Rural Communications Infrastructure

Options to improve rural connectivity and harness opportunities that this creates

A report for

By Jock Graham

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Executive Summary

Network Congestion is the major issue that affects many rural users using Interim NBN satellite and 3G services in peak times (4pm-12pm) averaging download speeds less the 2mbps (RICS Survey, 2015)

In 2015 40% of all rural users currently use 3G/4G as their primary home internet and pay on average the highest monthly rate for service and receive the least amount of data allowance for this (RICS survey, 2015).

The key technologies that are now becoming available to provide high speed connectivity to rural communities are fixed wireless, satellite, 4G mobile coverage, and to more populated areas, fibre to the node or house.

The best option for rural users who have no access to fibre is fixed wireless (either NBN or private) as this technology can deliver the fastest speeds, high data allowance plans with the lowest latency and cheapest monthly cost.

Mobile 4G service offers a great service for mobile use when in a coverage area in terms of speed but is not recommended for home broadband due to the high data plan costs and the congestion that occurs in peak times.

NBN Satellite (Sky muster) is the next best option for rural users, being accessible from any rural location, offers good download and upload speeds, and plan pricing, but has limited data allowances and high latency compared to fixed wireless.

The use of private networks run either by businesses, communities or individuals are the key to linking rural communities to faster, low latency, high data allowance internet services.

There are two key technologies available to improve in-home mobile coverage; being a femtocell device (offered by Optus) and Cel-fi devices (available on any carrier network to boost signal).

Voice over Wi-Fi is the new smart phone protocol that allows standard mobile calls to be made over Wi-Fi when mobile service is not available or weak, which is a great solution to poor mobile coverage in rural dwellings

Internet of Things devices (IoT) and farm sensors can start to be implemented across the farm, monitoring water levels, soil moisture, livestock locations and other valued information at low cost. Other areas that could particularly benefit are the transfer of precision farming data in large volumes being uploaded and the introduction of automated machinery.

Key benefits for the rural community include bringing about a level playing field and access to various online business tools; health access benefits; education benefits; and greater ability to use the resource for social reasons.

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Foreword

I am a fourth generation farmer from Coolac, NSW, Australia which is located in the south west slopes of NSW and operate a mixed family farm operation of angus cattle, merino sheep, mixed crops and a sand quarrying operation over 3600 hectares.

After completing a degree in Agricultural Economics in 2004, and working in Sydney for a few years, I moved back to the family farm in 2007. I am passionate about the use of technology in agriculture to increase productive capacity and the efficient use of resources.

This passion brought about the creation of a new start up app development company called Farm Apps in 2011 which creates smart phone apps, in particular F-track Live, to increase farming efficiency. The F-track system allows entry of data across multiple enterprises and is integrated with remote device feeds for on farm monitoring of water levels, stock movements and weather conditions.

In 2015, I was awarded a Nuffield Scholarship to research new technology solutions available to provide high-speed internet and better communications to rural and regional users. Through this research I have been able to trial new technology solutions for fast broadband in our local area and have setup point to point and multipoint wireless networks that have made this possible.

Connectivity for rural areas is a topic which I have been passionate about for many years and I believe that most farming families and businesses can improve the way they utilise communication technology. Once we have better communication infrastructure we can utilise the advancements made in automation and remote sensors.

My travels on the Nuffield adventure took me to amazing places including China, Philippines, Canada, USA, Ireland, France, England, Switzerland and Singapore. As part of this travel I met with many stakeholders in the agricultural sector abroad from large-scale dairies, organic farms, mainstream cropping and various technology businesses.

Acknowledgments

I would like to thank all those people that allowed me to undertake this project.

In particular my investor GRDC, my brother James and father Jim for running our family business in my absence.

And to my wonderful wife Kate, and two little girls Sophie and Eliza thank you for your patience and understanding, it was quite a journey.

Abbreviations

Mbps -Megabits per second. 8 megabits make up a megabyte

MB/s -Megabyte per second. 1 megabyte = 8 megabits (typical unit used for computer files)

Ms -Milliseconds (measurement of latency)

DSL -Digital subscriber line

ADSL -Asymmetric Digital subscriber line

LAN -Local Area Network

LTE -Long–Term Evolution

PTP -Point To Point

PTMP -Point to Multi–Point

VoIP -Voice over Internet Protocol

Wi-Fi -Wireless local area network (WLAN) products based IEEE 802.11 standards

WiMAX -Worldwide Interoperability for Microwave Access

VPN -Virtual Private Network

NBN – National Broadband Network

UAV – Unmanned Aerial Vehicle

Objectives

- Identify the current state of broadband connectivity in rural areas domestically and internationally.
- Identify key technologies that are available to provide high speed broadband to rural areas and analyse their cost / benefits for use and implementation.
- Identify key technologies to extend the coverage of mobile communications and analyse their cost / benefits for use and implementation.
- Identify new technologies that are enabled through the use of high speed internet connectivity.

Chapter 1: Introduction to rural communications

Understanding Connectivity

Before we get too far in examining rural communications infrastructure and its opportunities we first need to understand the very nature of measurements that are used to measure connectivity. Below are some simple explanations of the units often used.

Download speeds – Measures speed of a megabit to be received on your computer, typically rural Australia average less than 5mbps currently (Nuffield Survey, 2015)

Upload Speed – Measures speed of a megabit transmitted from your computer, typically rural Australia average less than 2 mbps (Nuffield survey, 2015)

Latency – is the time in milliseconds that is takes for data to be transferred from point A to point B. Fibre, copper or wireless average between 10-50 and satellite 600-800ms.

Mbps – Megabits per second. 8 megabits make up a megabyte

MB/s – Megabyte per second. 1 megabyte = 8 megabits (typical measurement used for computer files)

Jitter – The amount of dropped packets of data that are originally sent

Symmetrical service – Equal upload and download service

Asymmetric service – Unequal upload and download service (typically higher download capability to upload, i.e. (ADSL2+ 20mbps download and 1 mbps upload)

Backhaul – Main Internet delivery link that connects the distribution service points to the Internet, typically high capacity data throughput.

Rural Connectivity

High-speed rural connectivity all around the world is a common problem. In Australia, for instance, it is not uncommon for rural areas to be only serviced by 3G or satellite services that operate consistently below 1 mbps in download speed. Other remote and rural areas around the world largely remain unconnected to the Internet as they face challenges of attracting private sector investment (Kawasumi 2014). The current state of download speeds vary from location to location due to a multitude of factors some of which are determined by population density, landscape, access to infrastructure and their political situation. Identifying the current state of internet services locally and abroad will give us a good basis on which new technologies can dramatically improve their situation.

The key technologies that drive the ever increasing connected world are primarily access to fibre as the main transient conduit due to its high capacity and low latency to transmit data to any point in the world. Connecting to this are the last delivery methods, which can be ethernet, fibre, fixed wireless, ADSL, dial up, coaxial cable, 3G/4G or satellite services. A combination of these various methods are used throughout the world due to existing infrastructure from previous generations and advancement in modern delivery methods. These delivery options will

be explained in detail and critically examined to identify when and where they are most appropriate to deliver the best outcome for the end user.

With internet being a driving force behind business, so too is voice and mobile communication and having mobile coverage is essential for any rural business to be time efficient with communications and having access to modern day technologies. Accessing mobile services in rural areas can be difficult if they a situated away from large population areas as typically a telco cannot justify the business case to improve them. This leaves the rural community with very little resources other than political pressure to improve the mobile service as the telecommunication companies own the transmitting frequency so are the only ones that can implement the service. Even though this is the overarching problem, new technologies have emerged to improve mobile service in the home, with devices that boast the mobile signal over a short range or devices that use internet connectivity to convert to mobile frequencies.

When high speed communication infrastructure is available for rural users, the key question is what can we do with it? Obvious areas that it can be utilised are to improve business efficiency, being able to access cloud services, online information, access to markets etc. But further to this, it opens the door to a multitude of opportunities previously out of reach, such as farm sensor networks, livestock tracking, real time precision farming, driverless tractors and autonomous drones. Emphasis is often on download speeds but greater access to upload capacity for rural users could drive further development for new technologies utilising high resolution images or applications requiring large data storages. The requirement for large upload capacity was also highlighted in a meeting with James Szasbo stating that it is desperately needed to allow large data files to be transmitted such as precision farming data in real time, so access to symmetrical data services is key (Szasbo, 2016).

The other major areas to benefit are rural services such as education, health, environmental and social benefits from being able to access resources from home that were previously unobtainable. The education benefits that can be achieved include access to distance education, through real time classes, high definition conferencing, online activities and large file transfers. Health benefits will come from access to growing online medical services such as patient to doctor video conferencing, access to online medical histories and medical tests. Environmental benefits come in the form of access to early warning mechanisms for weather, fire and disease outbreaks and social benefits from online streaming of services and social media.

Chapter 2: Current level of connectivity

Domestic Review

Internet download rates in Australia are growing at over 20% each six months for fixed line services and 13% for wireless services (ABS, 2015). This strong growth rate depicts the trend in internet usage that users are requiring more and more data via the internet and the trend is unlikely to slow down. This kind of demand has pressured the capacity of internet providers to keep up with the growing demand.

The number of subscribers that accessed the internet at an advertised download speed of 8Mbps or greater increased by 23% to 10.2 million subscribers between June 2014 and June 2015 (ABS, 2015). This is a significant increase that can be attributed to the improvements in access to services that the NBN is providing. As might be expected over the same period there was a 40% reduction in users recorded with speeds less than 8mbps and a similar fall for those less than 1.5mbps to 2.4 million and 147,000 respectively (ABS, 2015). The current trend is heading in the right direction to improve internet speeds but needs to close the gap between the disparity that exists between the city and the country users.

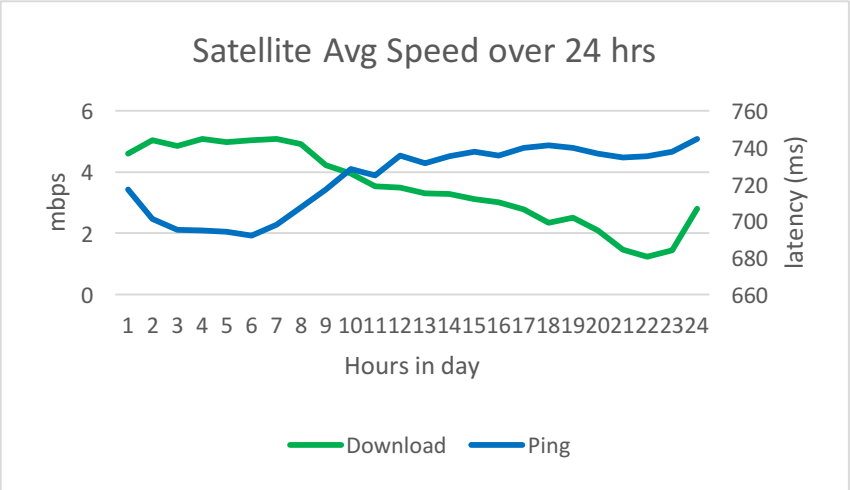
Rural Internet Connection Survey (RICS) – Domestic Results

As part of this research paper two research methods were undertaken, firstly a 21-day download speed experiment on three internet speed types in Australia and secondly an online survey undertaken in June 2015, that had 19 questions to identify the status of the respondents internet access. The experiment to test internet speed was conducted in Dec 2014, comparing ADSL2+ via wireless point to point network, 3G and NBN interim Satellite in the regional area at Coolac NSW. The first trial was conducted to understand the problems and possible solutions at the local level and is a good basis point for rural communications. The second survey analysis was to expand the understanding of communication issues from all rural areas domestically and internationally, which was well supported from the international Nuffield network.

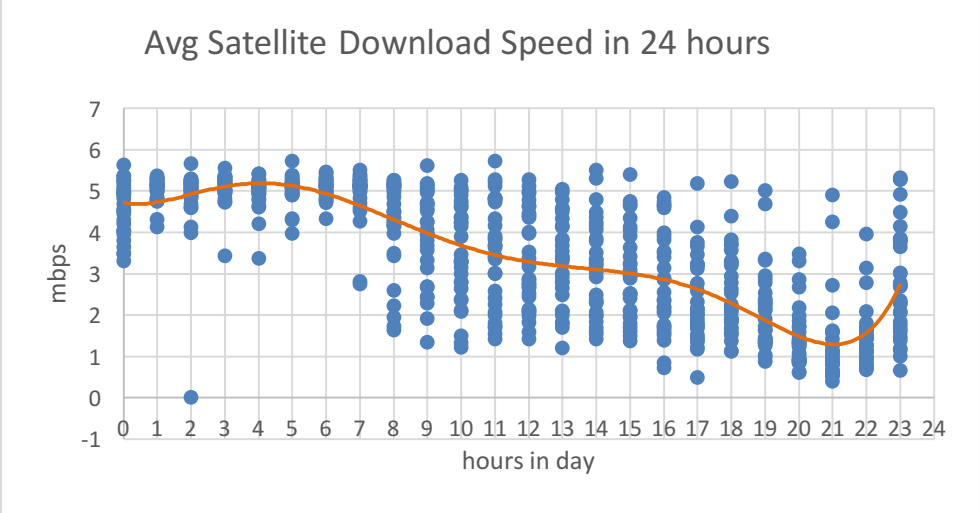
Download speed trial

NBN interim satellite results

Data was collected over a 21-day period every 30 minutes between 10/12/2014 - 31/12/2014 testing download speed and latency. Full results are available at request, summary is below.



The collated results of the trial show that the average download rate across all periods recorded was 3.48 mbps with an average latency 723 ms. This can be further split into three time groups to show variation of service in the table below. Non peak periods had almost 5 mbps download but peak periods it dropped to 2mbps and latency results never dropped below 700 ms which caused a lag in responsive time for the user compared to other connection methods.

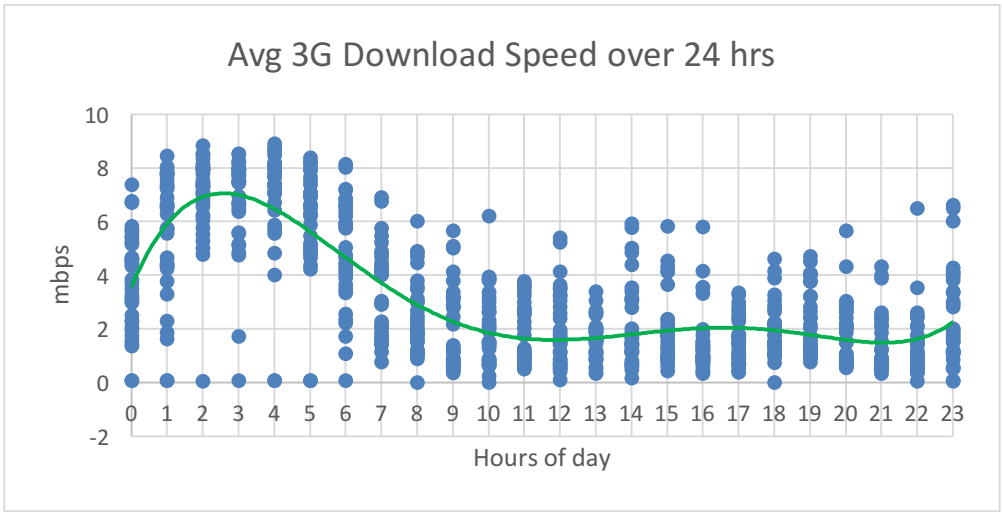


Above is the plot graph for download speed testing showing poor performance in peak periods and a maximum speed of 5 mbps in non-peak periods.

Telstra 3G results

Below is a graph of the average download speed from the Telstra tower near Gundagai (Dog on the tuckerbox) over 24hrs, data was collected over a 21 day period, every 30 minutes between 10/12/2014 - 31/12/2014. Full results are available at request, summary is below.

Times Averages	**Avg Download Rates (mbps)**	**Avg Latency (ms)**
12am – 8am	4.87	700
8am – 4pm	3.30	734
4pm – 12am	1.97	739



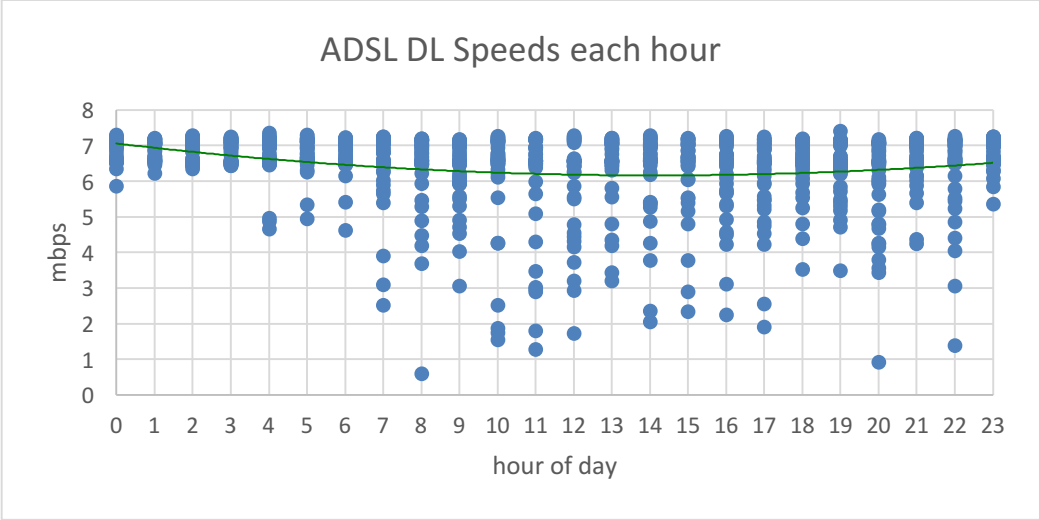
Times Averages	Avg Download Rates (mbps)	Avg Latency (ms)
12am – 8am	5.16	76
8am – 4pm	1.89	101
4pm – 12am	1.82	104

The graph and table above shows that there is enormous congestion of the mobile tower between 10am till 10pm, with the average download speed at just 1.8 mbps and many tests showing less than 0.8 mbps. The off peak periods between 12am and 8 am are far better averaging 5.2 mbps which demonstrates how the service could work if congestion was handled with extra capacity. As a home broadband service, a 3G connection is the most expensive connection available ($160/ 25gb/mth), which most rural users are forced to use. It is easy to see that not only do rural users pay the most but also receive a very poor service which could barely open a webpage in peak periods.

ADSL2+ results

(Figure 1)

In an ongoing trial established in Nov 2014, an ADSL2+ connection 14km away is being connected to a rural business via 2 sets of directional point-to-point radios that are relayed from a solar powered communications pole between the sites (figure 1). In the graph below it can be seen that on average the download speed was 6.4 mbps and it didn't vary much from this range. The data collected for this graph was taken every half hour over multiple 24 hr. periods, specifically 10/12/2014 - 31/12/2014, even under heavy use. Please note the ADSL2+ connection used in town for this trial had a max speed of 7.5 mbps due to the distance from the exchange.



When the results were collated into the three time zones very little difference can be seen in speeds and latency. When compared to the two other trials this connection had the highest average speed and lowest latency and all times.

When looking at the results together over this 21-day period the best performing option was the ADSL2+ connection for speed and latency over the directional wireless link. The results also highlight the average service levels of the various connection methods falling dramatically at peak consumer need periods i.e. (both NBN and 3G below 2mbps between 4pm and 12am). Essentially this shows that both these services are over capacity for the allowable bandwidth and customers using them. For the Satellite service it seems to be the issue that too many people subscribed to the service, but for 3G it is influenced by the amount of people passing through the immediate area at any given time.

Period	**NBN Satellite**		**3G**		**ADSL2+**	
	Download mbps	Latency ms	Download mbps	Latency ms	Download mbps	Latency ms
12am – 8am	4.87	700	5.16	76	6.7	51
8am – 4pm	3.3	734	1.89	101	6.13	55
4pm – 12am	1.97	739	1.82	104	6.34	54

A vital comparison here is that the ADSL service is a managed service with only a limited number of people connected to this service, which better manages the capacity problems and essentially gives a more consistent reliable service as opposed to 3G. If we analyse latency the satellite service is on average 10 times slower that ADSL or 3G, which makes instantaneous communication almost impossible to achieve (i.e. Skype, VoIP services).

Rural Internet Connection Survey (RICS) - Internet Survey

The online survey targeted rural and regional users all around Australia as well as international users, and had 351 respondents, with half coming from Australia (Graham, 2015). It was distributed via social media, rural based advocacy groups and through contacts made as part of the scholarship program internationally.

Times Averages	Avg Download Rates (mbps)	Avg Latency (ms)
12am – 8am	6.7	51
8am – 4pm	6.13	55
4pm – 12am	6.34	54

Types of Internet connections

Type of Internet connection	# of users	% of users
Cable / Fibre	4	2%
Fixed Wireless	37	19%
Mobile Broadband	78	39%
Phone line (DSL connection)	23	12%
Satellite	56	29%
Total	199	100%

The most popular Internet connection method from these results is mobile broadband with 40% of the survey group connecting to the Internet this way. The next most popular was satellite at 30%, with fixed wireless and ADSL being 20% and 10% respectively. These results show that 3G/4G coverage is the most utilised connection method for home broadband in rural and regional areas currently, but with the introduction of the NBN network this breakup is likely to change considerably. In the next few years there should be a rise in satellite and fixed wireless connections and a fall in mobile broadband as the primary internet source due the NBN expansion.

Download / Upload Speeds and Latency

Download speed (Mbps)	# of people	% of people	Avg D/L speed (mbps)	Avg U/L (mbps)	Avg Lat 3G (ms)	Avg Lat Sat (ms)
Group1 - 0 to 1.5	52	27%	0.70	0.42	66.36	903.13
Group2 - 1.5 to 8	108	55%	3.91	0.80	59.89	660.45
Group3 - 8+	35	18%	21.93	4.82	43.27	-
Total	195	100%	6.14	1.42	56.51	781

The information obtained from this survey identified 82% of Australian respondents (total 195) had independent download speed test results (Ookla speed test, 2015) of less than 8mbps and less than 1.50 mbps upload speed. When these results are compared to the statistics provided by ABS on subscribers achieving under 8 mbps, being 2.47m people (ABS, 2015) it is estimated that 82% are rural / regional users and estimated as (2.473m*82%) 2.03m people. This builds upon the case that over 2 million rural Internet customers are caught in a digital divide that is occurring between urban and rural users.

Based on the above table Group 1 had 27% of the respondents in the survey and they had, on average, less than 0.7 mbps download speeds and 0.42 upload, this is an extremely poor internet connection that would struggle to load most webpages. Half of the respondents in this group utilised a satellite connection and the above table shows that their average latency was 903 ms, which was the slowest result achieved in this survey. The other half of this group used a 3G connection which lowered their latency dramatically to 66ms but still the slowest compared to

the 2 other groups. Overall this group was the worst performing in all categories, their current service would severely restrict anything they wanted to do online.

Group 2 was the majority of the respondents (55%) and they achieved, on average, download speeds of 3.9 mbps and 0.8 upload speeds. This is also considered a very poor internet connection speed but would handle browsing of internet pages reasonably. In this group only a quarter utilised satellite connections achieving a latency of 660 ms which is more in line with a satellite service that is not functioning at full capacity. The majority (75%) of users in this group are using a 3G connection which improves their latency to be 60ms and could utilise VoIP services at this level. Overall this group as an average has the ability to browse internet pages with few problems, use VoIP services but would struggle to download large files and stream any online content.

Group 3 has the fewest respondents, with only 18% of the surveyed group. They achieved, on average, 22 mbps download speed and 4.8 upload, and these are fast connection speeds for rural areas. None of this group utilised a satellite service, 40% utilised 3G, 30% NBN fixed wireless 20% ADSL, and the remaining had a fibre connection. As all of this group used land based services the latency was very low at 43 ms making instantaneous communication very reliable with these connections. The average achieved speeds here would allow for great internet browsing, file downloading and online streaming of multiple services, this starts to show the impact of the NBN fixed wireless services.

Data usage

	# of users	Avg of Allowed D/L (GB)	Avg Monthly Cost	Avg Cost per GB
Cable / Fibre	4	613	$97.50	$0.16
Fixed Wireless	37	246	$88.16	$0.36
Mobile Broadband	78	17	$109.04	$6.47
Phone line (DSL connection)	23	345	$92.61	$0.27
Satellite	56	26	$63.81	$2.43
Grand Total	199			

A key part of current broadband plans available today involve data limitations for use each month. These data allowances vary based on the Internet connection method that the user connects through. In the table above the survey asked users how much data they received each month and the cost of their monthly plan. The monthly costs for all services are all within a $50 range of each other on an average monthly cost but the key statistic here is the cost per GB of data, with cable, fixed wireless and DSL all less than 40c per GB, but mobile data a staggering $6.50/GB. Satellite data is also comparatively very expensive at seven times the rate of fixed wireless (15 times that of fibre) but nowhere near as much as mobile data which costs 18 times more than fixed wireless or 40 times more than fibre.

National Broadband Network (NBN)

Now that the current level of connectivity has been identified domestically, it is very important to understand the role that the government funded NBN program is undertaking to improve national connectivity. Firstly, the NBN is a wholesale communications network, which is

designed to offer wholesale services to telephone and internet service providers who then sell products to everyday consumers. The NBN is creating a wholesale network with a variety of technologies that best suit each particular area on cost and benefit analysis, these technologies are constituted of various levels of fibre, fixed wireless and satellite.

Fibre – Highest speed internet connection

Fibre optic cable technology is the most preferred option to provided high speed broadband to every residence in Australia, as it is capable of supporting high amounts of bandwidth, with extremely low latency and loss of speed over long distances. It will replace much of the existing copper wire and HFC networks which use electricity to transfer data to run telecommunications services in Australia. It is by far the best solution to implement for high speed data networks, and some typical plans that are currently offered currently are:

- **100mbps download speed, 40mbps upload speed**
- **Fast latency**
- **Excellent plans $70 / unlimited**
- **VoIP accessible**
- **Unlimited capacity – Best option!**

Fixed Wireless

Fixed wireless technology uses fixed transmission towers or base stations to communicate 'over the air' (NBN, 2016) to businesses or residents. This technology uses the 2300 MHz spectrum and requires line of sight from the tower to the equipment at the home or business to work. It is capable of delivering up to 50 mbps down and 20 mbps upload although the standard plans are usually half this. These towers are usually connected to a fibre access point or high capacity wireless point-to-point backhaul link. As a rural solution this is one of the best options available as it can cover a radius area of 14km LOS and can be established very quickly to cover many users.

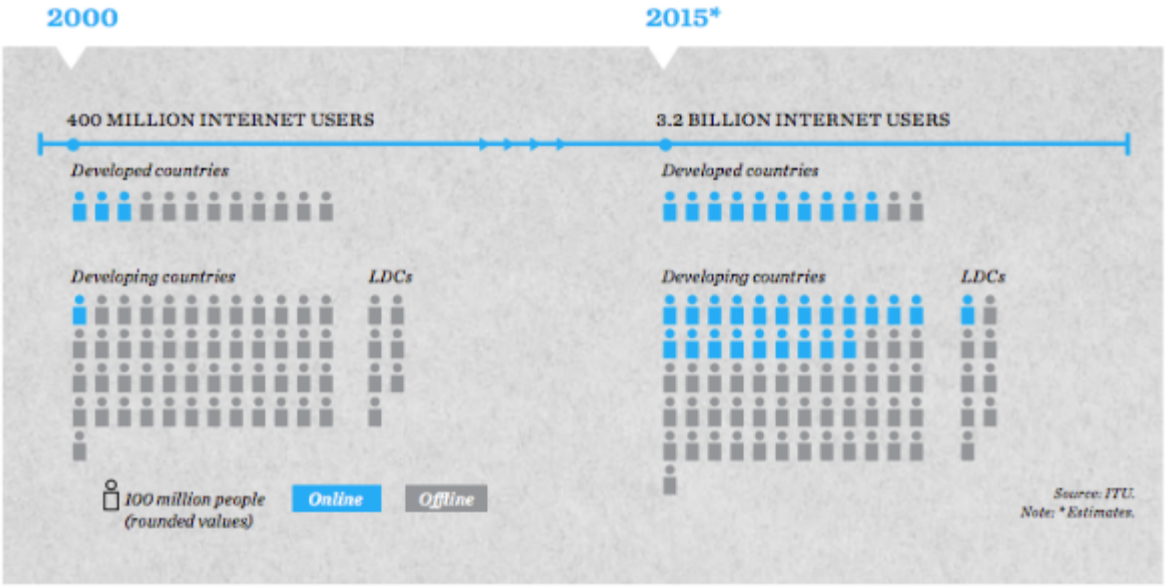
- **25mbps down, 5 mbps up**
- **Fast latency**
- **Great plans $80/ unlimited data**
- **VoIP accessible**
- **180 capacity per tower**
- **Best rural option**

Satellite

The NBN Satellite service is a newly created service that goes live in the 2nd quarter of 2016 and distributes Internet access via a recently launched satellite named Sky Muster (NBN, 2016). This is the solution designed for areas in Australia that are very remote and the cost benefit of delivering a land based service is too expensive. It has a capacity to service 200,000 customers and is offering speeds from 12 to 25mbps down and 5 up. This product offers the slowest latency of all the NBN services. Key points are:

- **12 or 25 mbps down, 1 or 5 mbps up**
- **Slow latency 700 ms, No VoIP**
- **Data plans up to 100GB**
- **200,000 capacity for Australia**

International Review



(ITU facts and figures, 2015)

In 2015 there was 3.2 billion internet users, two thirds of these people are from developing countries and the remaining from developed nations. This is in stark contrast to the 400 million users in the year 2000, from which 75% of all users were from developed countries. In 15 years the amount of users has grown eight times over and still there are over four billion people currently not connected in developing countries. If growth continues at this rate, we should have almost the entire population connected by 2030.

Rural Internet Connection Survey (RICS) – International Results

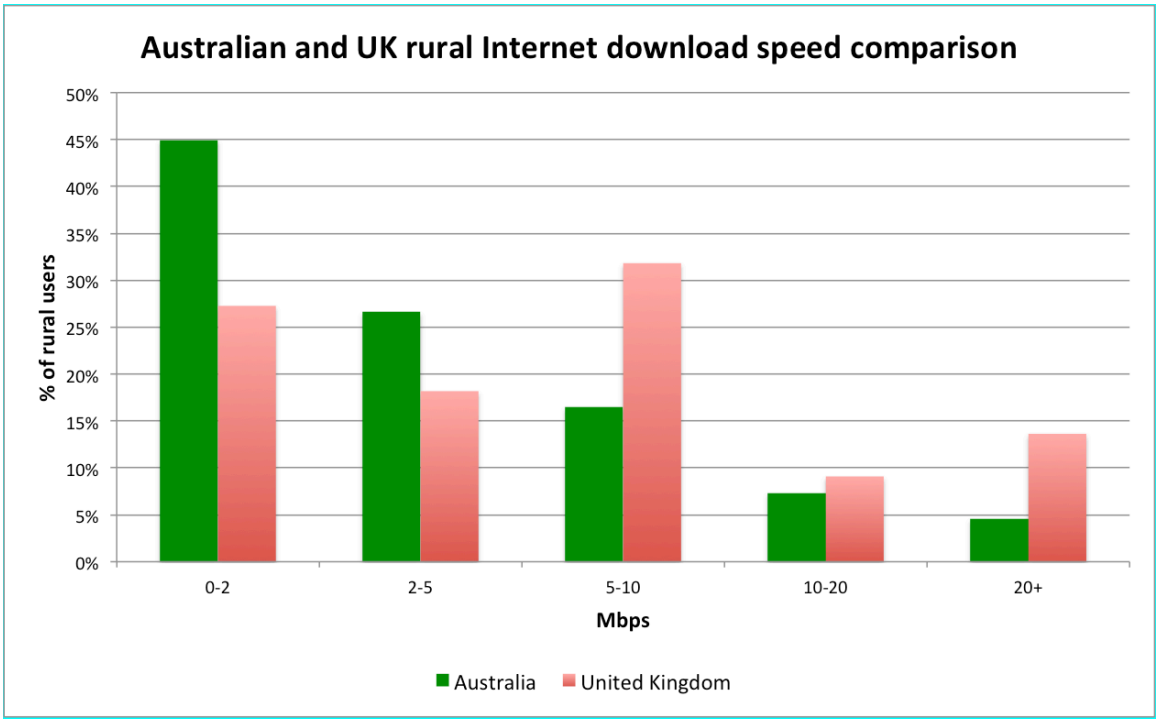
The survey undertaken on Internet usage as part of this research was conducted allowing overseas rural users to respond as well. Below are the collated results from all countries, with the UK having a good sample size but less reliance can be made from the three others due to the small sample size.

Results from Internet survey by country						
Countries	**Sample size**	**Avg D/L speed mbps**	**Avg U/L mbps**	**Avg Lat ms**	**Avg Monthly Cost ($AU)**	**Avg Cost per GB**
UK	75	9.91	3.65	85.41	$44.26	$0.03
Ireland	13	7.24	3.78	101.85	$33.31	$0.47
Canada	10	4.07	0.61	70.10	$75.27	$0.47
New Zealand	13	6.70	0.79	116.00	$101.15	$1.70
Australia	195	6.14	1.42	259.03	$91.04	$1.03

In analysing these results the UK and Ireland had the most similar outcomes with the highest average download speeds 10 and 7mbps respectively and the best upload speeds averaging 3.7mbps. This result, combined with the lowest latency average and low cost per GB is pointing towards a great amount of large capacity plans and services with access to fibre or cable. The monthly plan pricing (converted to Australian dollars) is half that of the average Australian or

New Zealand (NZ) plan and over half the price per GB of data. Australia also matched up with the biggest latency due to its reliance on satellite connections as a primary source for rural internet.

Below is a graph which more closely compares download speeds between rural Australian and UK users, 45% of all Australian respondents had less than 2mbps download compared to a quarter of the UK respondents. Similar results for the 2-5 mbps category comparatively but this turned around the more the speed categories increased with the UK having its highest percentage of people in the 5-10mbps category.



Chapter 3: Technology options

Broadband Delivery Technology

A key part of this study was to look not only at internet speeds but to identify all the available techniques that could deliver broadband to rural areas. Below is an analysis of these and some new technologies options becoming available.

Fibre

Is the best broadband delivery technology, due to its large capacity of data throughput, low attenuation, small cable size, and performance with very little interference. An optical fibre cable contains one or more optical fibres that are typically individually coated with plastic layers and used to carry light signals as means of data transfer (itu-d 2014). As light carries the data signals the latency of the service is very low sub 10 ms. There are various other terms to describe the use of fibre in the communications industry, mainly being to identify the extent to which fibre is connected in the infrastructure before another technology uses it.

- FTTB - (fibre to the building): The fiber is taken as far as the building, at which point technologies such as DSL, WiMAX, Wi-Fi, ethernet and so on takeover (last mile)
- FTTC (fibre to the curb): The fiber is laid as far as a distribution frame serving a group of buildings, and from there the list mile services take over.
- FTTH (fibre to the home): The fiber is taken as far as the user's home and supports very high data transfer. This is the best connection for any customer.
- FTTO (fibre to the office): The fiber arrives at the office, from where links are generally based on
  Ethernet or Wi-Fi technologies.
- FTTN (fibre to the node): The fiber reaches as far as the neighborhood and from there links with individual users are based on DSL, WiMAX, Wi-Fi, Ethernet and so on.
- FTTV (fibre to the village) is specifically related to rural and remote areas, in which topology the fiber is deployed as far as a node in/nearby the village and from there links are generally based on DSL or WiMAX technologies. (itu-d 2014)

As part of my Nuffield travel I met with Art Price, the CEO of the Axia Telecommunication group in Calgary, Canada who has established and runs a predominately fibre only network in Alberta. The benefits of rolling fibre out to every major regional center and linking in the major businesses in each town have been huge, creating a fast, well connected, inexpensive broadband platform for all its residents. Art's key message was that fibre is the key to a well performing broadband infrastructure plan and that it should be the first thing rolled out to every town in Australia. Once this is done, a level playing field is created, the digital divide is broken and private enterprise can effectively compete to service remaining residents through various last mile delivery methods (Price 2015).

ADSL 2+

ADSL2+ is the most common form of higher capacity, fixed line internet service for rural and regional towns based on copper lines delivering the service. In real life ADSL typically achieves 18mbps download speed and 0.9mbps upload speed. Standard ADSL connections uses a 1.1mhz frequency band to transmit its signal down a copper phone line and ADSL2+ doubles this to 2.2mhz to achieve double the download speed. Typically plans for this service are very

generous with data allowances over 1TB/mth or unlimited, and the latency of the product is very good around 20-40 ms.

A key problem with ADSL is that it is Asymmetrical in nature, so the majority of data is being directed one way, down towards the customer and only a small amount can flow upwards. It also dissipates the further it travels away from the telephone exchange, so if you are more than 6 km from the exchange your data rates would likely be less than 2mbps download. Multiple ASDL lines can be bonded together with specialised equipment and will increase bandwidth to the sum of the lines combined. Higher priced plans are offered for business customers than for consumer as these plans usually offer a less contended service (20:1) than a consumer service (50:1).

Fixed Wireless – NBN

Fixed wireless is one of the more recent forms of broadband delivery in Australia and is the preferred method of connecting up rural and regional areas where a fixed line connection cannot be achieved. The service is delivered at a specific frequency (NBN - 2.3 GHz) that the fixed wireless transmitting tower emits which the device on the customer's residence receives and converts into a usable high speed data connection. Theoretical speeds on this type of service are greater than 50 mbps each way but the maximum plans offered by the NBN are 50mbps down and 20mbps upload (NBN, 2016). This service has a maximum range of 14km LOS from the transmitting tower and good latency speeds typically between 30-50 ms.

This service is capable of delivering voice and data services, due to the low latency, high bandwidth nature of the service. Customers that can receive this service will have this option for all their existing copper phone line services transmitted via the fixed wireless connection. Some possible issues with the service include extreme weather degrading the signal; LOS obstructions over time; and power failure cutting the service all together. Most installations come with the option of a small uninterrupted power system (UPS) to run the client radio in the event of power failure.

Fixed Wireless – Private Networks

Fixed wireless technology is commonly available in unlicensed frequencies that can be utilised for private outdoor networks. They can deliver similar speeds and distances achieved in licenced spectrums but have more power restrictions on their use. This makes these products a great solution in regional areas to wireless connect remote locations to higher grade broadband services as they are inexpensive, extremely reliable, allow high throughput and located in typically low interference areas. The unlicensed spectrums that Australia allows are:

- 900 MHz (902 to 928 MHz)
- 2.4 GHz (2.4 to 2.4835 GHz)
- 5 GHz (5.15 to 5.35, 5.40- 5.72 (DFS), 5.735 to 5.825 GHz) (Enterprise Mobility, 2008)

Each range has different characteristics but follows the general principle that the lower the frequency, the better the range, but with lower bandwidth and vice versa for higher frequency.

The 2.4 GHz spectrum has been an unlicensed frequency for some time, so most wireless devices in the home use this but more recently some utilize 5 GHz for faster data speeds. Typically, these devices operate in the low 5 GHz spectrum due to the lower power regulations allowed for this range, suitable for indoor use. The higher 5.735 -5.85 Ghz frequencies are more suitable for outdoor use with better data transfer and higher power level allowances but are

susceptible to interference by anything in LOS of the signal. In rural environments the 5.8 GHz spectrum has huge potential to improve wireless connectivity due to low cost of available devices, long distances it can be transmitted and very little interference.

Licenced spectrums are typically in high demand with limited supply and as such are regulated and sold via spectrum auctions by ACMA. A spectrum licence authorises you to use a parcel of spectrum space - a particular frequency band within a particular geographic area - for a period of up to 15 years. (ACMA 2016). The main benefit of utilising licensed spectrum is that you have more flexibility to operate wireless services with greater power allowances and have rights to shut down any signal operating in that frequency in the licenced area. This gives wireless communication businesses security into the future to operate a service and reliable business model but can be an expensive cost for built up areas.

Point to Point networks

You can use unlicensed or licenced spectrum radios to create point to point networks which essentially are two radios connected together via a wireless link. Typically, they use two directional radios that are used to bridge networks together that range from a few hundred meters up to 20km (or longer). These links usually require LOS to be of the best quality and allow high throughput of data making them suitable to carry a networks backhaul data. It is also one of the cheapest alternatives to linking computer networks together over long distances and is one of the best methods for accessing higher speed internet services in remote locations.

As touched on above, private networks are the key to controlling and improving rural Australia's connectivity limitations as they extend the range and access from high grade services. A practical example of their use is with NBN fixed wireless, where coverage is accessible on the ridge of a property but the customer's house is situated in the valley. By linking the house to the ridge with a point-to-point network, where the NBN fixed wireless is accessible, that house can now access the full speeds delivered by that service and does not rely on a slower satellite product. A point to note too is that many possible networks might have limitations based on power availability but these sites should utilised solar / wind power as a viable option in these circumstances, due to low power requirements of radios.

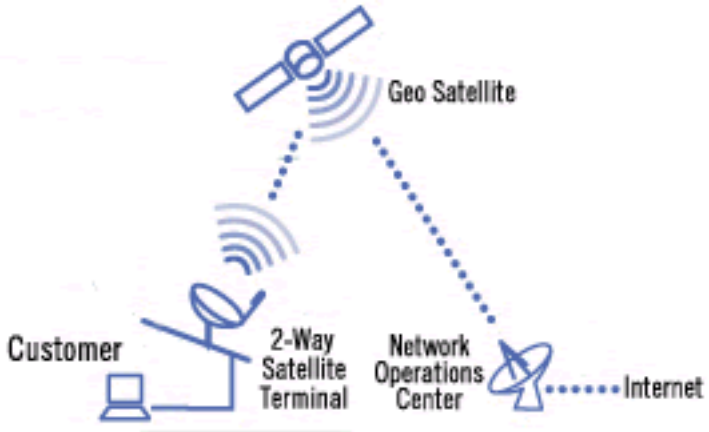
Point to multipoint networks

As the title suggests, this type of network broadcasts a wireless signal from its location into a surrounding area so that multiple clients can connect to it at the same time. This is the type of network design is used for distribution of mobile and wireless services whilst point to point networks are commonly used for backhaul purposes to support these point to multipoint sites. The key benefit when both these networks types are used together is access for those connected to better internet services. For example, these technologies can be utilised to connect small communities to existing faster internet services like NBN Fixed wireless / fibre when they are outside its nominated service range.

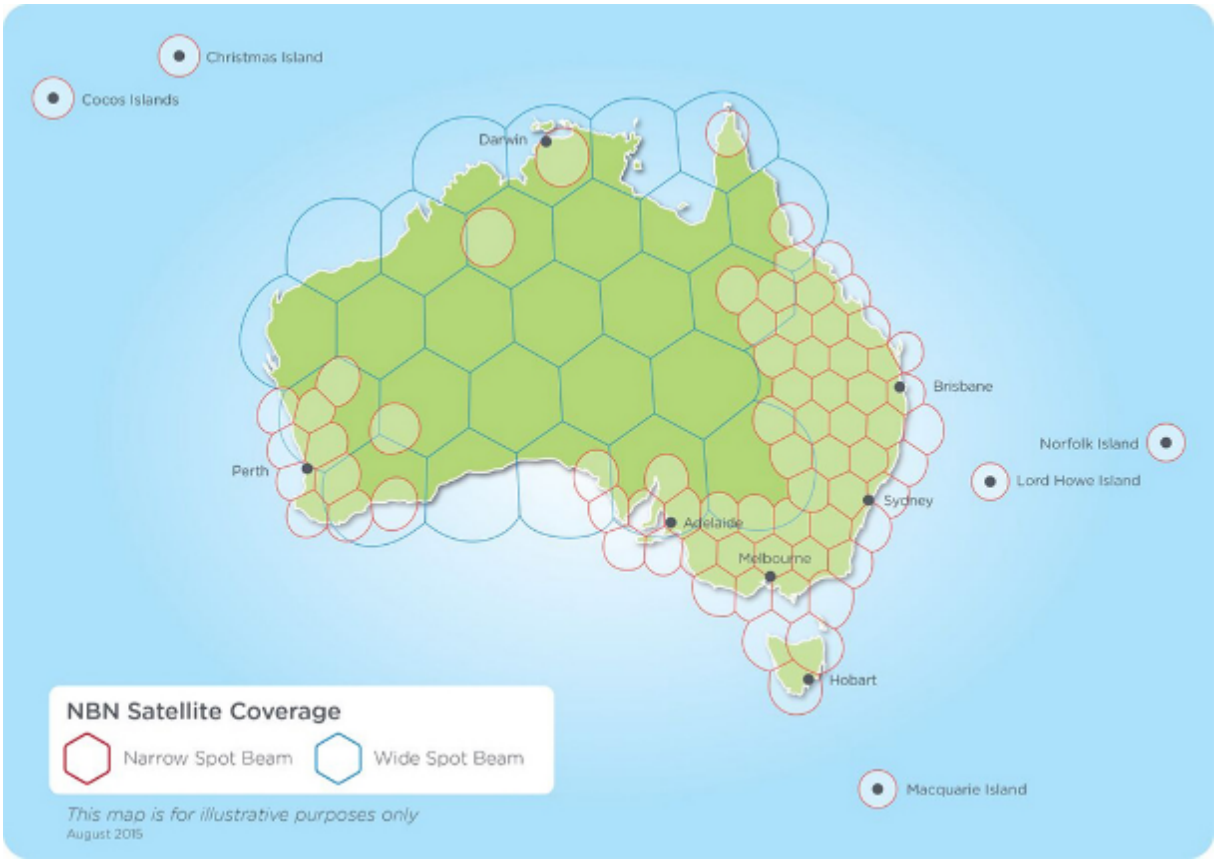
An example of a multipoint network could use the same technique described in the point to point network example but then connect multiple houses in the valley to the connection on the ridge. By doing this you effectively extend the range of the NBN service in your small community. Please note that there are some restrictions by ACMA when you provide a telecommunication service to other properties and customers, but private networks located on your own property for your own use have far less regulation requirements. Another example of an extensive multipoint network servicing rural areas was a business in the UK called Secure Web Services that I met in my travels, that uses the same technology and links up hundreds of rural clients into their network (New, 2015)

Satellite

Satellite internet transmits and receives data via a satellite dish on the customer's roof pointing at an orbiting geostationary satellite, 36,000km above earth. Essentially the satellite acts as a relay between a major ground facility called a Network Operations Centre (NOC). The NOC is connected to the internet and all communications are passed through this site before they go out to the Internet. After the initial setup, a satellite internet connection is very similar to ground based connections (connecting via a radio spectrum) with the only drawback being that it has a much higher latency due to the distance from earth.



The NBN satellite Sky Muster is positioned 140 degrees east longitude, and will be joined by a second satellite in the coming year to be situated at 145 degrees which provides redundancy options and further bandwidth. The Sky Muster satellite is designed with a life span of around 16 years, based on the amount of fuel it has on board to keep itself in orbit (Francis, 2016). To provide its service in Australia it utilizes 101 "spot beams" in the Ka band frequency that can roughly service 2000 people each, covering an estimate 220,000 people. This is a great service for the very remote areas where land based services are too expensive, and is expected to deliver speeds of 25mbps down and 5mbps up.



Australia's NBN satellite service is only one option when it comes to this type of technology with many other players entering this space internationally. Groups like Google, Facebook and One web are trying to bring connectivity to all places on earth utilising balloons, unmanned aircraft, laser technology and an extensive network of satellites in low earth orbit (One web, 2016). Which technology becomes the leader is still yet to be determined as they are in their early stages of development. With three of the biggest companies on earth focused on delivering internet to everyone on earth, the options to improve connections speeds and access are fast becoming plentiful.

Mobile 3G/4G broadband

This the most common form of rural internet connectivity, which allows anyone with a mobile device connected to that network to utilise its 3G/4G data service. To connect to this network it is reliant on mobile carriers (i.e. Optus, Telstra, Vodaphone) having mobile towers in your area and a device that can receive it (i.e. Mobile phone, 3G dongle). This has been one of the most common forms of connectivity due to its flexibility and low setup cost for users but can be easily congested as more users pass by local communication towers. Comparatively the monthly costs for data are quite high for the amount of bandwidth each month, so as a permanent solution for connectivity at home, it is less desirable than all the fixed line options based on price and speed.

Wireless is simply not as reliable as fixed-line alternatives, nor are leading-edge wireless technologies as fast as their contemporary fixed-line counterparts. While it is truly amazing that 4G LTE has already proven itself to provide speeds of up to 60Mbps in metro areas, those speeds vary wildly and can drop to below 6Mbps in just 4km. (WhistleOut, 2015)

Mobile communication Technology

Mobile communication technology has transformed the way every day Australians operate. We have moved from the first generation of mobile technology (1G) in 1981 with analogue transmissions, to 2G in 1992 in the form of digital information exchange, followed by 3G in 2001 and finally 4G in 2010. It is expected that 5G will be released in 2020 which will evolve the mobile communication technology even further.

Mobile Towers

3G LTE Technology

This is the start of the technology that has allowed mobile devices to grow significantly in the past 5 years. In theory, the service allows download speeds of up to 7.2Mbps, giving users the capacity to download an amount of data equal to a song per minute – however, in reality, actual experienced speeds are somewhat less than this, with the average download speed in the UK coming in at around 3Mbps (3G, 2016). Similar experiences can be seen in Australia as seen in the trial results shown in Chapter 2, with even lower average speeds at peak times. Putting aside the data rates, 3G mobile services have transformed the ability of rural and regional areas to connect through voice services improving productivity, management practises and emergency services.

4G

Released six years ago, 4G is the next generation of mobile technology and can be up to 10x faster than 3G in real world examples, having speeds commonly between 20 to 30mbps up and down (Hanlan, 2015). There are only two technologies that have been ratified by the ITU as 4G, these being LTE Advanced and Wireless Man advanced (Acharya 2010), with the most common being LTE. To be classified as 4G, the standards, amongst other requirements, were to achieve data rates close to 100mbps. Even though this has not been entirely met, these technologies are termed 4G and deliver significantly higher data rates.

5G

5G is the coming fifth-generation wireless broadband technology based on the IEEE 802.11ac standard (5G, 2016). It is estimated that 5G will provide better speeds and coverage than the current 4G services, possibly up to 100 times better. Some early indications in this area estimate that 5G will operate with a 5 GHz signal and is set to offer speeds of up to 1 Gb/s for multiple connections or high mb/s for thousands of connections. 5G is still in its development phase at the moment and is not scheduled for launch until 2020 so as we get closer to this release timeline we should expect to see more about 5G.

Femtocell

Femtocells are small cell devices that transmits a mobile carrier signal locally for private use but require to be connected via a broadband connection to work. This allows a mobile signal to be transmitted in the most remote locations if customers have fairly good broadband connections available. A major drawback of this device though is that it can only work on certain carrier networks that have enabled it in their infrastructure, such as Optus in Australia but not Telstra. This device is most common in the UK with the majority of carriers able to offer the service and priced quite cheaply around $120.

Cel-Fi

The Cel-Fi device (developed by Nextivity) is a smart signal booster designed with mobile networks in mind to boost customers signal in the home and not negatively affect the carrier's network. I visited them in San Diego in March 2016 and it works by using two devices, one to receive the carriers signal and the second to retransmit that signal in the home. The most common form of this device is the Cel-fi Pro for the home but there is also a suite of other products just out on the market to improve mobile coverage for different situations as can be seen below. These devices are locked to individual carrier networks but are available on all the Australian carrier networks.

Cel-fi Device	Description	Approx. pricing ($)
Cel-Fi- GO - Stationary	100dB system gain, stationary mount	**$400-$500**
Cel-Fi- GO - Mobile	Mobile booster, Personal space coverage	**$400-$500**
Cel-Fi - Prime	Single room coverage, Two (2) Bands, Pilot Pollution	**$500-$600**
Cel-Fi - Duo	10K ft^2 coverage, Two (2) Bands, LED display	**$795**
Cel-Fi - Pro	10K ft^2 coverage, Four (4) Bands, LCD display	**$1150**
Cel-Fi - Quatra	50K ft^2 coverage, Small Cell interoperability, 1NU to 4CU, PoE, MIMO	**$5000**
Cel-Fi – Quatra + small cell	50K ft^2 coverage, Small Cell interoperability, 1NU to 4CU, PoE, MIMO	**$10,000**

These are the only legal mobile boosters available in Australia that have no negative effects on carrier networks. The only drawback is that they require some carrier signal to work, so places where no coverage is available, will mean this device will not work.

Voice over Wi-Fi

This is the game changer for mobile coverage in rural areas. Voice over Wi-Fi is a new protocol that is being implemented into the Telstra / Optus networks in 2016 which allows certain smart phones to switch to Wi-Fi service if mobile service is patchy to make and receive calls. This technology is already implemented in most countries in Europe but is due to be integrated into Australia's two biggest mobile networks this year. The standard 3G/4G service and Wi-Fi are designed to be complementary, according to Telstra's head of networks Mike Wright. "It's transparent to the user — we stay on the 4G/VoLTE layer for calls, but if we need to we can transition to Wi-Fi if signal drops"(Simpson, 2016). For rural users with a good broadband connection this means that they now will have full coverage to make and receive calls without any additional devices to boost signal other than a Wi-Fi router.

Chapters 4: Cost / benefits of rural communication options

Broadband

Connection type	Benefits	Costs / Problems	Avg Mthly Plans
Fibre	- High Capacity service - Lowest latency - Low interference from surroundings - Small cable - Best connection method - VoIP suitable	- Expensive to replace existing copper with fibre - Harder to repair cables	$70/mth – unlimited data Speed – 100mbps down – 40mbps upload
ADSL2+	- Provides internet via phone line - Low latency - Provides consistent rates of download - Existing infrastructure in most towns - VoIP suitable	- Limited upload speed (1mbps) - Signal degrades quickly over distance (6km max) - Limited availability of service - Needs a fixed phone line	$110/ mth – 500gb data Speed - 18mbps down - 0.9 upload
Fixed wireless – NBN	- Higher capacity internet plans - Low latency - VoIP suitable - No line faults - No fixed line needed	- Needs LOS to tower - Needs to be within 14km - Loss of power on receiver will cut connection - Severe weather conditions can affect service	$80/ mth – 1000gb data Speed - 25 mbps down - 5mbps up Possible 50/20 plans
Fixed Wireless - Private	- Customisable setup to link networks. - Can be used with any broadband connection - Low latency - VoIP suitable	- Needs LOS between radios - Loss of power on receiver will cut connection - Severe weather conditions can affect service - Operates in limited frequencies / restrictions	Connection costs are based on broadband connection that link connects to 2 radio exp -$300
Satellite - NBN	- Connection available in any rural area - Higher download / upload speeds than past options - Bigger data plans 150gb	- High latency - Limited data plans - Requires fixed line phone service for phone calls	$80 /mth 100gb data Speed - 25mbps down - 5mbps up
Mobile 3G/4G	- Available across 95% country - Completely mobile - 4G service offers high speeds up and down - Low latency - VoIP suitable - No need for fixed line - Developments of 5G	- High data costs - Poor wireless signal affects service - Congestion of network by mobile users -	$160 /mth 25gb data Speed 3G - 7.5 mbps down - 4 mbps up Speed 4G - 30mbps - 30mbps

Chapters 5: New technologies available with connectivity

Internet of Things (IoT) devices

With the growth of connectivity, comes the growth of IoT devices. The previously only imaginable ideas to connect everyday items to the internet are now a reality due to internet connections becoming available from wireless access points in most houses around the nation. The massive potential of this surge can already be seen with smart televisions, fridges, washing machine, smoke alarm and home heating (image below). The growth is not just in the home but also across multiple industries that benefit from remote monitoring, like infrastructure management, utilities and agriculture.

The impact that IoT is having on infrastructure management already is reducing labour costs, increasing asset awareness (location and performance) and allowing better asset management. There are also flow on affects from IoT devices like lower insurance expenses for tracked assets such as cars, trucks and equipment hire companies. Agricultural focused IoT has got many companies around the world trying to invest as there are so many applications that these devices could be used for to improve productivity (i.e. World Agri-tech forum, San Francisco, March 2016). Some early teething problems are showing though with no one set standard for these devices to communicate with each other and data sharing parameters causing some potential problems going forward.

Farm sensors

Farm sensors are an important tool that have been widely used in the past decade predominately in new model machinery / equipment where a fixed power source was readily available. Increases in wireless / 3G coverage have also increased the number of wireless devices monitoring water levels, soil moisture and weather information. The cost of sensors and ongoing 3G fees has meant these sensors are only placed on high value targets but with other options becoming available (i.e. LoRa, Zigbee) they will start to become cheaper and work as a collective network to reduce connection fees. Once a set standard gains more traction and becomes fully commercialised these long range sensors will become common place on most farms going forward.

Some key sensors that are being used today and in early development:

- Water monitors – through various methodologies tank, dam, pipe and trough levels are being measured and recorded periodically with data displayed locally or through internet based user interfaces.
- Live camera feeds – Commonly used for monitoring water, infrastructure and security
- Soil / weather sensors – Soil and weather sensors positioned in field to track moisture levels and then being used in conjunction with irrigation systems to maximise efficiency
- Proximity sensors – have been implemented into most new cars to warn of potential obstacles and more recently to take access to avoid potential accidents and to park the car
- Livestock tags- NLIS tags track cattle through saleyards but new potential for location radio tags with long range technology.
- Grain moisture, yield sensors and machine diagnostics in all new harvesting equipment
- Satellite field analysis - on regular basis to analyse field growth, plant health and soil moisture remotely. Previous images to slow to update, now available every day.

Automated Machinery

Cars

Driverless cars are starting to trickle onto the Australian market. The technology is well advanced and the only real restriction to the technology is from government legislation on the issue. Current legislation in relation to cars restricts its use, except in South Australia, legislation was passed in October 2015 to allow trials of these cars on its roads. Volvo, the company running the trials, aims to have ready-to-buy driverless cars by 2017 (Tjandra, 2015). The natural progression of this legislation will allow farm machinery to have the same privileges of road access and remove the last hurdle blocking the wide expansion of driverless machinery.

Tractors

The introduction of GPS guidance in 2001 saw the emergence of the driverless tractor. However, this technology has not been politically acceptable to implement until the last few years (UWS, 2015). Trials of completely driverless tractors and semi driverless tractors have taken place in Australia in the past year and already been hugely successful, with researchers commenting “it’s better than what I expected” (Coghlan, 2015). For these tractor trials there were a lot of safety features so if something went wrong the tractor stopped and then an automated phone call went through to the designated field contact to assess problems. Key to the performance of these machines is access to corrective location information via satellite and ground based radio signals. As such, for these systems to be fully viable better coverage, higher speed and capacity services are required.

Aerial Drones

Drones or UAVs (unmanned aerial vehicles) are a growing trend in Australia for personal and business use. They do not require a licence to fly them for personal use (comes with certain conditions) but any commercial applications require a licence for the pilot and the business through CASA (Civil Aviation Safety Authority). Aerial drones don’t require internet connectivity to operate, but rather have their own frequency and LOS requirements for certain devices. Some uses in agriculture have been for aerial inspections of water infrastructure,

animal behaviour and security but it is still unclear if this type of device will become a predominant technology on farms going forward.

Hovering drone platforms to capture images and targeted spray technology (Underwood, 2016)

Ground Drones

Ground UAV devices also have huge potential in agriculture, and some earlier developments in this space have been for row crop management. A new Australian development called Rippa, was unveiled at the recent World Agri-tech conference held in San Francisco in March 2016 and displayed its ability to autonomously work in a row crop, identifying and spraying plants identified as weeds (Robotics Australia, 2016). This technology has some real benefits that could make it ubiquitous, adhering to less regulatory restrictions than aerial devices, solar powered, built to suit crop conditions and an alternative solution for modern crop management practises. If this device is completely integrated with online connectivity it would enable remote management / monitoring of its activities expanding its use as an autonomous farm machine.

RIPPA, (pictured on left) Robot for Intelligent Perception and Precision Application developed by the University of Sydney and the Shrimp robot (right) for acquiring data in orchards (Underwood, 2016).

Ladybird, a scientific research tool to measure crop phenotypes but it has been designed with the intention to improve efficiency for vegetable cropping. Its abilities include mapping, classification, detection, weeding and ultimately harvesting (Underwood, 2016).

Precision farming

A huge benefactor of consistent high speed connectivity can be identified for precision farming data capture and transfer. GPS mapping of paddocks for coverage, height, soil types, plant coverage and other various mapped images gather lots of data points and combined require significant upload capacity to transmit this data from the units to the receiving software that can turn it into information. This data transfer shows the importance of fast symmetrical internet access (equal upload and download speeds) so that data can be moved quickly and practically from the units in the field. Real time transfer of external sensors, imaging and professional advice would be a vital download direct to the guidance hardware in field, for these vehicles.

Business

The driving force behind better connectivity is access to business tools that increase efficiency and some of these opportunities are through cloud based management solutions. High speed and capacity plans allow cloud based accounting, marketing and management systems to be utilized at relatively low cost, increasing the speed and accuracy of decision making. Some examples that are commonly utilised at the business level are products like Dropbox / One drive that are online data sharing folders, online banking, online accounting (Xero) and various CRM systems. The key improvement is from the ability to share information of all sizes quickly and not loose time being able to access it.

Social benefits

One of the main impacts that high speed connectivity does for rural users is to improve their social benefits and reduce the digital divide that has occurred between city and country users. It allows online services to be accessible, opening up access to online streaming sites like Netflix, Hulu and Stan for entertainment and social media platforms such as Facebook, twitter, and Instagram for social interaction. A key requirement for this though is not just speed but data capacity, otherwise the rural user still faces a barrier to participate in these service. Distance in rural areas has been the restriction factor.

Education and Environment

Fast connectivity, and large capacity data plans are essential to handle distance education due to the requirement of real time streaming on both ends of the link. It is also vital in this example to have low latency connectivity so that the video conferencing call has no delays and dropout. Other forms of education also become accessible through podcasts event, online education courses. Environment benefits from access to online services such as weather forecasting, fire alerts and emergency updates are also essential.

Health

The benefits for health firstly link up existing medical information to be accessible from any hospital / medical centre across the country, which also takes into account the development of suitable software to handle this information. Secondly fast connectivity opens up the opportunity for an online medical appointment program so that no longer do people need to physically appear at a medical centre for an appointment but rather do it via video conferencing. This video streaming option would not be suitable for every visit but could be great for patients that are highly infectious (stopping further transmission in medical centres) and for minor ailments that require consistent care. Fast connectivity and an online medical appointment portal, would be quite disruptive to the current system and it would be expected to have effects on medical budgeting, staffing, pharmacy practices and home visitation practises.

Conclusions

The current state of rural broadband in Australia is lagging behind but there are signs of improvement starting to show through the implementation of NBN in some rural areas. RICS Survey results showed that 40% of all rural users currently use 3G/4G as their primary home internet and pay on average the highest monthly rate for service and receive the least amount of data allowance for this. Key services utilised in the past few years to service rural areas such as 3G coverage and the interim NBN satellite are constantly over capacity and provide poor services in the peak times, when they are required. ADSL services offer a more consistent product but are only accessible for those located in town close to the telephone exchange.

The key technologies that are now becoming available to provide high speed connectivity to rural communities are fixed wireless, satellite, 4G mobile coverage, and to more populated areas, fibre to the node or house. The best option for rural users who have no access to fibre is fixed wireless (either NBN or private) as this technology can deliver the fastest speeds, high data allowance plans with the lowest latency and cheapest monthly cost. Mobile 4G service offers a great service when in a coverage area in terms of speed but is not recommended for home broadband due to the high data plan costs and the congestion that occurs in peak times as it's a shared service with all other mobile devices. NBN Satellite (Sky muster) is the next best option for rural users, being accessible from any rural location, offers good download and upload speeds and plan pricing, but has limited data allowances and high latency compared to fixed wireless.

The use of private networks run either by businesses, communities or individuals are the key to linking rural communities to the faster, low latency, high data allowance internet services. This extends the reach of ground based services, to rural communities that have not be allocated these services and removes the reliance on satellite connections leaving this option for those only very remote. There are only two key technologies available to improve mobile coverage, these being a femtocell device (offered by Optus) and Cel-fi devices (available on any carrier network). The femtocell device connects to a home broadband connection and projects signal in the home whilst the Cel-fi device boosts the existing signal throughout the home, and it's the most widely used technology to improve in home coverage.

High speed connectivity in rural areas brings a new technological advancement age for agriculture which enables online connected tools to be implemented and become an everyday practice. Internet of Things devices (IoT) and farm sensors can start to be implemented across the farm, monitoring water levels, soil moisture, livestock locations and other valued information at low cost. Other areas that could particularly benefit is the transfer of precision farming data in large volumes being uploaded and the introduction of automated machinery. Some of the key benefits though are for the rural community bringing a level playing field and access to various online business tools, health access benefits, education benefits and greater ability to use the resource for social reasons.

Recommendations

- Fixed wireless internet services are the best rural solution for consistent high speed internet for rural users, offering high speed, low latency and high data allowance at low cost.

- Private use of unlicensed frequency radio devices can be used cheaply and effectively to improve internet connection options for rural users

- NBN rollout needs to connect every rural town to fibre and allow access to wholesale network in each of these towns. This will allow smaller ISPs to setup wireless networks to deliver targeted land based internet services to rural uses out of reach from main infrastructure.

- Two devices can improve in home mobile communication service, the first is a Cel-fi device that can boost signal and repeats throughout house and femtocell devices that use a broadband connection to emit signal but only available on the Optus network.

- Implementation of voice over Wi-Fi technology into smart phones and Australian mobile networks transforms every Wi-Fi router into a 5 bar service area for mobiles. So with a good broadband connection it will become the dominant signal your phone uses if mobile coverage is weak.

- Rural Australia needs to focus on investing in land based delivery methods of internet access (fixed wireless, fibre, ethernet) with satellite used as a last resort or interim service whilst they are implemented. These options offer access to higher internet speeds, low latency with large data allowances at cheaper pricing,

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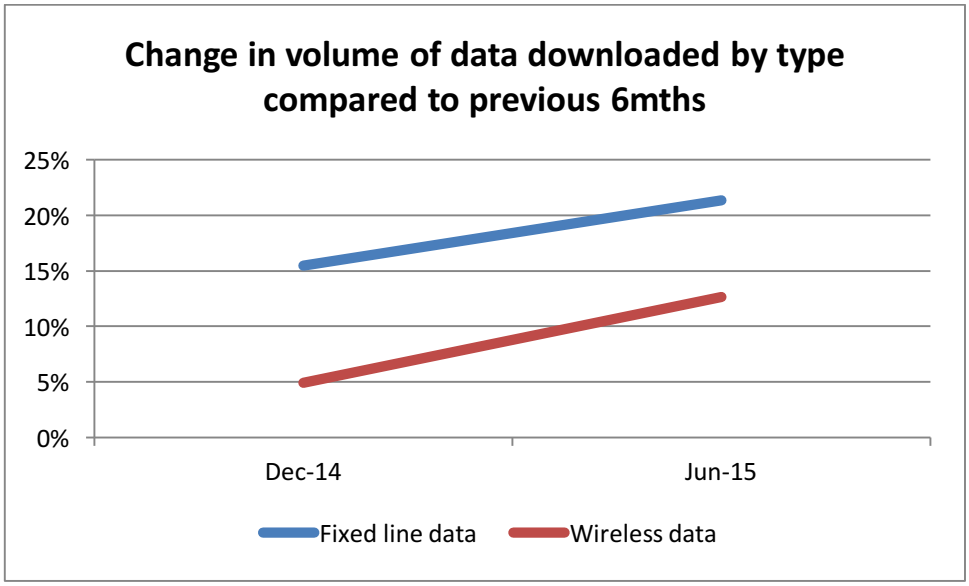
Appendix 1



(ABS, 2015)

Plain English Compendium Summary

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Project Title:	**Rural Communications Infrastructure Options to improve rural connectivity and harness opportunities that this creates.**
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Scholar:	Jock Graham
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Objectives	• Identify the current state of broadband connectivity in rural areas domestically and internationally • Identify key technologies that are available to provide high speed broadband to rural areas and analyse their cost / benefits for use and implementation • Identify key technologies to extend the coverage of mobile communications and analyse their cost / benefits for use and implementation • Identify new technologies that are enabled through the use of high speed internet connectivity
Background	Internet access, plans and speeds for rural and regional users has been well behind the services offered to people in urban areas. This project aims to identify the current state and the technologies to improve it.
Research	The current state of rural internet connectivity, the key technologies that can improve rural connectivity and opportunities that can be utilised from it.
Outcomes	A detailed analysis and comparison of existing technologies that currently deliver internet to rural areas, a survey of rural user connectivity results and some potential technology options for agriculture applicable with high speed connectivity.
Implications	This analysis can empower readers to actively improve their own communication infrastructure or identify ways to gain access to the best options available.