final report

Project code: B.GBP.0041

Prepared by: Bryce Leedham and Brendan Siebert
GHD Digital

Date published: 19 August 2019

PUBLISHED BY
Meat and Livestock Australia Limited
Locked Bag 1961
NORTH SYDNEY NSW 2059

Options for improving telecommunications across northern Australia for a connected beef industry

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

Executive summary

The purpose of this report was to review and assess the suitability of available and emerging technology options that could provide connectivity to the beef industry across northern Australia.

The infrastructure costs in providing communications to emerging AgTech devices are seen as prohibitive due to the extent of infrastructure to cover the size of properties across northern Australia. In one example, a property-wide Wi-Fi network would involve 30-40 new towers and a cost in the order of $500,000 in order to provide access to data services across the property, a cost that would not be incurred by a beef business which lies within 4G mobile carrier coverage range. For many property owners, it is difficult to justify the business case with a lack of proven returns on new technology across the scale of property size they operate.

While property owners and managers demonstrate a sound general awareness and appreciation of the advantages offered by new technologies, the return on investment is largely unproven. This is particularly true for expansive, remote properties requiring large numbers of base stations or repeaters, and with satellite communications as the link out of the property; case studies are few and far between. Producers surveyed for this report indicated that they are looking for clear evidence of profitability prior to committing significant capital funds in building the necessary communications infrastructure.

While properties remain with only NBN satellite as a commercially viable form of backhaul of data, it will remain difficult to implement large data-hungry applications on the property. There is no ‘obvious answer’ that will provide improved performance at a commercially attractive price. The value of data collection and ability to utilise the data for effective and improved decision making will drive the investment appetite for telecommunications across the property, a proposition to be considered on a case by case basis.

Future technologies within a three year window promise significant improvement but remain unproven at the present time, such as SpaceX’s global satellite Internet offering. Existing technologies will see small incremental improvements within that timeframe. For properties currently optimising their data availability given the options available to them, a wait and see approach is recommended with regards to emerging technologies that may provide better options. Incremental improvements in NBN Sky Muster and 4G cellular plans may provide a useful stop-gap in the interim for the extension of beef operations across northern Australia.

The following table provides a summary of GHD findings of the most available options against the key areas within the review. Flag ratings are used to indicate whether we consider the option to be either:

- acceptable;
- somewhat questionable, ambitious or lacking in detail relating to cost;
- extremely questionable based on current cost.

Technology Option	Technology Indicative Cost Range	Suitability to Northern Australia	Rating
Build (with per hectare cost)			
Private LTE Network	$70.00	Whilst providing the best connectivity options covering all requirements, this option is cost prohibitive.	
Install a privately owned 4GX-lite Tower	$25.00	Whilst on a $ / Ha basis this seems competitive providing the best connectivity options, this up front capital cost is considered prohibitive and requires ongoing maintenance. If Mobile Black Spot Program can continue this option may have future merit on a smaller scale	
Wireless Mesh	$20.00	Wi-Fi's limited coverage range requires many devices to cover complete property. Requires large number of poles / towers to support the mesh antennas. Limited backhaul connection options may constrain Internet Wi-Fi network capabilities.	
Digital Mobile Radio	$4.50	Largely for voice / text and whilst acceptable on a $ / ha basis does not address data transfer.	
LoRaWAN	$0.75	Data only (i.e. existing voice comms to be maintained) and requires up front purchase of end devices (sensors). Requires build of gateway devices to collect sensor data.	
Subscribe (with annual cost)			
NarrowBand-IoT	$1,200 per gateway $60 per sensor	Data only (i.e. existing voice comms to be maintained) and requires up front purchase of end devices (sensors). Lack of network availability in remote regions (largely follows 4G network with extended range).	
NBN SM+ Satellite subscription	$2,160	Available at all locations, service is improving over time. Performance is reasonable in terms of data caps and transmission speeds.	
4G mobile network subscription	$960	Best performing option, but limited footprint of coverage in the remote areas in question.	

Table of contents

Acknowledgement

GHD wishes to thank the following industry stakeholders for their time and thoughts with regards to the current and future state of connectivity across Northern Australia; Australian Agricultural Company, Hewitt Cattle Australia Pty Ltd, MDH Pty Ltd, The North Australian Pastoral Company, Paraway Pastoral Company and Australian Country Choice Holdings Pty Ltd.

1 Background

1.1 Purpose

The purpose of this report was to review, assess the suitability of, and guide the selection of currently available and emerging technology options that could provide connectivity to the beef industry across Northern Australia.

Specifically, the aims of the project were to:

1. Identify the connectivity needs of northern pastoral operations including working staff, actual or desired surveillance and management tools relating to paddocks, yards, employee and contractor safety, business as well as the private needs of resident families (homesteads/camps) including educational and social needs.
2. Survey current and emerging terrestrial and satellite connectivity options (internal and external). Assess the potential feasibility of each in the context of northern pastoral operations factoring in such issues like reliable speed, latency and owner/user complexity.
3. Identify and communicate the range of connectivity solutions available to northern pastoral operations which maximise Internet and phone connectivity within and between operational segments in regional and remote locations. Recommend methodologies to measure and evaluate services. Provide indicative cost bands of the recommended solutions (hardware, operational costs and ongoing subscriptions) and a listing of potential vendors. Give examples or cases studies of connected farms including needs, solutions and performance.
4. Provide recommendations to MLA on next steps in facilitating improvements in connectivity for northern pastoral operations.

1.2 Methodology

The market and current state understanding was developed through a comprehensive desktop search to find and assess the various options for connectivity available to northern Australian regions. A number of sites, located within four hours from Mount Isa across the Queensland – Northern Territory border were visited, with current infrastructure sighted and discussions held with station managers to understand the challenges they faced.

Similar technologies have been grouped and evaluated together to highlight the strengths and weaknesses, and relative cost differences between them.

The project has also considered options around funding and improvements to service availability.

1.3 Assumptions

Typical price ranges listed in this report are accurate as at July 2019.

The list of vendors for different technology solutions are indicative suggestions only. GHD has not validated or tested the claims made by vendors regarding the performance and cost of their products, nor expressly recommend them over alternative vendors not listed in the report.

2 The role of connectivity in key production operations

While there are many factors contributing to a successful livestock operation, it was identified during the consultation with various property managers and owners that there are four key areas which if not addressed, have the potential to halt operations.

These key components are:

1. *People* – The business has a duty of care to its staff, and providing sufficient amenities to attract talented staff involves the provision of personal telecommunications facilities. Key amenities include access to training, education, health and medical services in addition to personal Internet consumption.
2. *Environment* – Care for the land is paramount to providing the food and water to maintain the desired quantity of livestock year on year.
3. *Production* – Control and understanding of the key parameters and inputs to healthy cattle and maintaining the highest standards of animal welfare can provide efficiencies in delivery through early identification of concerns from birth to sale.
4. *Profit* – The collection and analysis of production and environment data allows for smarter decision making and increased profits through optimisation of sale prices or reduction in expenses.

Table 1 considers some of the key business case drivers for improvements in telecommunications to and around the property relating to the above core business success factors, for which improved connectivity allows for the implementation of technology solutions.

Table 1 Summary of Technology and Connectivity Enabled Strategic Drivers

People	**Environment**
HSE Duty of Care	Condition monitoring of land
Safety through location services	Improved decisions through analytics
Talent acquisition with progressive facilities	Sustainable and ethical production practices
Staff retention through social amenity	Water usage monitoring and control
Production	**Profit**
Whole of Life data capture for cattle	Maximising cattle sale prices
Pregnancy management	Minimising people and equipment costs
(e)NVD and supply chain improvement	Improving reporting requirements
Virtual fencing and cattle segregation	Smarter production through data analysis

Telecommunications and connectivity provide the base on which technologies and ecosystems to address the above applications (and others) are installed; playing the role of the enabler of improvements to productions operations and on-property life.

Whilst the remote locations experienced by northern properties provide a challenge, this should not stop opportunities from being explored that are readily available in the southern production zones.

3 Key factors in determining a suitable technology mix

Unless the property sits within mobile coverage, there is unlikely to be a single technology capable of meeting all connectivity requirements (voice and data). As a result, properties are more likely to consist of several separate or partially integrated connectivity technologies, colloquially known as a 'technology mix'. Many properties surveyed currently operate on a technology mix of NBN satellite and UHF radio.

3.1 Key definitions of telecommunications performance parameters

In order to understand the key concepts used by this document to profile the capabilities of each technology, consider them in the context of a water pumping system:

Table 2 Technology Performance Parameters

Terminology	Water analogy
Bandwidth	The size of the pipe, a larger pipe means greater water flow over a fixed unit of time
Latency	The time taken for water to get from one end of the pipe to the other
Data Cap	The total amount of water available in the tank to be pumped
Coverage	The irrigated (physical) area that the pump supplies water to

3.2 The difference between 'backhaul' and 'access' systems

The communications system for the property can be considered as two parts; the 'backhaul', which refers to the connection to the outside world, and 'access', which refers to connections between devices that exist completely within the property boundary.

The backhaul system needs to support the requirements for communications with others outside of the property. Applications using the backhaul data allowance may include Dropbox or other cloud systems, Internet browsing, emails, Wi-Fi calling, video streaming and teleconferencing amongst others.

Typically, the technology of choice for backhaul will be determined by which one can offer the fastest speed (bandwidth) and largest data allowance, of the available options in that area. In rural NT and Queensland however, options are typically restricted to 3G/4G network coverage or satellite technologies.

Communication requirements entirely within the property don't need to use the backhaul bandwidth. For example, UHF systems are self-contained within the site (repeater coverage area). Another such example might be the use of purpose built communications infrastructure to allow data captured on a tablet in the field to be relayed back to the property office in real time. It would only be when this data is uploaded to the cloud or head office that the backhaul is utilised.

It is important when determining the data requirement for each of these networks to understand where the information goes. If you wanted to use video cameras on-site, but only view them from

the property and not from head office, you only need to allow that bandwidth in your access network, not in the backhaul. If these cameras linked to the 'cloud' however, it would utilise the backhaul to transmit from the property to the cloud provider's location.

3.3 The applications determine the minimum telecommunications requirements

The best value and return on investment will be achieved not by the choice of the telecommunications technologies installed, but by installing a communications system appropriate to the various applications, devices and ecosystems that are to be installed. The savings on installing water sensors are realised not in the technology, but in the reduction of manual labour, fuel, vehicle wear and tear, and re-direction of efforts to more valuable tasks. The communications infrastructure is simply an enabler of improvements to core business activities.

These systems allow the collection of data, but the value comes from the use of the data; whether that involves the real-time response to alarm conditions, or longer term trend analysis to feed into business planning activities.

There are various forms of connectivity options available, but the suitability for an application or group of applications will depend on the amount of data required and the frequency of data transmission needed. Small data packages with in-frequent transfer periods, generated by "Internet of Things" (IoT) devices, can be serviced by an LPWAN or satellite communications, for example, however these services are not capable of supporting video streaming in the field.

Table 3 Typical Bandwidth Requirements for Data Types

Data Type	Examples	Typical Bandwidth Requirement
Single data value	Sensors	64 kbps
Email	Outlook, Gmail	0.5 Mbps
Website	General Internet browsing	0.5 Mbps
Audio	Wi-Fi Calling, Skype, Music Streaming	0.5 Mbps
Photos	Instagram, Flickr	2 Mbps
Online Gaming	Xbox Live, Steam games	2 Mbps
Standard Definition Video	Netflix, YouTube	3 Mbps
High Definition Video	Netflix, YouTube	5 Mbps
4K Definition Video	YouTube	12 Mbps

Appendix A lists user cases, with typical data rates and technology types supported, to understand the requirements for different on-property applications.

3.4 Compatibility of end-devices to the network infrastructure

Most applications / devices will only support one or a few communications technologies, so it is important to build a network compatible to the field devices you want to use, or else make use of some form of protocol conversion (such as the Fleet router that converts LoRaWAN to satellite data, discussed later in this document).

For example, if electronic scales only support Wi-Fi as a method of communications, then a Wi-Fi network would need to be installed in that area to support it. Similarly, a property-wide LoRaWAN network will be able to supports IoT sensors but not be able to support CCTV video streaming.

3.5 Understanding the risks of subscriber services against building your own network

The provider business model for these technologies typically fall into two categories: subscription services where the property owner buys access equipment and pays an ongoing monthly / annual fee for the service, or build services where a larger capital cost is incurred but no ongoing fees are charged. It is important to understand the benefits and ramifications of each option.

Table 4 Considerations between Build and Subscription Connectivity Options

Characteristic	Subscription	Build
Capital cost	Low	High
Ongoing cost for service	Monthly / annual fee	Nil
Access to resource	Shared: priority of traffic over others is determined through contract with service provider	Exclusive: only owner's data using the service
Capability	Potentially improvable over life: service provider investment in network may provide additional capabilities over time	Fixed: upgrades require owner investment to equipment
System and facility / repeater maintenance	Responsibility of service provider	Responsibility of property owner

3.6 Allowing for future expansion in capacity and coverage

In choosing the appropriate technology mix, consider (reasonable) future applications that may be implemented on the property, and allow for a system that can handle the requirements of those applications (sized for tomorrow, not today). Particularly for capital cost build networks, it can be difficult and expensive to upgrade retrospectively.

There are multiple ways to calculate current household data requirements. The simplest method is to check the monthly usage statistics through the ISP account / usage dashboard. This serves as a baseline to add data for future requirements. If historic usage statistics are not available then an

average (as published by Telstra in 2019) of 196 GB of personal data per Australian household, based on 2.6 people per household, can be substituted and then adding the total future business data requirements to this figure.

The last five years have shown 40% year-on-year growth of data usage. It is worth considering this when determining an appropriate data cap for the backhaul component.

3.7 Should the infrastructure be fixed or portable?

If the application relates to people, it may be advantageous to develop a system that is portable and travels with the person such as installing a high gain antenna and amplifier on a vehicle, or developing a trailer based solution, rather than trying to cover the entire property with a data-rich network that is rarely utilised.

Consider the following applications; firstly the need to monitor water tank levels, and secondly to provide voice and data communications to mustering camps which are only located in a particular area for a few days.

One solution is to provide a high capacity network across the entire property that provides the data channel for both applications; however it might be cheaper to run satellite connected sensors in fixed locations, and a data rich portable solution for the mustering camp in tandem than building the larger and more capable network, particularly given the large property sizes present in northern Australia.

3.8 Access to data through open protocols

Be wary of proprietary protocols and systems. Open protocols can allow for data to be integrated into dashboards and interactions with other systems.

The aggregation of data may prove useful for fulfilling regulatory (or ESG) reporting requirements; use of field data can improve accuracy of the results and reduce collation time from manual calculations. Open protocols can allow for direct export into Excel sheets or other programs to speed up this process.

4 Assessment of current state of property connectivity

GHD undertook interviews and site visits at a range of northern beef properties to discover and understand the current state of telecommunications at these sites, as well as future desires for operational efficiency through the use of technology. Station managers are increasingly aware of their footprint, social accountability and sustainability and the role that technology has to play.

There is a clear and obvious lack of parity in the types and pricing of telecommunications services available to remote and rural users. Consider the case of basic Internet and voice services; a remote user using NBN's Sky Muster satellite service is paying $165 per month for 300 GB of data, whereas urban and semi-rural users pay half that amount for unlimited data on faster technologies. While it would be unreasonable to expect complete parity in speed and data caps, these users are at an immediate financial disadvantage compared with those within fixed line or 4G mobile service catchment areas.

4.1 Backhaul Connectivity

The properties surveyed are all located over 100 km from the nearest significant size town and as a result were limited to the extent of 4G mobile coverage (in a few cases) and more likely NBN or other satellite services as their only option for backhaul connectivity to and from the property.

In both cases, multiple plans / sets of infrastructure were setup to provide different plans for business and residential use, creating a greater total data pool.

Some sites provided re-transmission of 4G or satellite Internet via mobile boosters or Wi-Fi to staff at the property within the homestead area. When 4G was available, the signal was typically poor on mobiles and required dedicated Yagi antennas and boosters to provide sufficient signal for the end-devices to connect.

In many cases, staff procure their own services (such as further NBN satellite plans) resulting in an array of antennas and satellite dishes around the homestead area.

Telephone services are typically provided by radio links or satellite with a local exchange installed, from which copper wiring was run to the buildings; latency for the satellite backed phone lines was a regularly identified issue (i.e. clear delay noted in response). Voice over Wi-Fi (also known as Wi-Fi Calling) was generally preferred by all operations surveyed if there was sufficient bandwidth available in order to overcome the latency issue.

Respondents regularly reported that they experience downtime in the order of 1-2 weeks across a year on their data backhaul link. Typically this would be deemed unacceptable for a business, but the property owners lack alternative options.

School rooms, where present on properties, were taking advantage of the education port on NBN Sky Muster satellite service to increase data availability.

Case Study: Converting Satellite Backhaul to Wi-Fi Access

In order to provide Internet connectivity to staff at one of the properties visited, a Wi-Fi network was setup within the homestead area through the use of directional and unidirectional antennas to cover the buildings at the property. The backhaul for this system utilises NBN satellite (satellite being the only connectivity option available). Staff at the property are able to purchase data packs on the Wi-Fi network.

Given the limited backhaul bandwidth available, it was reported that congestion at peak times was a concern and speed for each individual utilising the service would drop significantly.

So as to not compromise business data requirements, a separate satellite service was reserved for use by the main office.

4.2 Access Connectivity

The tyranny of distance for on property applications is abundantly clear across northern Australia, as sparse infrastructure spread over long distances impacts any calculation looking at providing site wide coverage. Those interviewed see the need to innovate, and the potential for operational efficiencies, but are not yet convinced of the value given the large costs.

All those interviewed have UHF systems installed with between 2-4 repeaters typically for voice in the field, which would offer in the range of 85-95% coverage.

No one interviewed had data communications infrastructure in the field (unless part of their paddocks were in a cellular coverage area). Any data capture currently being undertaken is limited to tablets with data downloads occurring back at base, or Bluetooth connection to pumps which require driving to the site to connect and collect data.

Some properties used personal safety devices such as In Vehicle Monitoring Systems (IVMS) or emergency beacons (EPIRB) to provide an alternative to UHF in the case of injury or emergency.

Around the homesteads, programs like WhatsApp and Facebook Messenger are being increasingly utilised for broadcast communications to groups of staff through ease of use and accessibility of Wi-Fi data within the homestead area.

Some properties are installing, or have already installed, infrastructure such as scales and pumps with network connectivity capabilities (such as Wi-Fi or Bluetooth), but don’t have the networks to those locations to enable remote operation or data capture.

Case Study: Satellite Device Connectivity

One of the properties visited utilised a small satellite modem (approximately 15 cm x 15 cm) for the transmission of low amounts of data connected to a water dosing system, allowing basic analytics of performance to be available remotely without the need to visually sight the equipment. A solar panel and battery arrangement was also installed to provide power to the modem and other equipment.

4.3 Desired Applications and Technology

Those interviewed were generally aware of key issues and AgTech innovations in the market at a high level and are considering, or in a few cases, trialling and implementing, these technologies where the business case stacks up.

The following is a non-exhaustive summary of the discussed opportunities for technology to positively influence operations.

Table 5 Desired Production Applications

People	
Connectedness	Teleconferencing for meetings between head offices and remote properties and for the running of daily / weekly toolbox meetings.
Health	Critical care and eHealth accessibility is a concern for meeting OHS requirements.
Training and education	Staff training delivered on demand by video Access to higher education studies remotely can be impacted by communications availability (for video tutorials or online examinations)
Social amenity	Younger generations increasingly adapting to technology – for example, use of click and collect facility for grocery shopping. As this becomes more common there will be an incremental increase in data usage associated with these new applications. Social media increasingly used to maintain contact with family and friends.
Environment	
Pasture monitoring	Capturing pasture biomass data to supplement pasture maps (such as those provided by Queensland Government) in order to plan cattle rotations.
Irrigation	Migration towards irrigation systems over current pump / tank / trough arrangements; remote control of the irrigation system is almost a necessity for it to make operational sense. A couple of surveyed properties are commencing the process of installing irrigation piping.
Water control	Installation of sensors for water tanks, troughs, bores and pumps to provide alerts when faults occur, reducing the need for the current quantity of regular runs to the site.
Paddock management	In-field video to allow for inspection of bores, troughs, tanks, fences etc. whether through live feed or scheduled images taken and transmitted. Whether this is best achieved with a connected IPTV camera or drone can depend on the communications network infrastructure available at the remote locations.
Production	
Herd monitoring	Electronic ID tags open up applications such as real time location tracking and health biometrics, providing verification of the highest standard of animal welfare.

Crushside efficiencies	Improve time to process cattle through crushside, collect key data parameters and automation of the administration of treatments such as external parasite sprays. Use of real-time data to improve crushside decisions. Implementation of autodrafting arrangements.
Mustering	Mustering activities (such as initial find and herding of cattle to a centralised area) by drones or use of virtual fencing.
Profit	
Supply chain management	Opportunities to influence the supply chain through whole of cattle life data sets such as prediction of weight at a particular day. Potential for connectivity between paddock books and electronic tags, with real time data provided to head office through cloud based software or feeding into vertically integrated supply chains.
Data mining and predictive analytics	Data mining for trends and patterns to develop and validate future plans.
Remote diagnostics for services	Live video streaming assisting with specialist services, such as showing a mechanic the problem with a vehicle through video feed for problem identification thereby saving on call out fees?

Concerns remain about the suitability of the technology for the harsh environmental conditions including heat, dust, wind and wildlife (such as corellas or eagles damaging equipment), for which trial programs are being monitored to determine the true impact.

5 National Broadband Network

The government owned NBNCo is in the process of rolling out a national fibre based broadband network. The original vision was to provide every premises in Australia a fibre broadband connection point to deliver an ultrahigh-speed, future-proof Internet connection. The project has since changed scope and retains fibre backhaul, but replaces the access network with a multi-technology mix (MTM) network (Figure 1). NBN retains the decision on which technology is offered to the property; usually Sky Muster satellite for remote and rural properties.

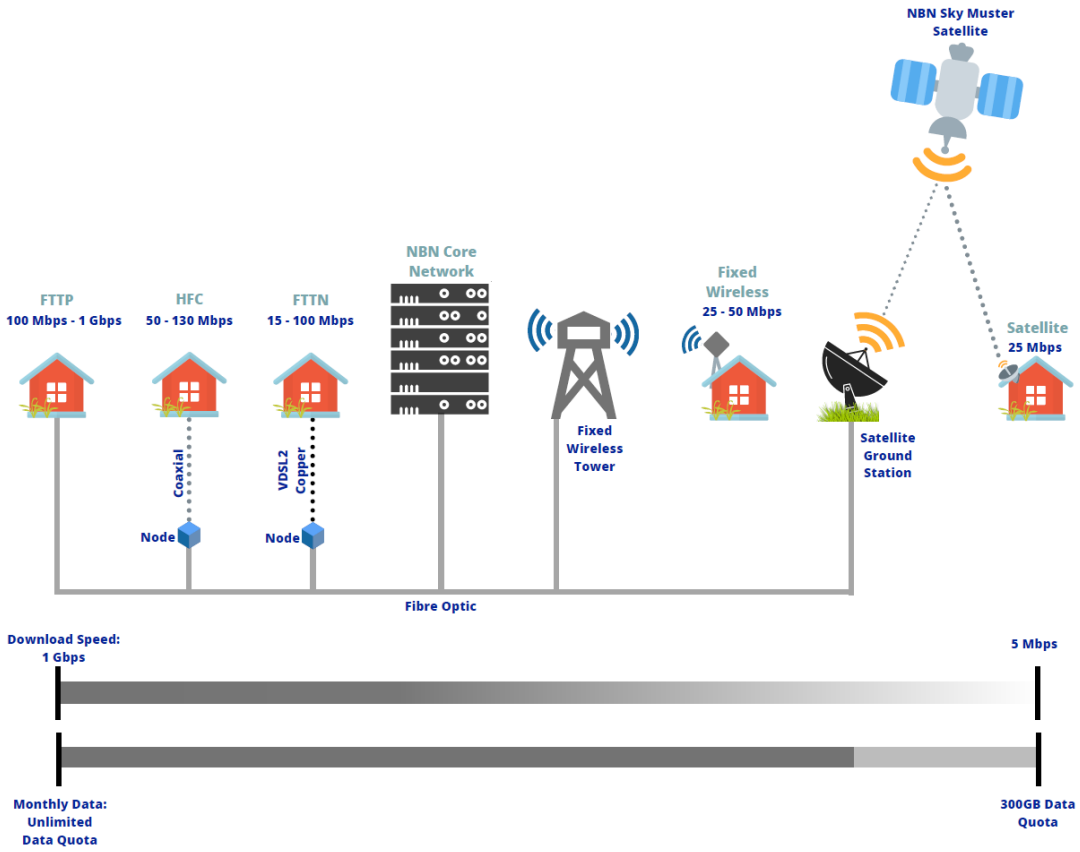

Figure 1 NBN Multi-Technology Mix Network Components

5.1 Comparison of NBN Technologies

Table 6 Comparison of Access Technologies for NBN

Technology	Typical Throughput (DL/UL)	Typical Latency	Typical Data Limit
Fibre-to-the-Premises (FTTP)	100 Mbps / 40 Mbps	10 ms	Unlimited
Fibre-to-the-Node (FTTN)	15 - 100 Mbps / 5 Mbps	25 ms	Unlimited
Hybrid Fibre Coax (HFC)	50 - 130 Mbps / 5 – 40 Mbps	25 ms	Unlimited
Fixed Wireless	25 - 50 Mbps / 1 - 10 Mbps	25 ms	Unlimited
Satellite (Sky Muster)	12 - 25 Mbps / 1 - 5 Mbps	2000 ms	300 GB

As the first three technologies in Table 6 require wired connections which are most likely not available to remote properties, they will not be considered in detail.

Should one of those three technologies be available, they will provide superior performance to any of the other backhaul options listed in this report (except possibly a very strong 4G mobile signal).

5.2 Fibre-To-The-Premises (FTTP)

A fibre optic cable is run from the nearest available common network box/fibre node directly to the user's premises. The fibre cable is connected to an NBN utility box outside the premises, and in turn connects to an NBN connection box installed in the house.

5.3 Fibre-To-The-Node (FTTN)

A FTTN connection is a fibre optic cable run from the nearest local exchange to a central cabinet in a neighbourhood i.e. the node. Each nearby premises is connected to the node using the existing copper landline phone wiring.

5.4 Hybrid Fibre Coax (HFC)

A HFC connection is similar to a FTTN connection in that a fibre runs to a central interconnection point in the area, which then converts the broadband signal to run on top of a Cable TV service delivered through a coaxial cable, which is daisy chained and shared to each home in the area.

5.5 Fixed Wireless

Fixed Wireless NBN utilises transmission towers and line of sight antennas to deliver the connection to homesteads within a maximum radius of 15 km of a fixed wireless tower. The signal from a transmission tower is beamed to an outdoor unit/antenna installed on or adjacent the home, which must have direct line of sight to the wireless tower. Local vegetation, tree density, mountains and other topographical features can prevent a property from achieving sufficiently strong signals.

Fixed wireless is susceptible to contention issues if there are many users on one tower (i.e. fixed pool of bandwidth available to all users of the tower), and unstable connections due to weather conditions such as rain or fog.

Table 7 NBN Fixed Wireless Profile

NBN Fixed Wireless	
Strengths	High data bandwidth and data caps Moderate latency
Weaknesses	Limited coverage area (typically centred around large regional towns) Requires line of sight to NBN tower Subject to atmospheric disturbance (i.e. rain, storms)

NBN Fixed Wireless	
Typical Applications	Internet access (browsing) Voice calls Video, streaming and teleconferencing Business and personal data transfer
Example Providers	Ant Communications Clear Networks Harbour ISP Ipstar SkyMesh Superloop Southern Phone

5.6 Satellite (Sky Muster)

NBN's Sky Muster Satellite service is made up of two geostationary communications satellites operated by NBN Co. The satellite dish at the premises is connected via a cable to a satellite modem installed on a wall inside the premises. This wholesale service is available Australia-wide however has much lower monthly data limits compared to other NBN provided options.

This technology operates over the Ka microwave frequency band, in the 26.5 – 40 GHz spectrum range. Due to this, the signals are more susceptible to rain fade, which is the interruption of wireless communications signals due to water droplets such as rain, mist, fog or snow.

Table 8 NBN Sky Muster Satellite Profile

NBN Sky Muster Satellite	
Strengths	Available anywhere in Australia
Weaknesses	Limited data allowances Moderate speeds High latency
Typical Applications	Internet access (browsing) Video downloads Business and personal data transfer

NBN Sky Muster Satellite	
Example Providers	Activ8me Ant Communications Clear Networks Harbour ISP Ipstar Reachnet SkyMesh

Education Ports / Plans

If a primary or secondary school student resides on the property, then the connection is eligible for an additional 50 GB of data per student per month. An additional port is configured on the NBN router specifically for a connection to student's PC, or student Wi-Fi access point located near their study area. Data usage through the education port is not reflected against the data limits of the main account.

6 Mobile carriers

Mobile network operators provide voice and data connectivity coverage using base stations in strategic locations such as towers and hilltops across Australia. Typically, each 4G LTE base station provides high-speed data coverage to an area in a radius of ~35 km of the tower. LTE supports various categories of operation ranging from high-speed – complex and high power consumption radios (such as mobile phones), to low-speed – simple and power efficient radios (such as IoT sensors).

When operating LTE in its most power efficient and lowest speed category (NB-IoT), the coverage range can extend 50+ km from a base station and up to 100 km if suitable external antennas are used at the device.

Table 9 Mobile Carriers Profile

Mobile Carriers	
Strengths	High data bandwidth and data caps Low latency Mobility
Weaknesses	Limited coverage in rural areas No priority to critical data (shared resource)
Typical Applications	Internet access (browsing) Voice calls Video, streaming and teleconferencing Business and personal data transfer
Example Providers	Telstra (greatest coverage) Optus Vodafone

Each provider's website contains indicative coverage maps for their respective networks.

6.1 4G / Long Term Evolution (LTE)

4th Generation / LTE is the latest ratified standard in mobile data communications. 4G LTE systems can provide speeds equivalent to an NBN FTTP connection. This generation of technology has improved data speeds in comparison to 3G networks of up to 150 Mbps for download. This makes it suitable for applications such as mobile web access, high-definition mobile TV, video conferencing and gaming.

In poor conditions and at the fringes of reception coverage, the 4G network may fall back to 3G speeds. Typical download rates on this technology can range from 550 kbps – 20 Mbps, which is appropriate for applications in mobile Internet access, video calls and mobile TV.

Table 10 3G / 4G / LTE Profile

Technology	Typical Throughput (DL/UL)	Typical Latency	Typical Data Limit
4G / LTE	150 Mbps / 50 Mbps	50 ms	10 - 500 GB
3G	0.5 - 20 Mbps / 1 Mbps	250 ms	As above (sold as 4G)

6.2 Narrowband Internet of Things (NB-IoT) / Cat M1

Telstra and Vodafone are providing IoT networks that extends beyond the reach of 4G signal through another LPWAN technology. NB-IoT makes use of narrow-band channels and provides higher sensitivity and longer range at the expense of limited data rates. The coverage profile generally follows that of the associated provider's 4G network, but extends further from the base station than the cellular coverage.

Refer to section 9.1 for Subscriber LPWAN services.

6.3 Mobile Phone Repeaters

Mobile phone repeaters can be installed in buildings or vehicles to increase and amplify the range of the existing mobile phone network (assuming it is located somewhere within the coverage zone). Mobile phone repeaters are a fixed radio communications device with the purpose of wirelessly regenerating or replicating a mobile signal. The repeater amplifies and disperses a mobile signal within a building / area without interfering with the mobile network or other users on the network.

The advantage of these devices is that they help increase the reliability of a service in poor signal areas. If the property homestead area sits on the fringes of mobile reception, the combination of an external, directional antenna and a mobile phone repeater can allow mobile phones in the homestead area to receive a stronger signal (by connecting to the repeater), where they otherwise would lack a powerful enough antenna to receive signal directly from the mobile carrier's tower.

Cel-Fi (currently) produce the only legal repeaters licenced by the Australian Communications and Media Authority (ACMA), the licencing body, and are approved for use on Telstra, Optus and Vodafone mobile networks. Their Cel-Fi Go (mobile) product is suitable for installation in a vehicle to provide a portable repeater / extender option.

For properties with access only to 4G mobile and satellite as backhaul options, the above infrastructure will likely provide the best performance of the available options. Cel-Fi Pro antennas cost in the region of $1,200 each.

6.4 Mobile Satellite Small Cell

The 4GX-lite (i.e. < 6 Mbps download speed) Mobile Satellite Small Cell is a recent solution offered by Telstra and Optus available to those at locations where no mobile coverage exists, which allow people in Australia's most remote areas to purchase their own coverage extension. The solution consists of a base station that utilises a satellite uplink to send data in and out of the area,

supporting applications such as voice, messaging, email, browsing and basic data. The signal coverage can range between 0.5 – 3 km depending on antenna mounting height and terrain.

This solution requires the cost of installation (and ongoing power) to be covered by the customer whereas Telstra / Optus will provide, install and maintain all the necessary small cell equipment. The small cell used in this solution is a small and lower cost version of a standard mobile base station.

By installing a small cell in the homestead area, staff and visitors will be able to access the 4G network on their devices without the need to connect into another service (such as Wi-Fi). The small-cell provides a partial solution to homestead connectivity requirements as it can deliver web, email, and voice, but is not suitable for video streaming applications.

Table 11 Mobile Satellite Small Cell Profile

Mobile Satellite Small Cell	
Strengths	Provides coverage to areas without coverage preciously
Weaknesses	Limited coverage area (typically centred around homestead) Limited speed available, not suitable for video applications Capital expense
Typical Applications	Internet access (browsing) Voice calls Business and personal data transfer
Typical Throughput	6Mbps – 6 Mbps download / upload
Typical Latency	As per satellite backhaul used
Typical Data Limit	As per mobile phone plan
Typical Cost Range	$70,000 installation and equipment fees, ongoing power costs only
Example Providers	Telstra Optus

7 Radio Systems

Radio based communications solutions scale from high bandwidth digital communication links, through to voice only analogue systems with the broad trade-off between data rate against coverage extent. Typically, coverage can be delivered from repeater sites placed in strategic locations around the property. Flat land works against extending coverage range and significant infrastructure requirements to cover these properties such as tall towers or guided masts may be required.

There are many different competing radio standards, protocols and hardware specifications all excelling in different aspects of communication and suitable for different applications. For systems delivering higher data rates, the rate of power consumption is increased. For systems with greater range, data rate scales with complexity (cost) of radio equipment.

7.1 Fixed Wireless / Private Microwave Backhaul Link

Fixed wireless / private microwave connectivity refers to any non-NBN internet provider who operates their own independent wireless ISP network. This option is generally preferable if it is available, due to high or unlimited monthly data allowances and faster available speeds than satellite. However, it can be costly for installation since there may be a need to erect more towers and radios on nearby or adjacent properties to get a connection. Despite higher capital costs, monthly usage costs are much cheaper than satellite. It is possible that during certain bad weather conditions the speed/quality of the link can degrade, but due to adaptive coding and modulation will generally not drop out completely.

Table 12 Private Fixed Wireless and Microwave Profile

Fixed Wireless / Private Microwave	
Strengths	High data bandwidth and monthly data allowances Moderate latency
Weaknesses	Limited coverage area (typically centred around large regional towns) Requires line of sight to relevant tower Subject to atmospheric disturbance (i.e. rain, storms), although fares better than satellite Capital expense may be high
Typical Applications	Internet access (browsing) Voice calls Video, streaming and teleconferencing Business and personal data transfer
Typical Throughput	10 Mbps – 60 Mbps download / upload
Typical Latency	15 ms -30 ms

Fixed Wireless / Private Microwave	
Typical Data Limit	Unlimited data
Typical Cost Range	$66 - $300 per month subscription plus installation and equipment fees
Example Providers	Wi-Sky Just ISP MarchNet

7.2 Private LTE Access Network

Private LTE refers to network infrastructure owned and operated by a private organisation rather than a mobile network operator (MNO). Private LTE utilises the same technology as an MNO's 4G/LTE data network, but the organisation must deploy their own dedicated radio equipment locally to serve their specific voice, video or IoT applications and service needs. Typically, multiple small cell base stations as well as core network equipment are deployed to create the property-wide private LTE network. Private LTE can be customised to suit required performance demands such as extended range coverage, low latency, fast recovery from failure or how traffic is prioritised.

Private LTE can operate on traditional licensed cellular bands or using MuLTEfire technology, unlicensed 5 GHz ISM spectrum. Dedicated coverage and capacity in a target coverage area is guaranteed when using licensed spectrum private LTE. Macro cells can provide high-speed data connectivity upwards of 30 km radius or less expensive small cells can cover up to 5 km radius each. An additional benefit of utilising a private network is that during a backhaul outage, data transfers over the network will continue to operate. Dedicated equipment is independent of traffic fluctuations in the wide-area macro network.

Sensors and devices can communicate directly with an LTE base station if they have either NB-IoT or LTE-CATM1 options built in. This can reduce complexity of each device installation and total network build out costs as less network devices such as gateways and protocol converts are required, as devices, voice and video can all utilise the same private LTE base stations.

Table 13 Private LTE Profile

Private LTE	
Strengths	High bandwidth Large coverage area Supports Quality of Service Low Latency Supports voice through normal phone and sim card Supports NB-IoT sensor data without additionally gateways/protocol converters at device ends Can allow network owner to resell bandwidth and access to staff, contractors and other periphery users to generate revenue
Weaknesses	High upfront costs May require spectrum licence Expensive
Typical Applications	Internet access (browsing) Voice calls Video, streaming and teleconferencing Business and personal data transfer Sensor IoT data
Typical Throughput	Up to 150 Mbps download / 50 Mbps upload
Typical Latency	9 ms – 30 ms
Typical Data Limit	Unlimited
Typical Cost Range	$400k - $450k per base station (5 km – 32 km coverage range) + cost of licensed spectrum which is generally bought through auction (optional)
Example Providers	URSYS Pivotel MuLTEfire PASTech Telstra

7.3 Wireless Mesh / Wi-Fi Access Network

Wi-Fi is a form of microwave communication which can be used outdoors to form short to medium range networks deployed on buildings, towers and/or vehicles to allow high-speed data access for smart phones, laptops, tablets and other devices. There are many manufacturers creating Wi-Fi

access point equipment and many devices have Wi-Fi built in which means typically the cost of equipment is cheaper than other technologies. Example applications are messaging, voice calls, video streaming or conferencing and file transfers.

Wireless access points can communicate in star or mesh network topologies which creates flexibility in installation and expansion options. One wireless access point can cover a radius of 2-3 km, adding high-gain directional antennas on end devices can extend the range to over 10 km and improve network reliability. Wi-Fi operates on the 2.4 GHz and 5 GHz ISM bands which do not require spectrum licensing.

Wi-Fi is a high bandwidth technology which is not designed for low power consumption, so is unsuitable for direct connectivity to low powered battery operated sensors (eartags). Wi-Fi is however suitable as a complementary technology to provide backhaul connectivity to LPWAN gateways which would connect to low power IoT sensors.

To cover an entire property with good Wi-Fi coverage requires many access points. A property of 50 x 100 km, for example, would require between 30 and 40 towers over 15 meters high, with an estimated build cost approaching $500,000. Covering specific areas, such as homestead, sheds and critical paddocks or water sources with Wi-Fi, and using satellite connectivity for remote areas or low bandwidth sensors may provide a more cost effective option.

Table 14 Wireless Mesh and Wi-Fi Profile

Wireless Mesh and Wi-Fi	
Strengths	High data bandwidth for internal to property applications Equipment costs are cheap with choice of vendors Everyone is familiar with connecting to Wi-Fi, don't need sim cards
Weaknesses	Limited coverage area (typical coverage of 100 m to hand held devices, or up to 2-3 km using small dipole antennas and up to 10 km with directional antennas on devices) Subject to atmospheric disturbance (i.e. rain, storms) Internet access speeds subject to external to property link capacity Prone to interference – remove as every property is massive? Slightly less secure
Typical Applications	Internet access, voice and video applications CCTV cameras Sensors such as weather stations Provide high bandwidth backhaul for LPWAN gateway
Typical Throughput	5 Mbps – 100 Mbps download / upload
Typical Latency	2 ms – 3 ms

Wireless Mesh and Wi-Fi	
Typical Data Limit	250 GB– 300 GB per month
Typical Cost Range	$6k - $7k per base station (5 km coverage range)
Example Providers	Agrinet Xcis MarchNet

7.4 Digital Mobile Radio and Terrestrial Trunked Radio

Digital Mobile Radio (DMR) and Terrestrial Trunked Radio (TETRA) are digital two-way radio communication systems with the ability to push-to-talk, or dialling to call, and provide text messaging. Base stations are installed with linked repeaters to extend the coverage across the property and are the key to making this system work. DMR and TETRA systems customers will own and need to maintain the infrastructure. DMR and TETRA can use licensed or unlicensed frequencies. Users operate handheld units in the same way as UHF CB radios.

Voice information is converted into digital data resulting in more crisp and clear audio, less background noise, static and distortion. Users are able to have multiple channels on a radio and additionally have the ability to make one-to-many voice calls to a group of people in the same channel. In agriculture, the ability to quickly broadcast voice messages in real-time to all staff is a valuable method for enhancing safety when working alone in a large property. This is practical for businesses that require wide geographical coverage and a dispersed workforce.

Benefits of DMR/TETRA include increased battery life compared to traditional handheld UHF CB radio, private calling, text messaging and GPS for location tracking. DMR installations can also be configured to allow site visitors who have their own radios to interface directly to the property wide system.

Table 15 Digital Mobile Radio and TETRA Radio Profile

Digital Mobile Radio / TETRA	
Strengths	Clear voice Increased battery life Private or group calling Text messages and GPS location Easy to use – very similar to UHF CB
Weaknesses	Requires DMR repeaters and trunking network More expensive than UHF CB

Digital Mobile Radio / TETRA	
Typical Applications	Voice calls Short data messages GPS location updates
Typical Throughput	4.4 kbps
Typical Latency	< 1 ms
Typical Data Limit	Maximum of 128 characters per SMS message or 288 bits of data per message Unlimited messages
Typical Cost Range	Costs are site dependent, starting at ~ $25k for a site requiring one repeater and radios for users and vehicles (up to 58 km coverage range).
Example Providers	Radlink National Wireless Motorola Solutions

7.5 UHF CB Radio

Analog FM UHF CB radio systems are used extensively in rural Australia. In 2017, ACMA has allowed older 40 channel UHF CB radios to operate alongside the new 80 channel standard, which allows readily available and ubiquitous UHF radios and repeaters to continue to be used and interoperate with each other.

UHF CB provides voice and telemetry data present at all properties surveyed, with only 2-3 repeaters to cover significant distances (i.e. 100 km x 200 km properties).

Table 16 UHF CB Radio Profile

UHF CB Radio	
Strengths	Large coverage area No latency Familiar technology Older cheaper equipment is interoperable with new equipment
Weaknesses	Requires line of sight Data limited to telemetry
Typical Applications	Group voice calls Telemetry data
Typical Throughput	1200 Kbps – 192000 Kbps depending on the modulation techniques

UHF CB Radio	
Typical Latency	No latency
Typical Data Limit	N/A
Typical Cost Range	$2k - $3k per repeater (up to 50 km coverage range).
Example Providers	Motorola Hytera

8 Satellite options

8.1 Alternative Satellite Backhaul

Better featured (depending on application), but more expensive satellite Internet access than Sky Muster is offered by a number of non NBN vendors.

Satellite networks tend to have a higher cost of data acquisition, usually in the form of monthly fees, in comparison to other methods of data communication. Furthermore, there may be limitations in how often data is transmitted per day as these services may have low frequency of data acquisition.

One of the key benefits of utilising satellite networks is that the setup is straightforward. Sensors can be directly connected to a communications transmitter and a small antenna, with no other further equipment such as gateways, base stations and other complex equipment and support required. This ease of setup and Australia-wide coverage comes at a premium price compared to other technologies.

Table 17 Non NBN Satellite Technologies Comparison

Type of satellite orbit	Sample Provider	Relative Throughput	Typical Latency	Supports Mobility	Typical Cost per handset
Geosynchronous Earth Orbit	Optus Thuraya	Fast	500ms	Requires realignment after move	$888 upfront + $360 per 24 months (Excluding $2.5 per 1MB of data usage and $1 per minute of voice usage)
Low Earth Orbit	Iridium	Fastest	< 40ms	Supports access while moving	$3240-$5185 per 24 months (Excluding $1 per minute of voice usage)

8.2 Very-Small-Aperture Terminal (VSAT) Satellite Systems

VSAT systems are 2-way data satellite systems that use third party commercial satellites other than NBN's Sky Muster. VSAT systems cost more than NBN Sky Muster but can provide alternative connectivity solutions if Sky Muster's reliability and variable data rates are not suitable for a business. These systems usually include a satellite dish of 3.8 m or less in diameter, a transmitter, receiver and modem to deliver the connection at a remote site.

VSAT satellite systems can be used for fixed, transportable and on-the-move locations. Both transportable and on-the-move options have the capability to be moved to a new location and setup easily at any time. On-the-move options include vehicle/trailer mounted VSAT satellites, which is ideal for users who require bandwidth wherever they go. These types of satellites may have auto-pointing antennas, which means no technician is necessary to install the dish.

VSAT systems generally have fixed costs based on the bandwidth (Megabits per second) and not based on the user's usage (GB/month). Various contention ratios are available, each with a different price. A contention ratio of 1:1 is the highest possible and the highest costing option,

guaranteeing/reserving the available bandwidth for critical systems that require dedicated bandwidth at all times. This provides consistent Internet experience and will never “slow down” at certain times like a highly contented Internet connection delivers. One satellite VSAT plan and bandwidth can be shared between multiple properties reducing the monthly costs per connection.

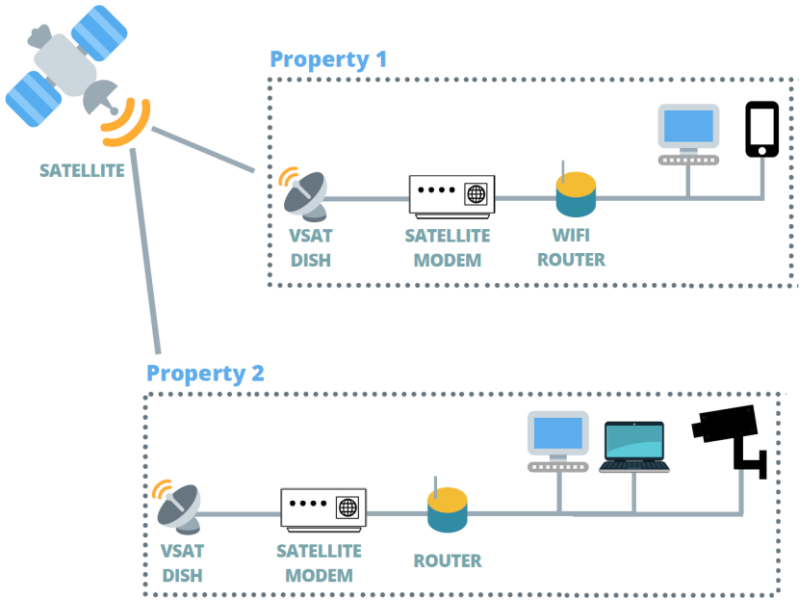

Figure 2 Example VSAT Terminal Network

VSAT systems are able to be set up at multiple sites with a common data pool / account. In Figure 2, Properties 1 and 2 would share a common data cap between them rather than running two separate accounts.

Table 18 GEO and VSAT Satellite Systems Profile

Geosynchronous Earth Orbit Satellite Systems / VSAT	
Strengths	Available almost anywhere Lower contention (sharing of total bandwidth with other users) than NBN
Weaknesses	Expensive Significant size and complexity of end user equipment
Typical Applications	Internet connectivity Large file transfer Video transmission
Typical Throughput	Variable depending on the chosen data plan 2 Mbps – 20 Mbps download / 512 kbps - 2 Mbps upload
Typical Latency	500 ms – 1000 ms
Typical Data Limit	Variable: 5 GB - Unlimited

Geosynchronous Earth Orbit Satellite Systems / VSAT	
Typical Cost Range	Satellite connection device: $15k (stationary device) - $30k (portable device) + monthly data plan: $400 (5 GB) - $2600 (Unlimited data) Monthly costs are variable depending on the chosen speed and data plan
Example Providers	AST Orion Pivotel BC Satellite Vansat

9 Terrestrial sensor networks

The advent of *Internet of Things* (IoT) networks sees a new wave of sensors and low-data devices that focus on short messaging, long battery life and cheaper cost that can operate on new network protocols collectively known as Low Power Wide-Area Networks (LPWAN).

LPWAN is a group of wireless communication protocols and systems that have low energy consumption and high transmission power for long-range communication of up to 10-40 km in rural zones. These protocols supports IoT applications, and are suitable for devices that require periodic transmission of small amounts of data, for example, a weather station sensing which may require transmission of a few times per hour.

LPWAN field devices send small volumes of data periodically (typically below a few hundred bits per second) upon 'waking up' in response to a trigger (timer or change in state), which prolongs the battery life of the devices. LPWAN technologies are therefore suited to rural applications due to the ultra-low power consumption, meaning batteries in sensor nodes can last up to a decade on a single battery charge.

Although both the communication technology and the sensor technology are mature markets, the combination of the two to provide an ecosystem is still emerging. There are few off the shelf systems that can be bought and set up with ease. An integrator will likely be required to configure each type of sensor, set up the transmitter channels and period, the gateway, a cloud server, and a dashboard. It is not "plug and play" technology, even though the hardware is relatively cheap, costs can add up given the vast quantities of sensors that may be required.

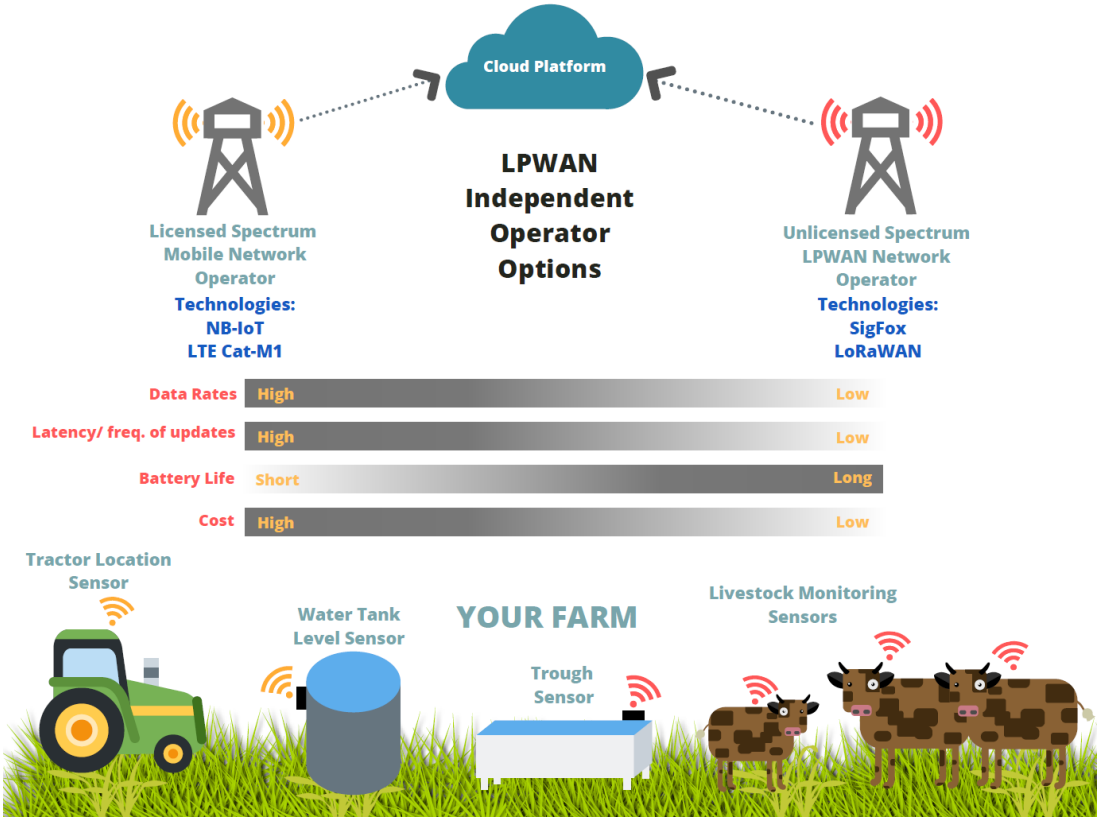

Figure 3 Example LPWAN Independent Operator Options

LPWAN options are typically split between licensed protocols (networks built by others offering subscription models) and unlicensed protocols where users build their own networks.

9.1 Subscriber LPWAN

There are existing LPWANs run by commercial providers that may cover areas of certain properties. When these exist, it is possible to buy sensors from the network provider that are already pre-configured to use their system. If an existing network does not cover the property, upon request, network providers may install their own gateway to cover the area.

The network provider generally charges a fee to use their network based on the amount of data / messages sent per month, number of devices using the network and the types / complexity of dashboards required.

Table 19 Subscriber LPWAN Profile

Subscriber LPWAN	
Strengths	Large coverage area (up to 100 km from base station for NB-IoT) Open standards allow for choice of device manufacturer Battery life of connected devices extends over 2 years, depending on message frequency Requires only the purchase of the end devices (sensors) and subscription plan for messages Greater message size and scalability than unlicensed protocols
Weaknesses	Small data packets only Limited to existing network coverage relative to property location
Typical Protocols	LTE CAT M1 NB-IoT LoRaWAN Sigfox
Typical Applications	Level sensors On / off state switches Basic telemetry data (for examples, eTags)
Typical Throughput	Cat M1: upto 1 Mbps download / upload NB IoT: upto 250 kbps download / upload
Typical Latency	Cat M1: 10 ms – 15 ms NB IoT: 1.6 s – 10 s
Typical Data Limit	Data usage can be adjusted to each individual needs. It ranges from 30KB to 20GB

Subscriber LPWAN	
Typical Cost Range	Monthly management fees: Gateway: ~$100/month/gateway + device management: $0.80 - $4 /month/device (NNNCo) Data Monthly Charge from $0.90 - $169
Example Providers	Telstra (CAT M1 and NB IoT) Vodafone (NB IoT)

Telstra and Vodafone are providing IoT networks that extends beyond the reach of 4G signal through Narrowband IoT. NB IoT makes of narrow-band channels and provides higher sensitivity and longer range at the expense of limited data rates. This technology utilises a simpler waveform, which significantly improves the power consumption of devices and as a result means the battery life is extended, in the range of years.

9.2 Private LPWAN

If a subscriber LPWAN network is not available in the area of interest, it is possible to build dedicated networks through the use of protocols which use unlicensed frequencies. These systems typically have a smaller coverage range, and would require a larger number of base stations to cover large areas.

Table 20 Unlicensed LPWAN Profile

Unlicensed (Build) LPWAN	
Strengths	Reasonable coverage area (15+ km) Open standards allow for choice of device manufacturer Battery life of connected devices extends over 7 years, depending on message frequency Typically lower cost of devices than licensed options
Weaknesses	Requires build and maintenance of own network Data limited to telemetry and short messaging
Typical Protocols	LoRaWAN Sigfox NB-IoT (over private LTE network)
Typical Applications	Level sensors On / off state switches Basic telemetry data (for examples, eTags)
Typical Throughput	0.3 kbps - 250 kbps download / 0.1 kbps – 250 kbps upload

Unlicensed (Build) LPWAN	
Typical Latency	LoRaWAN: 1 - 10 s SigFox: 1 - 30 s
Typical Data Limit	Maximum message size: 12 bytes - 240 bytes 140 messages/day – unlimited messages/day
Typical Cost Range	Gateway/base station: $385 - $4500 + sensors/modules: from $20
Example Providers	Fleet Goanna AG GeoWan NNNCo Meshed

9.3 LPWAN Backhaul Options

LPWAN is an access technology and hence requires backhaul in order to connect devices to cloud services that can process the data collected.

The LPWAN gateway requires an Internet connection to forward the sensor data to a cloud storage and dashboard monitoring system for processing. Typically, this will be through an existing Wi-Fi network, 4G LTE connection, NBN Sky Muster or other satellite connection. As a result, one of these backhaul technologies will need to be available at the LPWAN gateway location, which may be installed in remote paddocks.

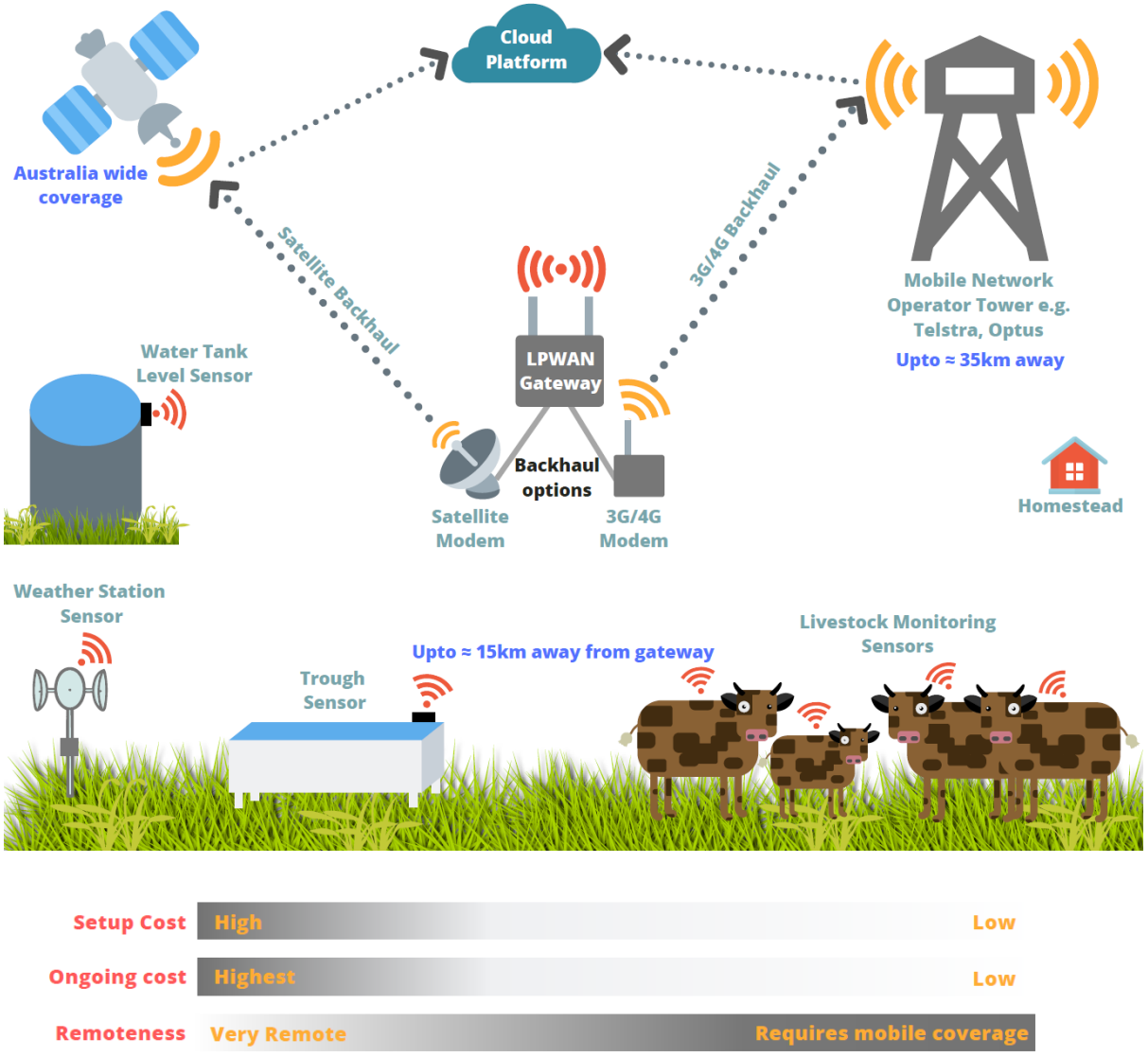

Figure 4 LPWAN Backhaul Comparison between Satellite and 3G/4G

Other technologies, such as Private LTE or Wi-Fi networks, can also be utilised in conjunction with the above backhaul options to transport the LPWAN data to the cloud.

9.4 Examples of LPWAN Connected Sensors

There are an abundance of LPWAN connectable sensors available in the market from a variety of manufacturers. While there are a number of case studies available regarding successful implementations of these networks, they are typically based on much smaller properties requiring less infrastructure and investment risk than would be experienced by northern producers.

Typical agriculture applications include:

- Water level monitoring
- Weather stations
- Smart buttons

- Asset tracking
- Pump monitoring
- Environmental condition monitoring (for example, soil moisture)
- On/off or open/close sensors (i.e. gates)
- Counters

Technology Case Study: Thinxtra's Digitanimal Tracking Solution

The Digitanimal solution from Thinxtra is currently being trialled through a Sigfox/Thinxtra project in Coolindown Farms, where 5000 sheep wear connected collars with the goal of improving lamb survival. A constant struggle for the farm owner in managing her farm is reducing the mortality rates in lambing ewes and post-weaners. With the Digitanimal app, the manager is able to obtain animal welfare data from her phone in real-time using either a mobile or Wi-Fi network. As part of the solution, the app uses GPS data and the collected readings to create an algorithm of normal behaviours for a mob of animals. This algorithm is used to detect abnormal behaviours, and identifies an individual animal in a different colour on the app. In this case, the app identifies low activity which could suggest an animal is stationary from either being hooked to a fence or due to birthing difficulties.

https://www.thinxtra.com/portfolio-item/digitanimal-collar/

Technology Case Study: Taggle – Barwon Water and the Irrewarra Farm Care Group

Some of the most common use cases for water level monitoring systems in agriculture include utility metering and water level sensors. Irrewarra Farm Care group in Victoria installed 200 digital water meters which provided them with hourly data and helped them to identify over 60 water leaks and which saved in water costs. The system also provided valuable information to Barwon Water as they were able to manage water demand on each zone more efficiently.

https://taggle.com.au/case-study-barwon-water/

Technology Case Study: Powertec's Ag IoT solution for Carwoola Pastoral

Powertec's IoT solution for Carwoola Pastoral was awarded the best installation for quality and robustness in 2018 by MLA. Powertec were among several IoT solution providers that MLA engaged to deploy and investigate the benefits of a range of technologies and solutions. This solution involved various types of devices which connected to a LoRa gateway, including:

- 4 weather stations
- 4 soil moisture probes
- 5 water tank level sensors
- 3 grain silo level sensors
- 10 gate status sensors
- 5 vehicle trackers
- A water pump machine control
- Industrial cellular router

- Long range high capacity Wi-Fi access points
- Blackhawk solar kits (to power some of these devices as well as the base station)

The goal was to deliver a solution across the 23 km^2 breeding property with the challenge of no access to mains power or reliable Internet. The aim of this trial for MLA was to determine what is commercially ready and reliable as well as to understand the value of the technologies. Overall, the solar powered base station included a cellular router for Internet connectivity and a LoRaWAN gateway to communicate with the devices including sensors, weather stations, soil probes and asset trackers. A semi-automated bore pump control device was also installed to control water flow to three tanks, which allowed staff to remotely turn the pump on and off using a dashboard. This system enabled more efficient real-time data collection which is directly streamlined to Powertec's online dashboard where historical information, event logs and alerts can be viewed.

https://myinsight.io/iot-solution-for-nsw-cattle-and-sheep-station/

10 Future technologies enabling AgTech and smart production

The next couple of years will see some fundamental shifts in connectivity which intend to create new low cost options for consumers, as technologies currently in trials hit the market with subscription models offering better value propositions than current offerings.

10.1 Ongoing improvements to NBN satellite services

As a result of innovation in satellite technologies, NBN is also improving its service offering to cater more for businesses as well as underserved rural and remote areas through the introduction of Sky Muster Plus and NBN Business Satellite services for businesses requiring greater broadband data and service levels than consumers.

10.1.1 NBN Business Satellite Service

The NBNCo are scheduled to release their Business Satellite Service in 2019. This wholesale product will be available to ISPs, who will then be able to offer enterprise grade services to rural Australians and will allow guaranteed connectivity backed by Service Level Agreements (SLAs). This should mean producers would have the ability to rely on their data being accessible, available and that business needs can be delivered upon at any time. The cost of this service will be higher than the standard Sky Muster plans, but as the entire satellite operation is government subsidised, it should be more affordable than private VSAT satellite links.

10.1.2 NBN Sky Muster Plus

Enhancements to NBNCo's Sky Muster service were released in August 2019, with the proposed Sky Muster Plus service offering unmetered data for crucial activities like web browsing, email, PC or smartphone operating system updates, which do not count towards a user's data cap. Data heavy applications such as video streaming, online gaming and file sharing are metered and count towards the quota. This upgrade occurs on NBN's equipment meaning satellite dishes installed at properties will not require a change. Additionally, Sky Muster Plus allows download rates to burst above the plan's rated download speed to up to 25 Mbps, for high-speed Internet access over short periods. This will be beneficial for users who frequently exceed their data quotas.

On Sky Muster plus, a user who has exceeded their data quota would be able to retain fast speeds for essential services that are unmetered. They are able to pay bills online and children can continue to manage homework. Although the user may not be able to stream videos for the rest of the month, they are able continue their essential work at broadband speeds.

Sky Muster Plus is available across three different data quota plans: 50 GB+, 100 GB+ and 150 GB+ which allow for 100 GB, 200 GB and 300 GB of data respectively, each split between peak and off-peak usage. Other enhancements are planned for this service in future, such as un-metering of more types of traffic including education and health applications.

10.2 Future Broadband Satellite Systems

Space Internet is an emerging satellite based Internet technology, where data networks are created with hundreds or thousands of small satellites. These satellites are different to traditional communications satellites as they orbit closer to Earth to form a grid-like pattern, which will theoretically provide continuous Internet coverage. Additionally, they are also able to work across the globe. Services are claiming the ability to deliver upwards of 10 Gbps connection speeds, well in excess of current NBN satellite capabilities.

This is a big opportunity for these companies to connect the significant proportion of the population that's unserved and underserved. With so many of these global companies working on space Internet, this makes the market very competitive and will likely transform a traditionally high-cost, low reliability service to a more affordable one.

At the moment, companies such as Facebook, SpaceX, LeoSat Enterprises and Amazon are working to enable these complex data networks and provide global Internet coverage. For example, Space X are currently testing their first lot of 60 satellites to form their Starlink network, which will potentially offer broadband speeds comparable to fibre optic networks. The expected completion of Starlink is by 2027, however it will be operational in some capacity from 2020.

Other advantages in comparison to normal satellite Internet include: coverage that covers the entire globe and reduced delays to around 20 milliseconds, in which it is hardly noticeable from a user's perspective. Overall, this means more consistent signals, better performance and improved reliability.

10.3 Satellite-based IoT Sensor Networks

Nanosatellite IoT is a technology network expected to gain the attention of the IoT market in the future. This is due to the market's ongoing issues of systems that are too expensive or have limited bandwidths, which nanosatellite IoT is expected to fill the gap of. There are currently three prominent providers for this technology network, including Fleet Space Systems, Myriota and Hiberband.

Nanosatellite constellation companies, such as Fleet and Myriota, are currently in trial stages of developing their IoT offerings and are advertising prices comparable to mobile 4G data solutions. They aim to reduce costs compared to traditional satellites by utilising many very small satellites at low earth orbit that are substantially cheaper to launch into space. These solutions can also provide localised IoT networks, allowing a range of sensors in the immediate area to connect back via one satellite modem device.

These companies aim to create low-cost, low-power and efficient satellite connectivity for the Internet of Things. The common goal is to form a global network of efficient and affordable satellites, so that data can be retrieved from anywhere on earth. The devices and modems from these companies are designed to have long battery life on a single charge and to be easily set up in a matter of minutes.

Fleet's IoT solution includes a gateway and a deployment of LoRaWAN devices to enable ultra-low cost connectivity. The gateway connects to devices or sensors and is able to provide satellite connectivity for up to 1000 sensors within a range of 15 km. This distance range is comparable to Wi-Fi towers and at a significantly lower cost.

Myriota's solution on the other hand is device based, where the devices/modules have an integrated Myriota chip built in, which allows them to transmit data to a satellite when it is overhead.

Future plans for nanosatellite IoT technology include companies launching more satellites to expand their constellations. The applications of this technology and its associated devices will also be likely to expand to a broader range of activities such as weather stations, tank monitors, water meters and asset trackers.

Technology Case Study: Myriota Enabled Water Level Sensors

In a project between Australian Livestock Spatial Innovation Program, Meat & Livestock Australia and the University of New England, Myriota designed a solution that connected water level sensors in water tanks to Myriota modules. This solution allowed producers to retrieve water level data directly from their phones.

A notable situation where the Myriota system improved efficiencies was when one of the trial sites experienced a pump failure, which quickly caused the water tank to become drained. Situations like these, if not acted upon quickly, result in unwatered stock. This is a particular issue during calving periods or over dry / hot periods. Without a remote sensor system like Myriota, a failure like this would usually take the owner days before it is recognised through regular inspection. In this case, however, the owner was able to identify the issue remotely on an app and have it resolved within hours.

At another trial location, the tank monitor helped the producer to determine the time taken for the pump to refill tanks by reviewing historical data. Prior to using the tank monitor, guesswork was usually involved to estimate the refill duration which often led to tanks overflowing.

10.4 Sensor Ear Tags/ Smart Ear Tags

Smart ear tags are an emerging agriculture specific trend, where sensor ear tags or collars are placed on individual livestock as a means of health and location tracking. These devices aim to provide real-time information on an animal's behaviour, temperature and whereabouts, which is generally viewed through a web portal or mobile app. This information is useful for locating animals and tracking mob movements to reduce human effort to locate animals.

Individual animal health data is important as it is a method to identify potential health issues. This will reduce the amount sick livestock, prevent the spread of disease and in turn prevent economic losses. Producers can also make management decisions based on this data, for example, to identify injured animals and intervene at the earliest opportunity.

The method of how data is offloaded from the devices to the cloud will greatly impact the battery life of the device. Each type of device will have varying battery lives. The desired frequency of livestock status updates will also impact the battery life of devices.

Data can be transmitted to a portal by deploying a fixed network of wireless receiver stations, base nodes or gateways. It may be possible to rationalise the network infrastructure to common areas or choke points, for example, covering all of the water troughs and setting alerts should cattle not been seen at any water troughs over a 24 or 36 h period.

Table 21 Smart Ear Tags and Implants Profile

Smart Ear Tags / Implants	
Strengths	Theft reduction Increased operation efficiency Increased location awareness of livestock Increased animal biosecurity
Weaknesses	Can be costly to purchase tags for all cattle Requires the development of infrastructure to read data in real-time Many providers are still in trial or developmental phases
Typical Applications	Livestock health tracking Livestock location tracking Livestock behaviour tracking Heat stress tracking
Example Providers	Smart Paddock IDS Herddogg IoTag Ceres Tag Moovement Allflex EmbediVet Thinxtra – Digitanimal Collar

Cost is an important consideration for this application especially for properties with large numbers of cattle. Smart Paddock currently offer tags with location and biometrics monitoring for under $30 per tag, whilst Allflex's solution is $99 per tag. Instead of tags, implants such as EmbediVet (sponsored by Cicada Innovations and MLA) may potentially prove a better solution.

10.5 5G rollout and onwards to 6G

5th Generation technology is rolling out in Australia in 2019, which has the ability to transmit even more data and at faster speeds in comparison to 4G. Telstra and Optus are currently building their 5G networks for launch later in 2019; in particular, Telstra's 5G is built upon the foundation of their

extensive and fast 4GX coverage. To access and use this network, 5G-capable devices and smartphones are required.

Table 22 5G Mobile Profile

5G	
Strengths	High bandwidth capacity High data volumes Very low latency providing mission critical quality fast response High availability, reliability and resilience Value for money
Weaknesses	Reduced coverage range per base station compared to 4G means providers need to build new sites Very limited coverage at present time, limited to urban areas
Typical Applications	Internet and cloud services Mass machine connectivity IoT sensor connectivity (where 5G is supported by the device)
Typical Throughput	10 Gbps download / 0.5 Gbps upload
Typical Latency	5-10 ms
Typical Data Limit	120 GB - unlimited
Typical Cost Range	$100 per month
Example Providers	Telstra Optus

Research is currently being undertaken into high altitude wireless internet delivery methods to support the availability of 5G services into rural and remote areas. This may take the form of drones or air balloons.

The Airbus Zephyr drone can achieve 14 d continuous flight on solar power, ultimately targeting to reach 100 days flight per charge, then a year or more in future versions. Infrastructure on the ground would connect to the Internet through the drone, the equivalent of having a base station tower in the air. None of the Australia network providers have plans to launch drones at the present time.

As 5G is starting to be rolled out, development on 6G (nominal name) is already underway. Speeds in the order of 1 terabyte per second (the equivalent of downloading 300 movies in one second) are proposed. While speeds in that order are much less important to the context of rural production, the continued reductions in latency will have strong practical applications in machine to machine (M2M) communications.

10.6 Impact of Edge Computing on Telecommunications

The increased provision of greater computing power at the site that data is collected (i.e. edge computing) allows for transmission of the 'processed data' rather than the entire data set, reducing the amount on bandwidth required to the field 'edge' device. Reducing the amount of data that needs to be sent will potentially allow for cheaper, lower bandwidth networks to be used.

These devices are increasingly able to talk to each other, for example, a water level sensor may be able to initiate a pump cycle without manual intervention based on a series of predefined rules, rather than sending data back to a central control system location many kilometres away.

11 Considerations for funding technology infrastructure upgrades

There are opportunities to minimise the financial impact on installation and maintenance telecommunications systems; potentially altering the outcomes of business cases in favour of proceeding with the technology improvement.

11.1 Infrastructure Sharing

If there are multiple properties within a certain area that have similar coverage requirements for particular applications, then these properties together can request network providers to provision a network by installing their own gateway to cover the area for multiple users.

Nearby properties may also decide to install their own LPWAN gateways in order to access LPWAN technologies and share cost of installation between the parties.

Adjacent properties may consider economies of scale through installation of the same system with the same installer, even if the systems installed remain separate to each property.

11.2 Mobile Black Spot Program

The Mobile Black Spot Program is an Australian Government program aimed at improving mobile coverage with a significant investment into telecommunications infrastructure. This investment is aimed at addressing mobile black spot areas across regional and remote Australia. It is encouraged that interested communities contact mobile network operators, state and local government authorities to make their needs known.

New base stations will be built as part of this program, which is delivered in rounds of installations (at time of writing, the program is delivering Round 5 and planning for Round 6). For properties close to major highways, any planned new base stations for those highways can provide 4G coverage to the property without an investment in property-owned infrastructure.

As of the 20th of March 2019, 683 base stations had already been installed and placed in service nationally by the program to deliver improved coverage.

11.3 Grants and Co-Funding Models

There are a range of grants currently being provided by governments and organisations available for uptake of new technology and improving of productivity in production businesses.

The following demonstrates some examples of grants and funding models available for northern Australian applications.

11.3.1 Co-investing with Super Funds

Australian domestic superannuation funds have been looking for new infrastructure investment opportunities, open up the option for co-funding project in agriculture. The long term stable returns across the cattle industry provides an attractive investment opportunity for these super funds. The opportunity exists to improve profitability on a mature industry through the use of technology and

create potential investment vehicles around infrastructure that are long term, stable and have a sound risk return correlation.

11.3.2 AgTech Venture Capital Partners

It is interesting to note the recently announced partnership between GRDC and Artesian Venture Partners who have created the $50 million GrainInnovate Fund to invest in start-ups driving the future profitability and sustainability of Australia's grain growers.

Given the parallels and commonality of AgTech requirements between the industries, industry partners, in conjunction with Meat and Livestock Australia, may wish to consider exploring a similar Venture Capital (VC) Fund via co-creation / joint venture arrangement for cattle producers. Whilst the metrics around VC Funds and Private Equity are different to co-investment with Superannuation Funds, such a vehicle may stimulate innovation in the use of technology to drive efficient operations.

https://www.artesianinvest.com/graininnovate-fund-2-pg-summary/

11.3.3 AgriConnect (MLA Co-Funding)

Marchnet's AgriConnect service offers telecommunications to remote sites, aimed at farms, feedlots and processing facilities. Use of this service to innovate and increase productivity may attract MLA co-funding through existing funding models.

https://marchnet.com.au/agriconnect/

11.3.4 Smart Farming Partnerships Grant

The Smart Farming Partnerships Grant is an Australian Government run grant in the National Landcare program aimed at supporting substantial projects to trial, develop and implement innovative tools and ideas. The grants aim to help groups of organisations to take make the most of upcoming ideas, develop, trial, and implement innovative tools that support sustainable agriculture practices.

https://www.communitygrants.gov.au/grants/national-landcare-program-smart-farming-partnerships-round-2

11.3.5 Rural Economic Development Grants

This grant is managed by the Queensland Government and is aimed at funding projects that contribute to economic development primary production sectors as well as job creation in rural areas. Eligible projects include those that:

- Implement new technologies or innovations that improve productivity
- Add value to agricultural products, for example by developing new markets for value-added products
- Assist with business development and expansion
- Achieve economies of scale

- Enable businesses to become investment and export ready
- Improve energy use efficiencies, including transition to renewable energy sources.

This grant offers up to $250,000 in co-contribution funds, which are to be matched by the successful applicant. Round 1 of the grant program closed in late 2018, however the program has been planned to run over a 3 year period ending in 2021. Funding for round 2 will be announced in 2019.

http://www.qrida.qld.gov.au/current-programs/rural-economic-development-grants

11.3.6 Smart Farms Small Grants

This is a nationwide small grants program over several rounds to support adopting of best practices that will improve the management and quality of natural resources and increase on-property productivity. These grants will fund short-term projects of up to two years that are able to address one or both of the following:

1. Implement and foster sustainable natural resource management best practice
2. Capacity building for sustainable natural resource management

Round 2 of the program closed in early 2019 but has been scheduled to run until 2022-23, with small grants ranging from $5,000 to a maximum of $200,000.

https://www.communitygrants.gov.au/grants/national-landcare-program-smart-farms-small-grants-round-2

12 Options for discussion

The following considerations are suggested for the improvement of remote connectivity and technology adoption.

12.1 Champion Northern Australia for increased coverage in future rounds of the Regional Black Spot Program

Producers, Industry groups and AgForce can review the areas of major highways within their area of interest without coverage by the mobile carriers and champion those areas for upgrades under the Regional Black Spot Program.

Whilst these routes are well known, the CSIRO TraNSIT model provides a blue print relating to Supply Chain logistics for the Beef Sector in Northern Australia as an initial base. This argument can carry further weight where the highways are highly trafficked by tourists.

One such example is the Barkly Highway between Camooweal in Queensland and Tennant Creek in the Northern Territory, where no mobile reception is available for several hours of travel, yet is a popular stretch with 'grey nomads' and tourists. These three groups combined provide a stronger argument for coverage being required in the area.

For homesteads close to major highways, they will benefit from instantaneous mobile coverage, and for those further away from the road, reception at the homestead may now be possible through Yagi antennas and amplifiers / boosters.

https://www.communications.gov.au/what-we-do/phone/mobile-services-and-coverage/mobile-black-spot-program

https://www.csiro.au/en/Research/LWF/Areas/Landscapes/Transport-logistics-TRANSIT

12.2 Encourage state and territory governments to invest in Regional Digital Connectivity

Some state governments have shown initiative in providing funding for remote connectivity, such as NSW announcing $400 million (over 4 years) for its Regional Digital Connectivity program. Such investment may lead to a have / have not scenario, where NSW producers are able to operate at greater efficiency than their interstate counterparts. Producers may be able to gain support through their local members for Parliament to raise this issue.

This opportunity may also be pursued through NAIF (Northern Australia Infrastructure Facility) and CRC-DNA (Cooperative Research Centre for Developing Northern Australia) in their role as a financing mechanism for a range of infrastructure projects in Northern Australia. Whilst GHD has no line of sight on projects that NAIF are reviewing, that are commercial in confidence, it could be reasonably expected that NAIF may have projects in their pipeline that are looking at investment around the mining sector, water infrastructure, freight and logistics. These investments would have potential technology requirements similar to that being sought by producers in these areas and opportunities to leverage this may be worth exploring.

http://www.crcna.com.au/

12.3 Develop targeted technology education, extension and adoption through MLA meetings and events

Highlight to the industry the advancements being made by pilot programs and provide education on the options available to property owners, with their respective strengths, weaknesses, applications and cost models. MLA programs such as Edge workshops, and connectEDGE, may provide a mechanism for this information dissemination.

12.4 Continue co-funding trial technology programs

MLA already provide co-funding against a series of technology pilot programs.

Consider the capacity of MLA to engage in a process with vendors for go-to-market ready solutions for communications infrastructure. A vendor may provide competitive pricing to industry/producer groups (AgForce, QFF, NTCA members) on a combined tower, communications equipment, solar and battery repeater site or trailer option, essentially producing an off the shelf communications ecosystem product.

12.5 Lead industry drive for production to plate systems integration

MLA are in a unique position to influence the adoption of common procedures and technology across the industry to develop a consistent and integrated production to plate process for cattle identification, tracking and recording above and beyond current systems.

Discussions can be further progressed with transport and freight providers to move away from paper based systems (such as the NVD) to allow for electronic forms or ID scans at key junctions.

13 Scope and Limitations

The scope of this report is limited to the identification and subsequent evaluation methodology for telecommunications options for the beef industry in northern Australia. This report has been prepared by GHD for Meat and Livestock Australia Limited.

GHD has no affiliation with, endorse or recommend any network provider, suppliers, integrators and manufactures identified in this report and are listed as references only. All data rates, plans and pricing information are indicative only and subject to change at any time.

GHD otherwise disclaims responsibility to any person other than Meat and Livestock Australia Limited arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer below assumptions section of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

Suppliers mentioned in this report are provided as examples only and are not endorsed or recommended by GHD or MLA. Lists of potential suppliers are non-exhaustive.

GHD has prepared this report on the basis of information provided by Meat and Livestock Australia Limited and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

14 Appendix A – Example Use Cases

14.1 Table A1: Cattle Applications

Need	Type of Data	Typical Data Requirements	Example Technology
Remotely monitor livestock	- Video feed to remotely monitor livestock - Regular image snaps during the day to monitor livestock	Mobile data req: 5.5 mb x 10 = 55 mb/day Satellite data req: 5.5 mb x 3 = 16.5 mb/day	- 3G/4G Cellular networks - Satellite communications
Remotely and accurately monitor as well as visually check locations of herds and livestock as well as check livestock movements Remotely detect missing animals	- GPS Locations to track individual livestock whereabouts - Livestock ear tags or collars	Each gps location: 80 to 100 bytes For example: 10,000 cows x 90 bytes = 900Kbytes/update Five updates/day = 900k x 5 = 4500kbytes/day	- 3G/4G Cellular networks - Satellite communications - Private radio networks - LPWAN
Accurately determine livestock health conditions without the physical effort required to individually check each animal Early detection of livestock illness	- Remote livestock health monitoring - Livestock ear tags or collars - Load dashboard of herd biometrics: - Temperature Humidity Index, behavioural data, speed	1000 head: 36bits+/hr = 24.4Mb/month 100 000 head: assuming 100bits (16.7bits/10 mins) = 7.2 Gb/month	- 3G/4G Cellular networks - LPWAN

Need	Type of Data	Typical Data Requirements	Example Technology
Use a tool that can easily assist in predicting livestock health based on previous data in order to know which livestock are at risk or may have health problems A method that will potentially reduce the amount sick livestock and prevent the spread of disease. This will in turn will prevent economic losses	- Data science software that can learn patterns from old data		- Software Platforms - Predictive analytics
An easy method of record keeping on the property's map with key livestock and paddock areas showing livestock numbers in each paddock.	- Software or tool that keep track of locational data on a graphical map		- Software Platforms - Data acquisition - Analysis tools

14.2 Table A2: Water Applications

Need	Type of Data	Typical Data Requirements	Example Technology
Be alerted when a water level threshold is met (too low) in order to action upon this	- Remote water tank level sensor e.g. ultrasonic sensor, float sensor, contactor - Data in form of water level reading	1 reading = 84 bytes 4G data req: 24 readings/day = 2.1 kbytes/day Satellite data req: 1 reading/day = 84 bytes/day"	- 3G/4G Cellular networks - Satellite communications - Private radio networks - LPWAN
Remotely track water levels in real-time on a visual dashboard to identify strange patterns & water leak detection	- Software platform that acquires/ communicates data from water sensors or devices		- Software platform: Data acquisition

Need	Type of Data	Typical Data Requirements	Example Technology
Easily check the water usage history on an agriculture software dashboard to monitor and summarise usage (utilities)	- Software platform that acquires utilities usage for smart management - A dashboard that shows water usage history		- Software Platforms - Data acquisition
Remotely view and assess the state of water troughs without having to go out to the location, in order to check the cleanliness, state and number of livestock drinking from it	- Real-time monitoring using cameras		- 3G/4G Cellular networks - Satellite communications
Remotely check and test the quality of the trough water	- Water quality monitoring systems - Sensors		- Satellite - 3G/4G Cellular Networks - Private LTE - LPWAN
Remotely turn on and off water pumps and taps to a water tank	- Smart pumps and taps - Remote automation of equipment		- Satellite - 3G/4G Cellular Networks - Private LTE - LPWAN
Use a tool that can easily assist in predicting water usage based on previous usage history in order to estimate upcoming expenses, without having to spend lots of time to track back and make guesses	- Data science software that can learn patterns from old data		- Software Platforms - Predictive analytics

14.3 Table A3: Environmental Applications

Need	Type of Data	Typical Data Requirements	Example Technology
Precisely monitor weather and environmental conditions: Remotely access real-time information about rainfall, temperature changes, wind conditions, air pressure and humidity for the precise location. Alerts for extreme weather events (cyclones / floods / etc.)	- Remote monitoring weather station - Sensor system - Data: wind speed, direction, temperature, pressure, rain, hail, snow	Temperature and Humidity: 40 bits = 5 bytes Data req = 5 bytes x 2 = 10 bytes/day	- 3G/4G Cellular networks - Satellite communications

14.4 Table A4: People and Business Applications

Need	Type of Data	Typical Data Requirements	Example Technology
Easily contact or communicate with a staff member on the premises	- Handheld 2-Way Radio communication - Mobile Phone Call	Data rate: 9600bits/s = 1200 bytes/s	- Digital Mobile Radio - UHF
Fast and reliable Internet connection to easily upload reports and benchmark results between properties	- Cloud storage platforms: Google drive, Dropbox	Typical 5MB	- 3G/4G Cellular networks - VSAT - Independent Fixed Wireless - NBN Satellite Sky Muster
Fast and reliable Internet connection to easily upload timesheets to the cloud	- Cloud storage platforms: Google drive, Dropbox		- External connectivity: - VSAT - Independent Fixed Wireless - NBN Satellite Sky Muster

Need	Type of Data	Typical Data Requirements	Example Technology
Fast and reliable Internet connection to easily check livestock prices or international market conditions	- Webpage or app that collects buyers prices and shows the producer offers on a daily basis - E.g. Livestockpricing .com		- 3G/4G Cellular networks - VSAT - Independent Fixed Wireless - NBN Satellite Sky Muster
Easily review profit and loss for the current month as well as previous months in order to help in financial planning for the coming months	- Profit and lost summaries and analysis data - Numerical Data		- Software Platforms - Data acquisition
Use a tool that can easily assist in predicting profit and loss trends based on previous data in order to help the owner with business planning and development. This will in turn will prevent economic losses	- Data science software that can learn patterns from old data		- Software Platforms - Predictive analytics
Be able to easily find, view and manage all clients and contracts to eliminate physical paper documentation or scattered documentation Aim to keep clients and contracts in one secure location	- Software that keeps track of and manages clients contracts		- Software Platforms - Data acquisition
A tool that integrates with other already used apps or tools on the property	- An integrated property management software		- Software Platforms - Data acquisition