# RFC – ON FARM CONNECTIVITY PROGRAM

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# 1 RESPONDENT DETAILS

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# 2 ORGANISATIONAL CAPABILITY AND CAPACITY

Powertec is a national wireless technology company established in 1995. The company comprises a team of over 80 permanent staff, supported by a network of over 100 telecommunications field contractors, and over 1000 local distributors, installers, and dealers spanning Australia, New Zealand, Pacific Islands, Thailand, and Bangladesh.

Powertec's extensive capabilities encompass everything a wireless project requires, including communications towers, solar systems, microwave links, long range antennas, sensors, and modems. Strategic partnerships with wireless vendors, mobile network operators, and IoT providers coupled with its national network of field technicians allows Powertec to deliver truly turn-key wireless and communication systems.

With a company history spanning the decades, Powertec's engineering success is built on a solid administrative foundation. The company operates an industry-leading Enterprise Resource Planning suite, along with CRM and technical support ticketing systems. Powertec is ISO 9001, ISO 14001, and AS/NZS 4801 certified.

OBSEQUENTIA
QUALITY CERTIFIED
ISO 9001:2015

OBSEQUENTIA
ENVIRONMENT CERTIFIED
ISO 14001:2015

OBSEQUENTIA
SAFETY CERTIFIED
AS/NZS 4801:2001

# 3 SCOPE

The purpose of this document is to respond to the Department of Infrastructure, Transport, Regional Development, Communications and the Arts' On Farm Connectivity Program. The Program seeks feedback from equipment service providers' interest in participation. Powertec has a long history of providing IoT and broader wireless technology hardware and solutions into the agricultural sector.

Powertec intends to use this Request for Comment to provide broader context on the available solutions, recognising that specific hardware and technologies will differ between geographic locations and use-cases. The document will step through the solutions available to the agriculture sector with respect to practical, technological, and legislative restrictions.

## 3.1 EXTERNAL DOCUMENTS & STANDARDS

[1] On Farm Connectivity Program Discussion Paper.

# 4 DEFINITIONS, SYMBOLS, AND ABBREVIATIONS

### 4.1.1 Definitions

*Not in use.*

### 4.1.2 Symbols

*Not in use.*

### 4.1.3 Acronyms and abbreviations

For the purposes of the present document, the following acronyms and abbreviations apply.

| | |
|---|---|
| ACMA | Australian Communications and Media Authority |
| CSP | Carriage Service Provider |
| LEO | Low Earth Orbit |
| MPN | Mobile Private Network |
| NCM | National Coverage Map |
| NTN | Non-Terrestrial Network |
| RFC | Request for Comment |
| RSRP | Reference Signal Receive Power |
| RSSI | Receive Signal Strength Indicator |
| SDR | Software Defined Radio |
| VoWiFi | Voice over WiFi |

# 5 OVERVIEW OF ON FARM CONNECTIVITY TECHNOLOGIES

The present landscape of remote connectivity is one that has changed dramatically over the last two to three years. Historically, providing connectivity solutions to remote and regional farms was a challenge due to fundamental technical limitations of cellular, IoT, and satellite networks.

Today, both mobile and data connectivity can be provided anywhere and everywhere with the right tools and is positioned to become extraordinarily simple over the coming years.

Below is an overview of the technologies available to the Australian agricultural sector.

## 5.1 CELLULAR REPEATERS

Cellular 4G-5G Repeaters are a technology that has been available in Australia since 2014 when Powertec first introduced the Cel-Fi. Cel-Fi remains the only legal repeater due to its unique mechanism of operation, leading to its approval on all three of Australia's mobile networks. Cel-Fi is a network-aware 'intelligent' repeater capable of self-organising and self-configuring by listening, and responding, to control messages from the mobile network. Its technology is dramatically different to 'wideband' repeaters of yesteryear which blindly boosted an entire frequency band regardless of the networks or sources of interference present between its start and stop frequencies.

Today, Powertec has provided more than 160,000 repeaters to Australian families and businesses.

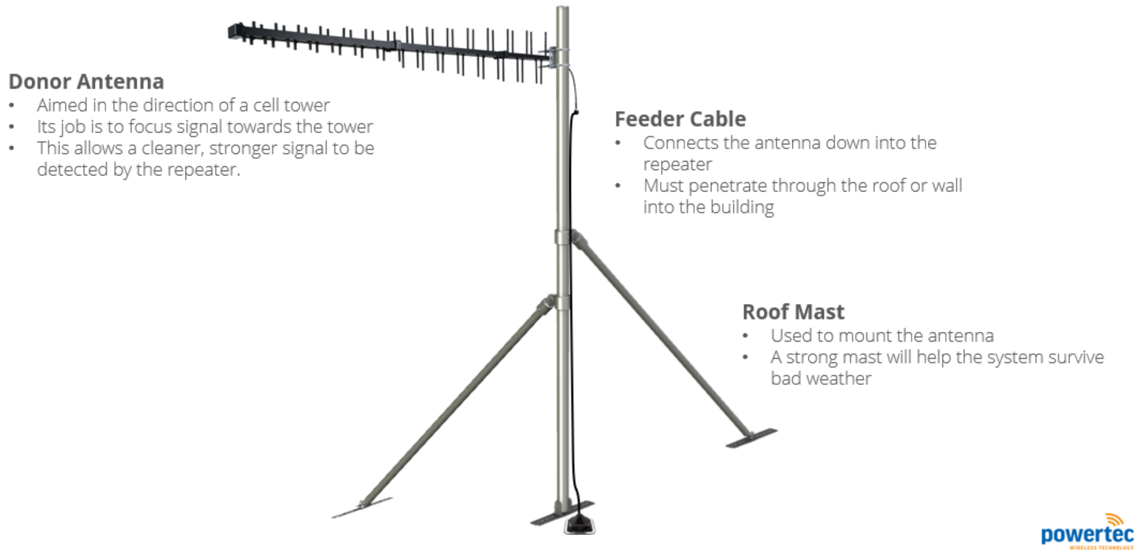


*Figure 1 – Equipment on roof*

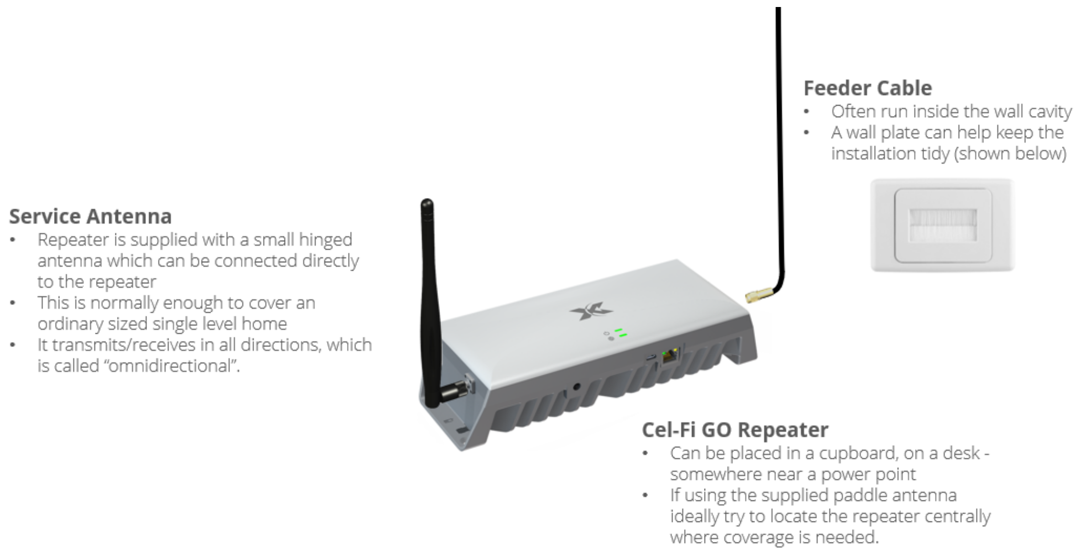


*Figure 2 - Equipment inside house*

### 5.1.1 How Cel-Fi works

With a guaranteed interference-free mechanism of operation, Cel-Fi is used across the country to boost Telstra, Optus, and Vodafone signal up to full strength in vehicles, houses, large buildings, and outdoor areas. In order to do so, it requires an input signal from the local cell tower. A signal can be detected to about as weak as about -121 dBm RSRP, which in more familiar terms is a signal level of 'zero bars' on a mobile phone. The repeater is connected to an antenna, called the Donor Antenna, mounted on the roof of a building or vehicle, which aids in improving the strength and quality of the input signal by as much as the stated antenna gain (if correctly aligned) plus about 1 dB per additional metre of height, and adding back any signal that would be absorbed by a building's walls or the vehicle itself. An antenna located inside the building or vehicle, called the Service Antenna, outputs the boosted signal.

Cel-Fi identifies the control messaging from the mobile network and configures itself for the most optimal frequency band. An amplifier then adds up to 100 dB of system gain, up to a maximum downlink RSSI of +20 dBm for the G41 Cel-Fi, or maximum RSSI of +0 dBm for the R41 vehicle repeater. It's an important technical note to clarify the difference between RSSI and RSRP – all values for the Cel-Fi are based on RSSI and not RSRP, as such the conducted RSRP is typically 30 to 35 dB lower than the observed RSSI. Hence the RSRP at the service antenna interface is typically a maximum of -10 to -15 dBm, which is important in understanding the coverage radius of the repeater. When signal quality degrades, the coverage radius will shrink due to a greater difference between the RSSI and RSRP values. Accordingly, correct design is essential in achieving maximum coverage range.

In it's ordinary configuration, Cel-Fi can provide enough coverage to service an entire home. When installed as part of an In-Building Coverage system, solutions can be developed to cover buildings as large as four storeys. When installed outdoors coverage can be output between 300 metres and one kilometre, depending on the quality of input signal and shape of service antenna.

### 5.1.2 How locations are qualified

In order to determine whether a location will benefit from a Cel-Fi, Powertec developed a National Coverage Map (NCM), understood to be the only one of its kind. NCM consists of a high resolution nationwide 3D model of Telstra, Optus, and Vodafone signal strength, data speeds, and best serving tower.

Importantly, this model factors in the most up-to-date available terrain, vegetation, buildings, population data, and cell tower configurations. The propagation models used to determine how well each frequency band travels across land and penetrates vegetation and buildings have been tuned from thousands of kilometres of drive-testing across Australia.

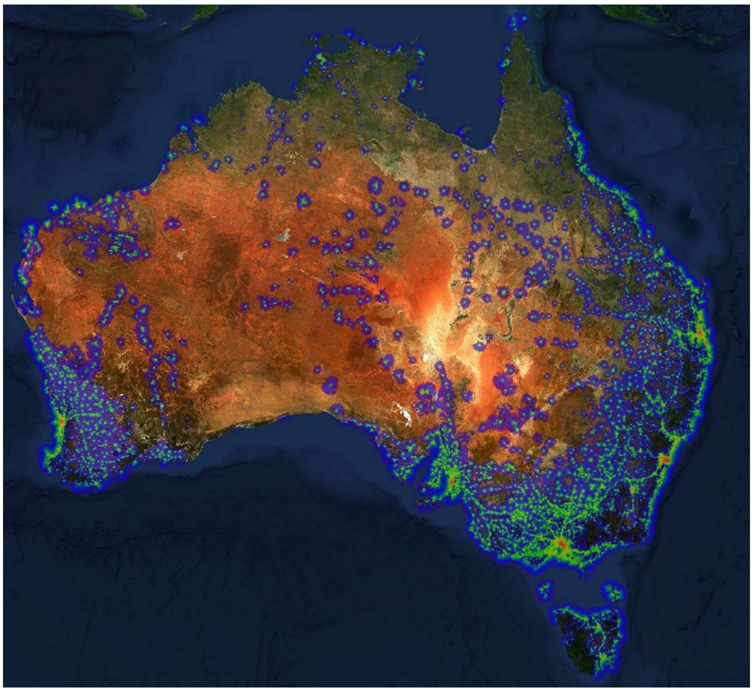

*Figure 3 - Nationwide Telstra RSRP*

This tool allows Powertec staff and its licenced users to log in and perform address searches to determine the cause of poor 4G and 5G signal facing a user, and what type of cellular solution would be most appropriate.

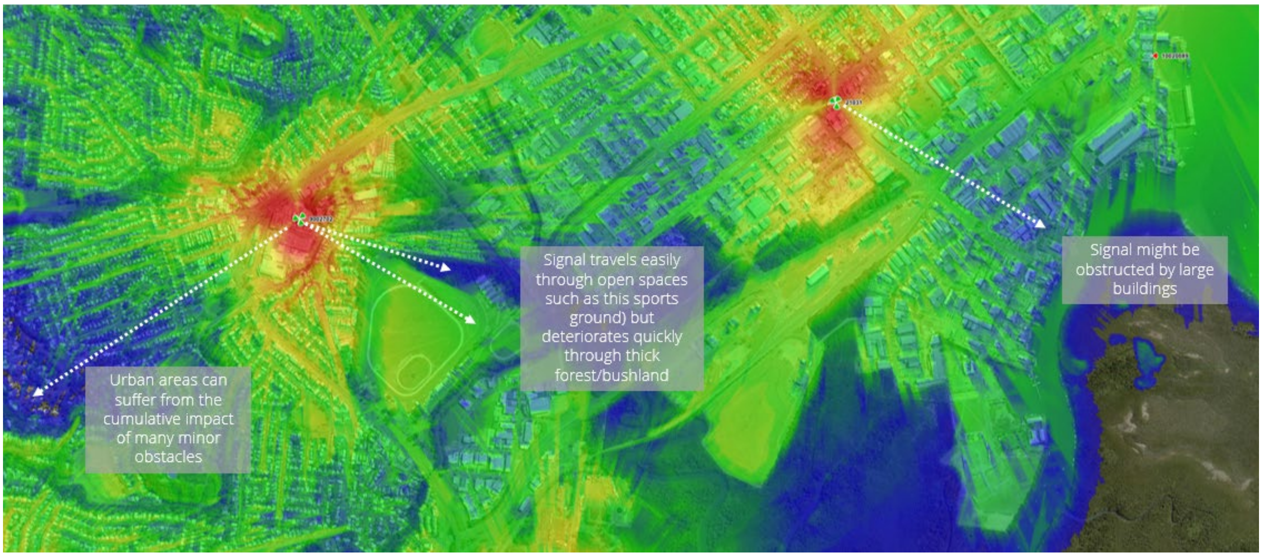


*Figure 4 - Causes of poor 5G signal in Cairns urban environment*

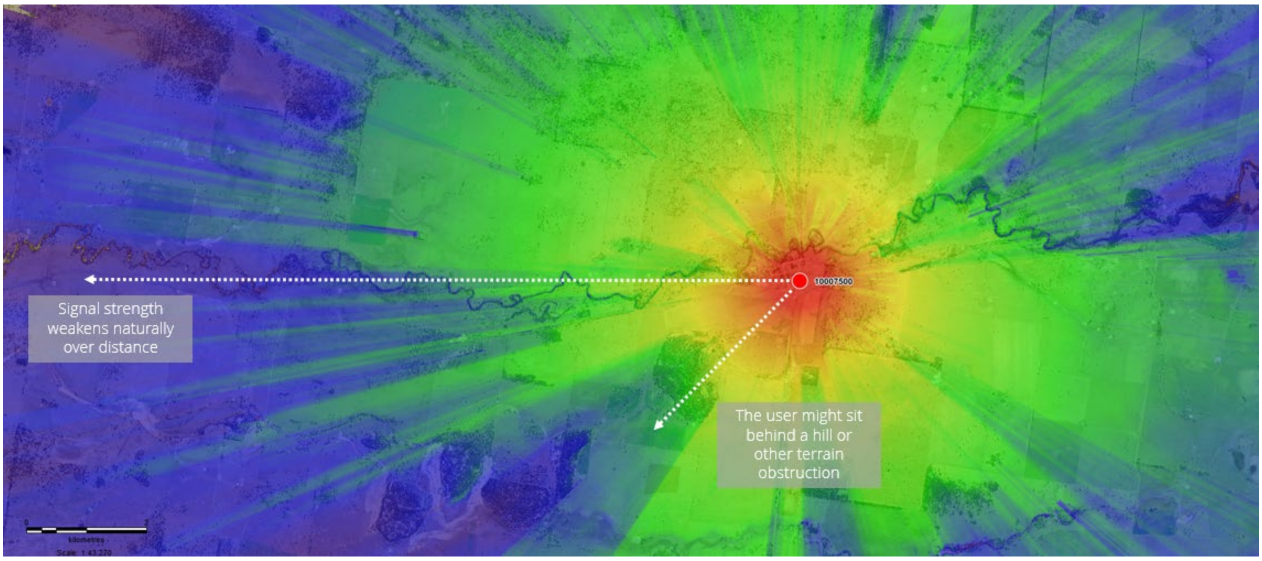


*Figure 5 - Causes of poor Telstra 700 MHz in a regional town*

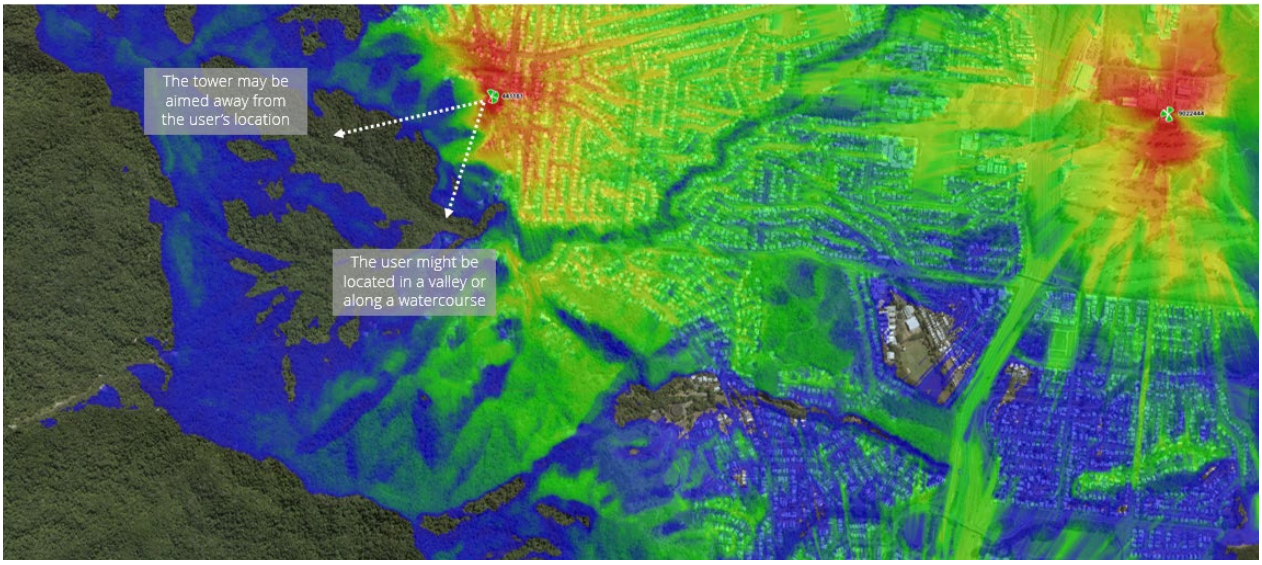


*Figure 6 - Causes of poor 5G signal in hilly and forested areas*

Once the root cause of the issue is identified, determining the correct solution is straight forward. This is of course on the basis that sufficient input signal is available. In the below case, a reliable solution may not be possible at this farm without considerable effort and complexity, all which carries a cost. Accordingly, it is necessary to explore alternative technologies to service the farm.

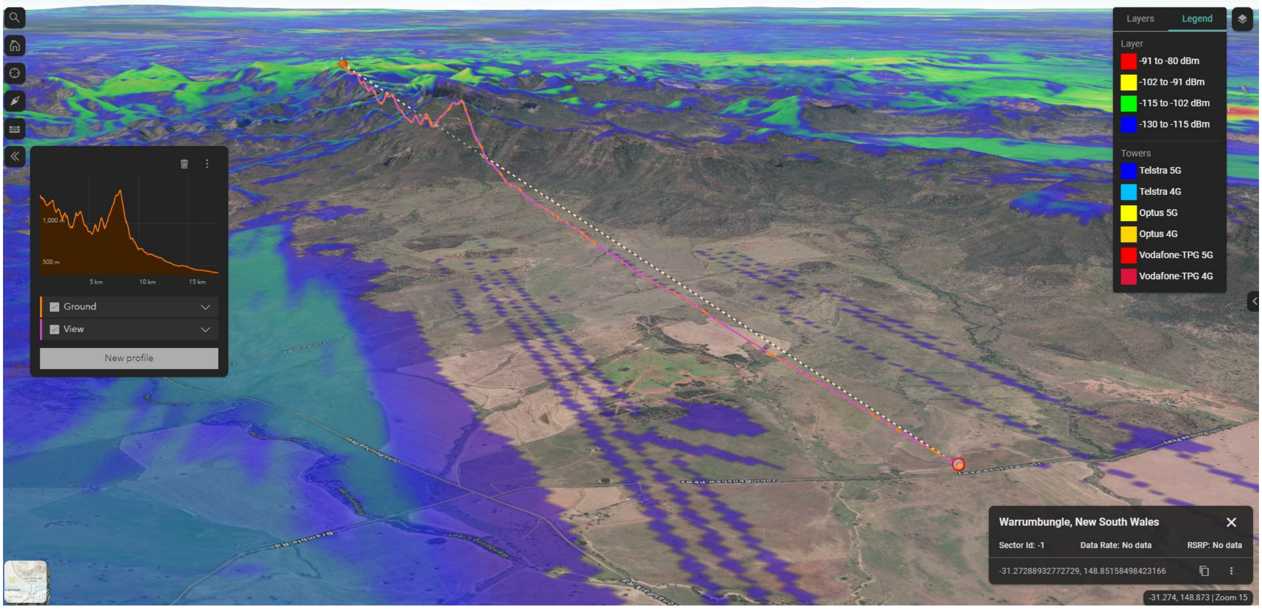


*Figure 7 - Location where sufficient signal is unavailable due to terrain and vegetation obstruction*

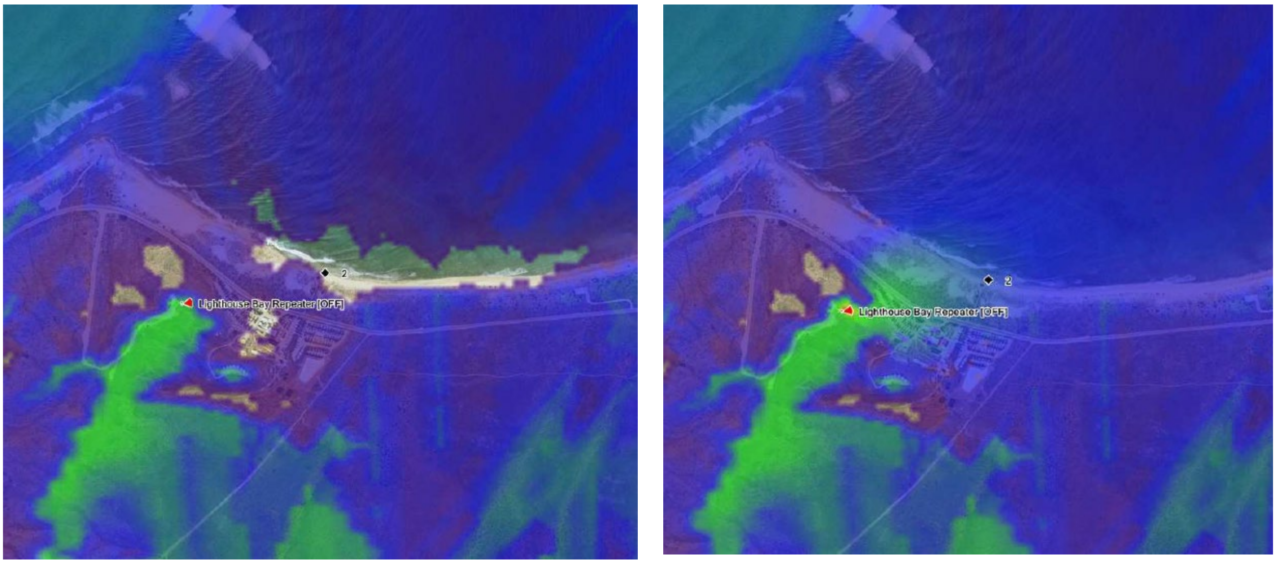


*Figure 8 - Before and after using Cel-Fi to infill blackspot caused by sand dunes*

Repeater technology cannot be used to solve connectivity challenges in all situations. Cel-Fi requires an input signal, where no input signal is available the technology is of no use. The natural question to be explored is how can an input signal be provided in areas with no existing coverage. With the availability of global internet connectivity through Low Earth Orbit, an opportunity is present to create new coverage which will be discussed further in Mobile Private Networks.

Repeaters and associated antennas should be considered highly valuable to the Program as they represent the most common means of improving farm connectivity due to their modest pricing. A portfolio of repeater and antenna products, or pre-defined 'packages' could be made available for rebate through the Program.

## 5.2 LOW EARTH ORBIT

Low Earth Orbit (LEO) are a class of wireless technologies which make use of non-stationary satellite constellations which provide faster connectivity and lower latency (delay) due to their much closer proximity to the earth. LEO constellations typically operate between 500 and 2000 km from the earth's surface. Contrasted to geostationary services like NBN Satellite which operate at around 36,000 km, leading to performance being capped by the fundamental laws of physics.

LEO constellations are able to provide a wide range of technology solutions, including broadband internet popularised by Starlink, IoT sensor connectivity, and even 4G-5G mobile voice, text, and data.

### 5.2.1 LEO Broadband

Starlink has revolutionised connectivity to the agricultural sector and the broader remote/regional communities. As far as Powertec is concerned, the remote internet connectivity challenge is solved. High speed data connectivity can be achieved anywhere, both stationary and vehicular assets, and to a level comparable to that of most urban areas.

Currently, Starlink provides internet access using a mmWave frequency band (Ku and Ka, 12 and 18 GHz respectively) to communicate with fixed User Terminals (UTs). These UTs require clear unobstructed view of the sky and use phased-array antennas to track multiple Starlink satellites simultaneously without motorised adjustment.

The UT is set up simply by placing it outside with a view of the sky. No installation or configuration is required. Starlink is the simplest and lowest cost means of providing high speed internet to the agricultural sector.

Starlink has announced its intentions to expand connectivity to ordinary mobile handsets by provision of a 2 GHz cellular network operated from its constellation. This will be discussed further in LEO NTN section.

Presently however, mobile voice and text services are still available anywhere in Australia courtesy of VoWiFi technology enabled by the country's mobile network operators. VoWiFi allows any compatible handset to operate as though it were connected to a 4G network except using the phone's WiFi connection.

Combining Starlink with a WiFi Mesh Network is a simple means of extending mobile voice and high-speed data across farms. VoWiFi mobile services can be propagated across even complex point to multipoint networks, allowing the creation of even very large networks across large geographical areas.

*Figure 9 – Starlink + WiFi covering 250 m radius with voice, text, and data services*

In the above example, Starlink provided Telstra/Optus/Vodafone voice, text, and data services using VoWiFi, by connecting through a central highpoint which using a Cambium multipoint radio distributed connectivity down to each paddock where a receiving dish and WiFi access point provided coverage within about a 250 metre radius from the station. A 12 Vdc solar system was used to power the equipment.

The limit of this technology however is that establishing large scale networks is a fundamentally complex process. While lower cost from an OPEX perspective, the steep learning curve may lead the agricultural sector to bypass the construction of multipoint networks and simply deploy a large quantity of Starlink units.

### 5.2.2 LEO IoT Technologies

Sensor networks can make use of LEO constellations much more cost effectively. There are several LEO IoT constellations currently providing global connectivity, such as Myriota, Swarm, and Sateliot. These constellations are cheaper and simpler to maintain due to the intermittent connectivity and low data rates required by IoT devices. These satellites typically pass overhead once per hour, sufficient for most IoT use-cases.

This relatively new technology has tremendous benefit to the Australian agricultural sector as prior to its availability Powertec like many others had to erect large towers, power systems, and wireless networks. The approach was to use a LoRa transmission over the 915 to 928 MHz ISM band which could create sensor coverage to a radius of about 5 to 25 km depending on tower height.

Due to the large CAPEX requirements and IT nature of these projects, farmers were often faced with an economics problem. Working the numbers it was frequently cheaper to send a farm hand out to monitor assets manually than to implement and maintain complex technology.

The introduction of LEO IoT has eliminated the need for expensive infrastructure builds as devices now need only have view of the sky in order to successfully communicate.

*Figure 10 - LoRa IoT base station in remote Northern Territory*

LEO IoT constellations themselves are not protected from being rendered technically redundant and as such farmers need to remain extremely vigilant and perform due diligence before investing in a platform. Swarm, a popular LEO IoT now operated by SpaceX, is facing major competitive threat from 3GPP standardised players like Sateliot. Swarm uses a LoRa-over-VHF transmission which requires proprietary modems to be installed compatible with the network. Sateliot however provides an industry standard cellular NB-IoT service which not only allows users to bring their own off-the-shelf device, but provides roaming between terrestrial networks such as the NB-IoT networks of Telstra, Optus, and Vodafone.

Although not yet available in Australia, this technology will allow farmers to purchase off-the-shelf and low-cost soil probes, weather stations, level sensors, actuators, etc., without worrying about the connectivity problem.

### 5.2.3 LEO Non-Terrestrial Networks

One of the most exciting advances in LEO technology is the development of cellular Non-Terrestrial Networks. These networks can be thought simply of a constellation of cell towers in orbit providing ordinary 4G-5G connectivity to ordinary smartphones and modems.

While there are several LEO companies developing these networks, the two more advanced of which are Starlink and AST SpaceMobile.

Starlink intends on using its existing Gen2 satellite design to provide 4G mobile voice and text services over the 2 GHz band (currently LTE Band 25 in USA during its initial test phase). Starlink expect to provide global voice and text messaging services, data speeds however will be extremely limited with the technology only capable of providing a maximum of 4.4 Mb/s DL & 3.0 Mb/s UL for areas with a 1.4 MHz channel, and 18.3 Mb/s DL & 7.2 Mb/s UL for areas with a 5 MHz channel. These data speeds however are shared between all users within the cell radius, which is currently estimated to be about 20 km from FCC filings.

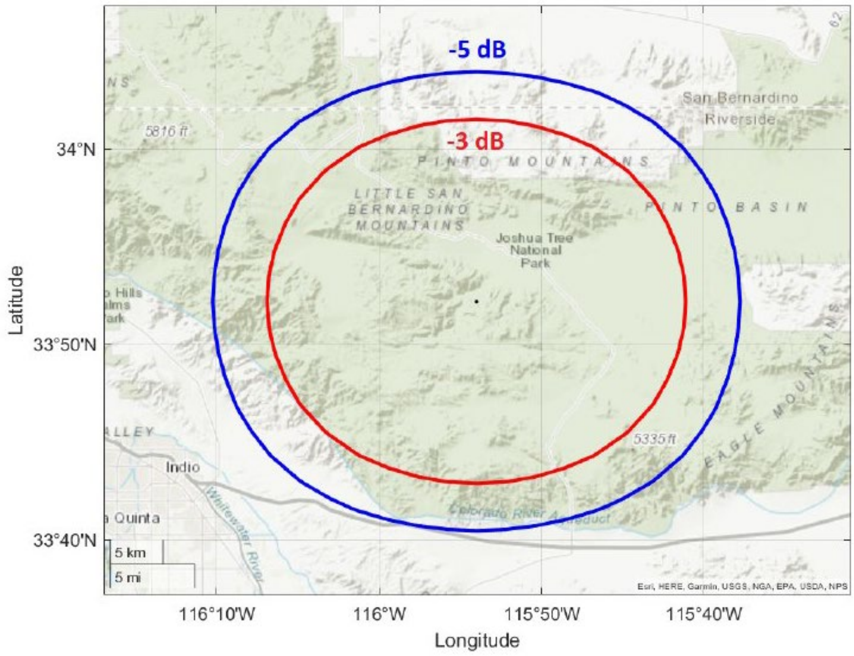


*Figure 11 - Starlink 2 GHz Cell Radius*

Accordingly, Starlink is expected to provide global 4G voice and text services, internet services however are expected to be of equivalent quality to 2G and early 3G networks. The timeline for coverage from +58 to -58 degrees (i.e., excluding the earth's most northern and southern regions) is reported to be mid-2024.

By establishing a roaming agreement, Starlink's 4G NTN enables network operators to provide near 100% geographical coverage while simultaneously divesting from poor performing regional infrastructure such as towers operated at a financial loss. Accordingly it is expected that Australian mobile networks will establish agreements whereby users moving beyond the range of the ordinary Telstra/Optus/Vodafone network will automatically connect to Starlink's network.

A potential competitor to Starlink is AST SpaceMobile who intend on creating global internet connectivity direct to handset through the use of large Massive MIMO arrays. AST's prototype BlueWalker 3, launched in September 2022, is a 64 $m^2$ (10 metre diameter) satellite which expects to provide speeds as high as 30 Mb/s DL and 3 Mb/s UL direct to ordinary 4G mobile phones and modems using a combination of low and mid-band frequencies.

While AST's technology has the capability of providing superior performance, there are concerns about the company's ability to execute given their reliance on SpaceX to conduct launches on its behalf. With Starlink conducting a continuous stream of generation upgrades and launches it is also unclear whether at some point Starlink may evolve quicker than AST can build a full constellation.

While the future cannot be known, it is clear that ubiquitous mobile voice and data connectivity is well on its way and expected to revolutionise connectivity for Australian farmers in a few short years. Accordingly, any investment undertaken by the Department needs to focus on the immediate term (1 to 3 years) needs of farmers rather than developing long-term solutions.

## 5.3 MOBILE PRIVATE NETWORKS (MPN)

Mobile Private Networks are commonly referred to as Private LTE networks. Implementing an MPN involves obtaining a spectrum licence and operating a small-scale mobile network by installing a set of servers which operate as a core network and then one or more ‘cell towers’.

MPNs can be built both small and large, which when assessing its suitability for the agricultural sector Powertec loosely divides into Local MPN and Multi-site MPN based on available budget.

### 5.3.1 Multi-site MPN

Multi-site MPN refers to a traditional Private LTE network whereby a core network is built and then several cell towers are deployed. The typical cost to deploy a 4G-5G core network is upwards of $500,000, with the cost per cell tower starting at $150,000. Accordingly this is largely unaffordable for single-site farming operations and as such is a solution more appropriate for agricultural conglomerates which can share the deployment cost of the core network across multiple properties.

Historically, due to unavailability of high speed backhaul this technology was out of reach to the agricultural sector. The launch of Starlink’s business grade internet services allow cell towers to now be deployed at any arbitrary location, particularly in combination with off-grid power.

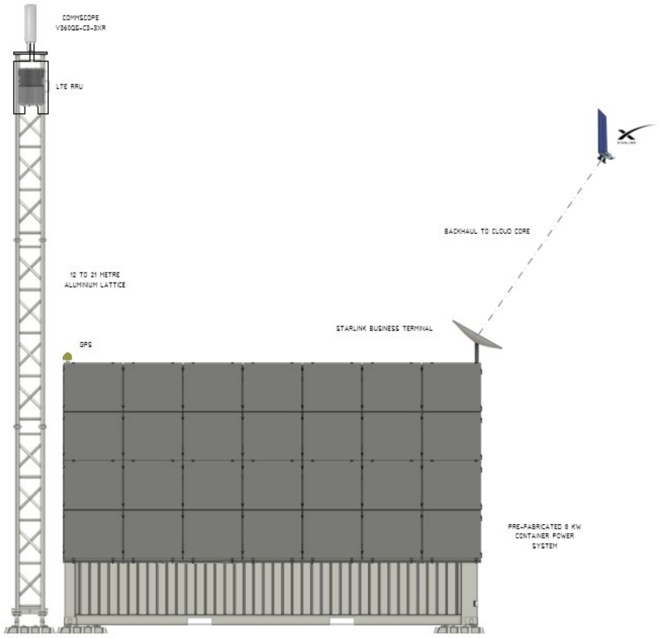


*Figure 12 - Typical off-grid MPN site*

While the challenges of remote voice and data connectivity are likely to be solved by LEO NTNs in the coming few years, data speeds and latencies will however be restricted by the limitations inherent to communicating with satellites 500 to 2000 km away. As such applications which require higher throughputs are likely to continue requiring MPNs and the technology will grow in relevance to future-focused digital agriculture businesses.

As the technology matures MPNs are expected to trend lower in cost over time and demand for mobile data to continue its rapid acceleration, making the technology more in reach of the agricultural sector over time.

### 5.3.2 Local MPN

Smaller farming operations are unlikely to be able to afford the cost to deploy a core network, but the need for high speed data remains. Local MPNs fill this gap by enabling farmers to deploy small scale base stations that provide voice and data connectivity to a radius of around 2 to 3 kilometres per cell tower depending on the spectrum available in the area.

The hardware and software driving Local MPNs is Software Defined Radio (SDR) which can be either DIY open-source or vendor-specific depending on the technical appetite of the client.

Being a more lightweight low-cost technology, Local MPNs can support fewer simultaneous devices and generally don’t support any sort of interconnection, i.e., receiving/calling mobile phones or landlines outside of the network is not possible.

*Figure 13 – Typical Local MPN Radio Unit*

A major challenge limiting the uptake of Local MPNs in the agricultural sector is the lack of available spectrum for licencing. Typically only narrow channels of the B1, B3, and B39 bands are available in regional areas, which being the 1800 and 2100 MHz mid-bands face reduced coverage range and penetration through vegetation.

The Department could assist farmers by petitioning the ACMA in opening up low-band spectrum, particularly with planned review of the 600 MHz band (617 to 698 MHz), or following a US-style CBRS approach to reduce the complexity associated with spectrum licencing in remote areas. Another approach could be to investigate licencing of the 450 to 470 MHz UHF band for LTE450, although a limited device ecosystem would reduce its feasibility.

### 5.3.3 Place-based networks

The third option open to farmers is engaging a partner who has already undertaken the expense of deploying a network core. Companies such as Powertec’s partner Field Solutions Group (FSG) specialise in the construction of place-based mobile networks. Under this type of arrangement Powertec and FSG arrange all licencing and construct one or more cell towers on the agricultural property which are connected back to a core network which FSG operates centrally.

This approach allows the farmer to trade-off the ~$500,000 spend on deploying and managing their own core, for more manageable monthly access fees per device. As a licenced Carriage Service Provider (CSP) FSG can also provide interconnectivity, allowing inbound/outbound calling beyond the network itself which is unavailable with Multi-Site and Local MPNs.

## 5.4 WIRELESS MESH NETWORKS

Wireless Mesh Networks are used to extend connectivity across the farm using licence-free spectrum in the 900 MHz, 2.4, and 5 GHz bands. The most common and familiar form of wireless mesh is WiFi.

While frequency bands are similar to that of cellular technology, coverage from a WiFi access point is dramatically shorter in distance. This is due to a combination of transmit power limits imposed by the ACMA (4 W EIRP) and the receive sensitivity of mass-manufactured 802.11 chipsets. For 802.11n/ac devices this range was typically at most a 200 metre radius. For 802.11ax WiFi-6 devices the useable range has been extended to about 400 metres due to advancement in multi-antenna technology and receive sensitivity.

WiFi has the advantage of providing seamless handover between access points, allowing WiFi networks to be expanded as large as required. Interconnectivity between WiFi access points is generally achieved using point to multipoint links using sectors and dish receivers. Links can be designed to cover distances as far as the farmer’s budget will permit, typically up to 15 kilometres can be achieved with relative cost effectiveness using the 5 GHz licence-free band.

With multipoint technology lacking the ability to hand-off between sectors and needing to make use of high gain highly directional antennas, these links can only be deployed in a fixed stationary manner. As such WiFi solutions generally don’t have any sort of vehicular mobility without making use of a different form of backhaul like 4G or Starlink.

Where mobility is however desired, Powetec can implement a proprietary Wireless Mesh technology developed by Rajant Corporation. Rajant is a true mesh system whereby any node can communicate with any node, through any intermediate node, over any available frequency band. While its high cost has historically seen the product most popular in the mining sector, with digital agriculture becoming a greater focus Powertec believe the technology can provide major benefit to farmers.

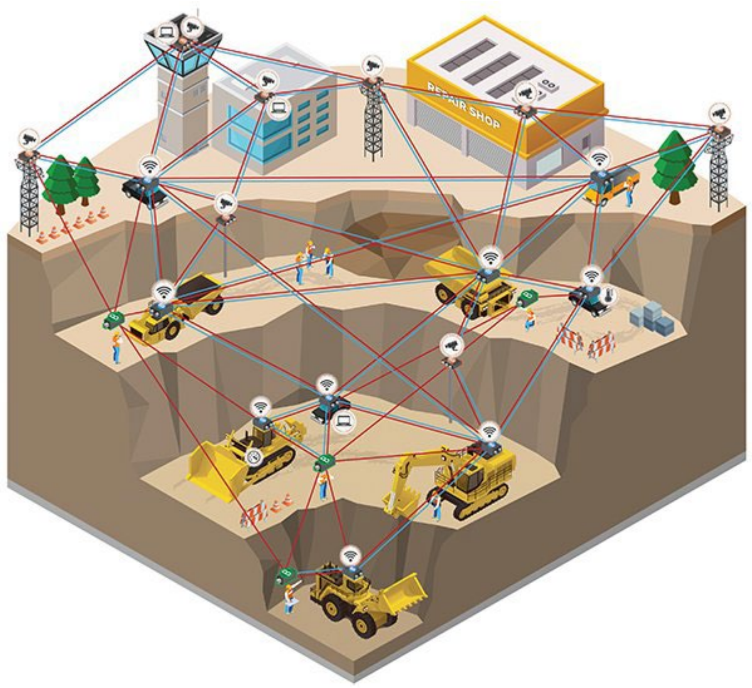


*Figure 14 - Rajant nodes communicating through any means necessary*

Of the technologies immediately and affordably available to farmers, Rajant stands out as the only method of achieving high quality connectivity to workers, vehicles, and equipment whether the application is stationary or in-motion.

As a self-organising network, a farmer can construct a series of solar powered nodes placed around the property without having to conduct tedious alignments. These nodes would ensure any vehicle or plant equipment moving on the property remained in constant contact. The farmer does not need to concern themselves with how or by what path the data will reach the desired destination, provided there are a sufficient number of nodes in range of each other.

Rajant was developed for the US Department of Defence who sought an extremely durable self-configuring, self-organising, and self-healing mesh technology that was deployable by entry-level personnel. While Australian farmers no doubt have the skill to learn how to deploy complex wireless networks, rarely do they have the time to learn.

This military-grade technology does however come at a higher price, with nodes ranging anywhere from $4,000 to $10,000 each. While still affordable in comparison to other technologies mentioned in this document, Rajant would be well suited to the proposed 50% rebate offered under the Program.

The Department could also assist the range and effectiveness of radios operating on the 900 MHz licence-free band by providing conditions permitting the current EIRP limit of 1 W to be increased in remote areas. This would serve to provide greater mobility and meshing capabilities of a technology like Rajant, as well as opening up the potential of other long range 900 MHz technologies currently in development such as 802.11ah Ha-Low.

# 6 SUMMARY

Powertec has outlined the current technologies available to Australian farmers, and provided its view on where wireless technologies are headed in the near future. The Department is urged to consider the benefits and limitations of each technology as part of the Program's development. With the industry evolving rapidly, this serves to ensure the public's money is invested into technologies which have long term value and ensures Australian farming community is lead towards solutions which are practical, current, and sensible.

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