirable being water tank monitors, trough water detection solutions and livestock tracking.

5. Discussion

The discussion below on each component of the project will be framed in light of suitability of the technology for the livestock industry as well as factors impacting business model and pricing approaches.

5.1. Network

Whilst the overall operation of the network was satisfactory, it must be remembered that these were property specific installations. In other words, a general network rollout approach was not adopted, and therefore the site for network installation could be selected to provide the best coverage of each property individually.

Regardless, a single gateway failed to provide full property coverage in at least three instances. This was caused by topography of the landscape for two properties with the limited coverage being attributable to size of the property in the third instance. An additional gateway was installed for this participant to provide broader coverage in the later parts of the project.

Installation of a single gateway costs just under $5,000 + GST. If 2 or more gateways are required to provide more contiguous coverage for a property, the up-front investment becomes a barrier to entry for most livestock producers.

The final questionnaire shows that over half of respondents indicated a willingness to pay up to $5,000 on average to realise property specific connectivity. Indeed, all applicants had previously invested in alternate forms of connectivity in an attempt to satisfy this fundamental need.

At the start of this project, the alternative to property specific installation was a more typical network rollout, akin to a telecommunications network, where general infrastructure is installed across a region to provide multiple industries and clients coverage.

This type of rollout however is imperfect and can be significantly impacted by topography and landscape size. An example of this is the Telstra 3G network which theoretically has sufficient infrastructure to provide coverage to most production areas in the footprint contemplated by this project. The operating reality however is vastly different as highlighted by survey responses showing the majority of participants have limited connectivity anywhere on their properties.

Better coverage is realised through densifying infrastructure installations under such an approach, however large numbers of devices need to be connected to warrant that additional investment. The findings of this project are that there are not enough mature IoT devices available for use in the livestock industry alone to warrant consideration of this type of investment.

To overcome issues of terrain and distance, the only foreseeable solution for broad scale telecommunications of any type to be satisfactory need to be underpinned by low-cost satellite. Although not commercially available at conception of this project, these services are now starting to become a reality however still have a number of technical limitations including not always being "on" ie data is not transmitted in real time

It should be remembered that we focused on LoRaWAN connectivity, which only represents a part of the IoT spectrum (ie there are devices that connect to other IoT protocols). There are indeed other IoT solutions available in the marketplace, however these work on either an alternate IoT protocols, or a different variant of LoRaWAN incompatible with the standard that was deployed in this project.

The standard that was adopted in the project was 923Mhz – the LoRaWAN standard for the Asia / Pacific region. A different standard is adopted in each of the different territories of the world – as an example, the US utilises 915MHz. Any 915 LoRaWAN device will not work on the 923 network utilised here.

This intricacy of differing IoT standards introduces a significant level of complexity to assessment and adoption of solutions. It introduces a very significant barrier to entry for most producers who are often time poor or lack the technical skillset to determine what solutions will work with each different network type.

The challenge remains that whilst individual farmers may benefit from network and solution access, the investment required for either site specific or broad scale IoT telecommunications infrastructure may far exceed these individual benefits. Buy-in from parallel industries would be necessary in order to underpin a satisfactory business case for investment.

5.2. Sensor Solutions

Success of each solution from both an ROI and a pure ability to operate in a livestock environment varied across the suite.

A livestock paddock is a harsh environment to be deployed in, and ensuring the solutions are ruggedised enough to interface directly with live animals is a very different operating environment for such technologies and proved challenging for some solutions – particularly trough sensors.

Value realised from solutions was often attributed to devices that automated otherwise manual routines on the farm – checking tank water availability and rain received. In other words, the value realised came from improved efficiencies which are hard to measure in dollar terms.

The sensor solution that provided the highest level of value without question across all participants was the tank sensor. Whilst all had a desire to utilise trough sensors, the reliability issues experienced with trough level sensors did not instil confidence in participants, who all agreed at the end of the project that they were all relatively happy to use a tank sensor on the head tank as a surrogate for trough water presence sensing.

Both devices used to measure the rain and weather were highly appreciated by those who used them, however a higher level of integration with their software packages was needed to drive full value from the products. As an example - development and use of the heat load index for 2 of the participants during the project was highly appreciated and has become a fundamental indicator for their businesses. Overall however, it is clear that the maturity of fit-for-purpose devices on offer to the livestock industry is somewhat lacking.

Without question, the one sensor solution that all participants wanted was an IoT livestock ear tag. Their end use varied for each of the participants with some wanting to track their bulls only for security purposes, some wanting to track individual members of each herd and align it with medical treatment histories and some wanting to look at temperature and other vital information for breeding purposes. Regardless, availability of trial ear tags would see at least 6 of the 8 participants re-engage to provide feedback in the future.

5.3. Participant Feedback

Based on our observations, the feedback was inconsistent and – at times – contradictory, particularly in light of some of the general discussion feedback received in the second half of the project. In a general sense, a number of themes emerged, including –

- All participants appeared content with paying the infrastructure costs for connectivity across their farm in order to access technologies that provided value. The ongoing operating costs for these networks was not tackled in the questionnaire as these costs were assumed to be included in the ongoing solution fees.
- There were concerns about the performance of some devices, particularly trough sensors. We share the respondents view on this issue and well prior to this survey, we had already taken the decision to withdraw these devices from our range.
- There were some respondents who were less than happy with our ongoing servicing of devices. This was largely related to connectivity and hardware related issues in the early stages of the project. We spent considerable time on farm working through resolution, ultimately discovering that one of the key components supplied to us had a terminal software 'bug'. At considerable expense, we returned over 300 of these units and replaced with a more mature and reliable solution; but we accept and understand those initial frustrations.
- Perhaps not surprisingly, with regard to pricing models, there are various views on how ongoing charges are considered. Some respondents would prefer an upfront, once only transaction. Whilst this sounds reasonable in theory, it is commercially impractical when one considers the varying 'lifespan' expectations, the unknown future costs of communication and data storage/ management, hardware & platform enhancements and the ongoing support costs of the devices themselves amongst others. In both this project, and across our business more generally, we find that the overwhelming majority of users understand the requirement for an ongoing annual fee. Our goal is to both minimise that cost and maximise the value we deliver.

6. Value / Business Model

The project was structured so that participants contributed 40% of the overall cost of the project. This was to remove any potential barrier to entry in the project based on up-front pricing.

Engagement of an external economist to perform an independent analysis was included as part of the initial project brief. Upon discussion with two external consultants, it was determined that there was insufficient data to perform a technical analysis and that broad observations from aligned responses was the most appropriate path forward.

Feedback from participants consistently showed a willingness to invest up to $5,000 to deploy telecommunications infrastructure on their properties to realise any benefits from IoT devices.

Participants were also relatively consistent in their desire to pay for devices up-front rather than on a subscription basis. Whilst this appears reasonable, it is in contrast to the clear expectation that IoT providers will provide a high level of hands-on support for their solutions during both the installation and operation phase which in itself is quite a considerable expense given the spatial spread of properties each IoT business has the potential of needing to service.

Feedback from participants at the end of the project around the level of support offered was particularly negative. Whilst a number of site visits was provided to undertake installation and troubleshoot devices when issues were incurred, particularly during the early stages of the project, responsiveness clearly was not immediate enough. This feedback is a significant consideration on the business model to be adopted by any IoT solutions provider into the livestock industry. By and large, IoT devices are meant to be priced at a very low point to drive ubiquity of uptake. The low price point stands in contrast with the requirement to provide full, and immediate support on farm to troubleshoot technical issues which in turn increases operating costs in the adoption of this business model. If this expectation is to be satisfied, then annual charges for IoT solution use must become a consideration.

One potential resolution to the ongoing requirement for support is for IoT providers to work through typical distribution channels in the livestock industry. Our experience has shown however that more often than not these channels are happy to sell solutions, but do not have the bandwidth, nor the technical skillset to provide support as required.

7. Conclusions/recommendations

Overall the project highlighted a number of compounding issues preventing the full realisation of the espoused benefits that digital devices are meant to bring to the livestock industry. These issues are not limited to one part of the digital supply chain.

Despite the speed at which technological solutions on farm are being developed, it is clear that connectivity, complexity of the solution vs the operating environment and pricing aspects that this project sought to understand remain impediments to broader value realisation and adoption of IoT in the livestock industry.

At a network level, it is clear that there remains insufficient adoption of IoT sensor solutions to justify investment in a broad scale telecommunications network. This may change as sensor solutions mature however one would argue that investment in the infrastructure is a fundamental requirement to lower the barrier to entry and drive uptake.

In contrast, whilst producers have an appetite to pay for farm specific installation of network infrastructure, the undulating topography typical of livestock production areas prove to be an impediment to providing full farm coverage from a single infrastructure installation. The result of this is increased hardware costs, driving network pricing above what appears to be the nominated threshold of $5,000 per farm. That being said, the option of producers paying for connectivity remains the most appropriate path forward in lieu of more generally available networks satisfying the connectivity requirement.

Pleasingly, the more recent commercialisation of number of low-cost satellite connectivity solutions will grow to satisfy connectivity requirements however much like the sensor solutions themselves, this technology is immature, and far from resolving the issue as stands today.

Producers have a clear appetite to increase efficiencies within their business and move toward the use of sensors and automation for some of their time consuming and less technical tasks including water point monitoring and livestock tracking. Whilst a significant amount of investment is being made in these solutions, their robustness needs to become a focus to ensure reliability and longevity in the paddock. There is somewhat of a gulf between the maturity of devices on offer in the sensor market today versus producer expectations.

There remains a clear need for ongoing support for solutions once they are deployed on farm which comes at a cost. Whilst there is benefit in an up-front pricing model of IoT solutions to both the producer and the IoT provider, we do not believe there is any alternative to having an annual fee included in addition to the initial price to support these ongoing costs in order to satisfy producers requirement for full service support in the paddock.

Certainly, the resounding feedback from providers through the course of the project is that they see the highest level of value from IoT in the ability to remotely monitor water supply points across their farm, as well as near-real time tracking of their livestock.

8. Key Messages

In conclusion, the following points are the key take-away messages from the project:

- Site specific LoRaWAN network connectivity proved to be sufficiently reliable to support deployment of any IoT sensor solution, however topography did impact total available coverage from a single gateway installation;
- Producers have an appetite to pay up to $5,000 for farm specific connectivity if the attached solutions provide value;
- Solution providers should be weighted to an up-front model, with a small annual recurring fee to provide the close level of support expected by livestock producers;
- The three key solutions that producers see as driving efficiencies and benefit on their farms are:
    - Water trough sensing solutions
    - Water tank monitoring solutions
    - Livestock tracking solutions
- Solution provider's business models should factor in a high level of both in person and technical support for their client base; and
- Post installation, solutions need to be robust and protected enough to withstand both interactions with livestock and the extreme climate conditions experienced across seasons in rural and remote Australia.

9. References

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2. New South Wales Department of Primary Industries (July, 2017) *Collaboration takes big data on-farm* 1st September 2020 https://www.dpi.nsw.gov.au/about-us/media-centre/releases/2017/collaboration-takes-big-data-on-farm