TELSTRA CORPORATION LIMITED

House of Representatives Standing Committee on Communications and the Arts

Inquiry into the deployment, adoption and application of 5G in Australia

5G – Digitising Australia for the Future

Public submission

1 November 2019

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EXECUTIVE SUMMARY

We welcome the opportunity to respond to the House of Representatives Standing Committee on Communications and the Arts inquiry into the deployment, adoption and application of 5G in Australia. At Telstra we believe this fifth generation of mobile network technology (5G) will underpin the 'fourth industrial revolution'. Our economy and society are entering a period of unprecedented change as digital technology enables us to better monitor and manage our industries, businesses, impact on the environment and our lives.

What is 5G?

5G is the next major evolution of mobile network technology. It enables much faster speeds and data throughput, lower latency (transit time), and large-scale deployments of machine-type communications.

There are three key elements that make up a mobile network:

- the core network which manages all the mobile voice, data and internet users and their connections to other users;
- the radio access network (RAN) consisting of radio base station facilities that use radiofrequency spectrum (through the air) to connect mobile phones and other user devices; and
- the transmission (or backhaul) network that connects the RAN to the core network.

These three elements are shown in Figure 1 below.

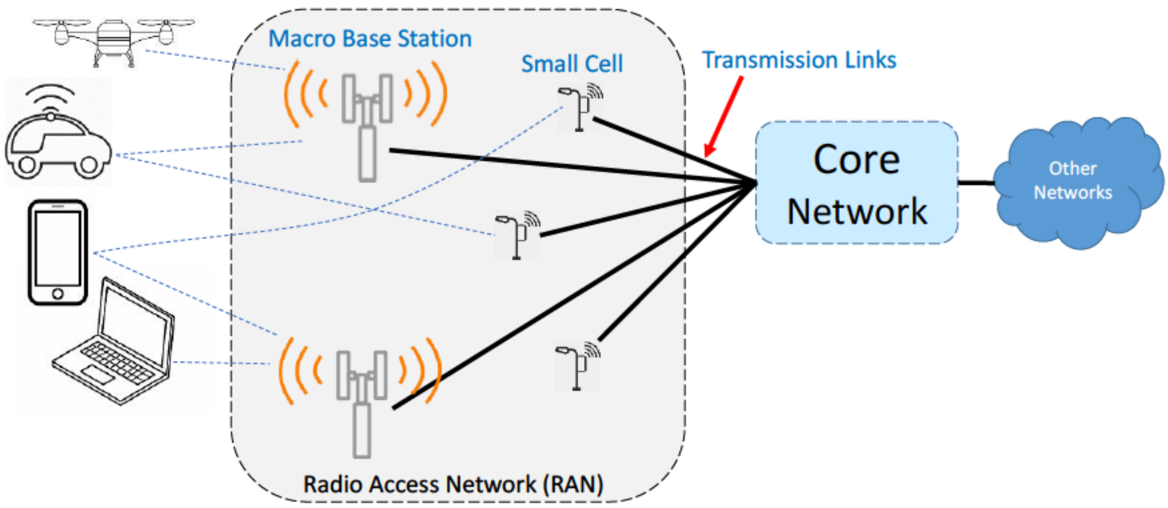

Figure 1: Simplified 5G Architecture.

The technical architecture of 5G varies from previous mobile network generations, with a different approach to both the RAN and core network elements.

Early 5G deployment uses the 4G core, as international standards for the core of 5G have only just been completed. This has made it possible to leverage the capability of existing 4G networks to deliver many of the benefits of 5G earlier than would have otherwise been possible. This is known as 'non-standalone' 5G.

A future standalone 5G core will introduce new architecture and will be the most significant change to the core network design since 2G. This will support the full low-latency benefits of 5G and when coupled with the use of new technology in the radio access network, such as intelligent beam steering antennas, will unleash a raft of new mobile capabilities. It will also support network slicing, which makes it possible to created dedicated channels for applications such as communications for emergency services.

Why 5G?

Innovation enabled by 5G's higher bandwidth, lower latency and massive machine-type communications will bolster our economy through productivity gains. The Deloitte Access Economics (DAE) report **Mobile Nation 2019: *The 5G Future***[1] projects an additional $65bn GDP will be added to Australia's economy by 2023 through mobile technology; the equivalent of $2,500 per person. The incremental impact of 5G mobile technology alone is estimated to be worth between $1,300 and $2,000 in additional GDP per person by 2030 according to the Bureau of Communications and Arts Research[2].

Mobile technology largely achieves this uplift in GDP by boosting labour productivity. 5G will greatly enhance emerging and future technologies such as cooperative autonomous vehicles, virtual and augmented reality, artificial intelligence and machine learning, smart cities, farms, factories and homes, remote surgery and health care. These technologies will improve our quality of life by reducing congestion on our roads, making our lives more connected and healthier, reducing our impact on the environment and delivering efficiencies for business and government.

5G also unlocks an array of new use cases for mobile technology. While many use cases for 5G are still to be imagined, below is a summary of some of the key use cases that we believe will transform the way we work and live – as members of the community and in delivering government and business services.

- *Health Care*: 5G will enhance today's telemedicine capabilities as a result of its reduced latency and faster speeds to provide a wider range of expert consultation and treatment options without either the practitioner or patient having to travel large distances. For example, it will, in some cases, be possible for a specialist to consult and diagnose a patient's condition, with real time and historical data aided by 4K high-resolution close-up video camera and 4K resolution video conferencing technology. 5G, in conjunction with Internet-of-Things (IoT) devices and applications, will also facilitate better outpatient monitoring by alerting patients and health care professionals to early warning signs, thus enabling a patient and their health care team to make proactive interventions.

- *Education*: 5G will further enable and accelerate lifelong learning anywhere, anytime due to its faster speeds. Borderless classrooms, where students are not bound to a classroom or books, will be enabled by 5G's faster speeds and low latency. Regardless of distance or location, 5G will empower students to access the same information and exercises as their peers. For example, 5G enhanced virtual reality is expected to greatly assist learning through closely integrating theoretical concepts with real-life experiences.

- *Transport*: 5G will improve the management of road traffic by enabling improved real-time connectivity with massive numbers of roadside sensors, vehicle telemetry and sensor data from vehicles. Using 5G mobile technology alleviates the need to deploy wired (fixed) connectivity to roadside infrastructure and will provide the bandwidth to enable a wide range of telemetry including

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[1] https://www2.deloitte.com/content/dam/Deloitte/au/Documents/Economics/deloitte-au-economics-mobile-nation-2019-080419.pdf

[2] Impacts of 5G on Productivity and Economic Growth, April 2018. https://www.communications.gov.au/publications/impacts-5g-productivity-and-economic-growth

video monitoring. 5G will also underpin communications with autonomous vehicles. Elderly and disabled citizens will benefit from autonomous or assisted driving, increasing their mobility and quality of life, and road safety will be improved by reducing the potential for human error to cause accidents. We also expect 5G to play a similar role in supporting the safe operation of unmanned aircraft (drones) in low altitude airspace.

- *Public safety*: 5G will enhance the ability of emergency first responders to rapidly capture and access critical information so that they can provide higher levels of safety to the public. This could include accessing data collected from remote sensors and cameras to improve the understanding of natural disaster impacts in inaccessible locations and on critical infrastructure, to inform response decisions. Paramedics would have faster access to patient data and remote diagnostics while patients are being rushed to the Emergency Room (ER).

- *Government*: In addition to the above use cases, which are core services delivered by government, 5G will enable further public sector productivity gains through improved workforce management practices, staff collaboration and greater delivery of services via digital channels. We also see 5G's enablement of massive Internet-of-Things deployments (enabled by massive machine-type communications) bringing significant benefits to government, particularly in the implementation of smart cities and asset management. Benefits will flow down to communities through the improved management of city infrastructure, transport systems and energy usage.

- *Enterprise*: 5G will bring immediate benefits to enterprise with faster speeds and lower latency leading to greater work efficiency, lower operating costs and ability to communicate more effectively with people and infrastructure than is possible with 4G. As 5G matures and a wider body of use cases are supported, specific industries can start to take advantage of 5G's ultra-low latency for equipment and machinery control in factories, industrial campuses and on farms. 5G will enable corporate or branch offices to establish 'day one' connectivity for new sites, and expand, contract, adapt, move and evolve as modern agile businesses do. Augmented and virtual reality solutions will enable workers in areas such as plant maintenance, operations, and equipment training to perform their jobs more efficiently and effectively.

How is 5G being deployed?

As at the end of FY19 we had rolled out 5G to selected sites within 10 major and regional cities. Over FY20, we expect to increase our 5G coverage area almost five-fold with 5G coverage to be present within 35 Australian cities across metropolitan and regional Australia. Initially the coverage rollout focuses on CBD areas where high numbers of our customers live, work or pass through on a regular basis, with coverage extending over time into other areas in line with demand.

3G traffic is already rapidly declining so we recently commenced trials to share unused 3G bandwidth in the 850 MHz spectrum band with 5G technology. Like the 700 MHz band for 4G, low-band spectrum such as the 850 MHz band will deliver wide-area coverage which is crucial to the success of 5G. We plan to deploy this capability once 5G devices enabled for the 850 MHz band become available in 2020.

It is worth noting that Telstra has achieved several world-firsts in the lead up to the commercial launch of our 5G technology. In December 2018, we announced[3] that we achieved a world first connection of a commercial mid-band 5G device to our network, through the connection of the HTC 5G Hub. At the

3 https://www.telstra.com.au/aboutus/media/media-releases/Telstra_leads_with_the_worlds_first_connection_5G_commercial_device

same time, we announced Australia's first 5G to 5G video call. Earlier in the same year, we announced[4] that we had successfully completed a world first end-to-end 5G non-standalone data call on a commercial mobile network working in collaboration with Ericsson and Intel at our 5G Innovation Centre on the Gold Coast. Prior to that in 2017, we announced[5] that we had achieved the world's first 5G trial data call using 26 GHz mm-wave spectrum.

Each base station in the radio access network delivers one or more cells of coverage. Base stations for macro cells are designed to cover larger areas that can typically reach from a few kilometres to several tens of kilometres. They often use antennas on tall masts or buildings to help achieve the wide coverage. Small cells use smaller and lower-powered base station equipment to either provide localised coverage or supplement the capacity of macro cells. Small cells have been used extensively by network providers since rolling out 3G, often mounted on light poles and buildings in dense urban environments. While our early 5G rollout does not involve small cells (the 5G small cell technology is still in development) we will be using small cells for 5G in the future.

5G base station deployment is similar to that for 4G except that, over time, there will be more small cells deployed. Base station deployment (including small cell deployment) is undertaken in accordance with an ACMA enforceable industry code[6] that requires carriers to consult widely and address any reasonable concerns the community has. The code prescribes consultation periods and mechanisms for notifying Interested and Affected Parties. Telstra devotes significant resources to these consultations, including responding to comments and concerns. Where possible we seek to adjust deployment plans to address concerns raised by members of the community.

We are often asked if base station equipment can be shared by multiple mobile operators, to reduce the visual impacts and electromagnetic energy levels. Where it is technically feasible and makes economic sense, mobile network operators often share passive infrastructure (including towers, poles, buildings and housings). However, sharing active infrastructure (electronics including radio transmitters and antennas) is a different proposition. As well as not always being feasible (due to technical design issues or different vendor choices), sharing active infrastructure removes competitive differentiation, which undermines the incentive to invest in upgrading or replacing infrastructure to offer better services and, ultimately, delivers a less than optimal outcome for consumers. Telstra had experience of active network sharing in the early days of 3G when we shared with Hutchison. It was not until we launched our own Next G mobile technology that we fully realised the capability of that technology and unleashed our ability to differentiate and provide customers with a superior experience.

EME and health

The health and safety of the public, and our staff and contractors, is paramount for Telstra. We recognise there is some public concern regarding 5G mobile technology and possible health effects from radio frequency (RF) Electromagnetic Energy (EME)[7]. We are committed to addressing those concerns responsibly.

Scientific research over many decades has enabled national and international health authorities to develop standards and guidelines that establish safety limits for exposure to RF EME that incorporate large safety margins for added protection. Scientific and medical testing, both in the laboratory and real

4 https://exchange.telstra.com.au/5g-step-closer-another-world-first/
5 https://exchange.telstra.com.au/world-first-5g-trial-data-call-over-26ghz-mmwave-spectrum/
6 C564:2018 Mobile Phone Base Station Deployment Code. https://www.commsalliance.com.au/__data/assets/pdf_file/0018/62208/C564_2018-181206.pdf
7 Electromagnetic energy (EME) and electromagnetic fields (EMF) are used interchangeably. 'Radiofrequency' is a term used to define frequencies from around 3 kilohertz (kHz) and up to 300 gigahertz (GHz).

world, has confirmed that RF EME from 5G is well within the safety limits specified by standards setting organisations and is comparable to Wi-Fi and previous generations of mobile technology.

Compliance with the EME safety standards set by the national and international health agencies, including the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), is fundamental to Telstra's deployment of 5G and earlier generations of mobile technology. We apply a range of processes and controls to ensure RF EME is managed in accordance with the global and domestic standards and regulatory parameters, for the health and safety of the community and our workers.

All mobile handsets and other user devices are designed and tested to ensure that they operate within the safety limits. We also model and design our network base station equipment to operate well within these limits. Each base station is tested by a NATA[8] accredited person after commissioning to ensure that the EME levels are safe and in accordance with the EME design objectives.

Testing that we have undertaken in and around our Gold Coast 5G Innovation Centre, in a real-world environment, shows that the RF EME levels from 5G base stations are typically around 1,000 times below the safety limits. These levels are similar to those observed for 3G, 4G and Wi-Fi. In addition, the many efficiency improvements of 5G over 4G and 3G, including beam forming antennas, mean that when more devices are connected to a network, EME levels remain low on 5G. This is one of the main advantages of the new technology.

How can government help?

There are many roles for government. Key to maximising the opportunity for Australia is a policy and regulatory framework that creates the right environment for the substantial investment and innovation required to deliver 5G infrastructure, devices and applications, in the interests of customers and inclusive of all members of the community. Mobile network deployment is especially capital intensive and over the last 5 years to 30 June 2019, Telstra has invested around $8bn in its mobile network, including the initial build and spectrum purchase for the 5G rollout. At the end of FY20 we will have invested almost $1bn in 5G spectrum and network infrastructure. We anticipate that our expenditure over the following two years for rollout and spectrum acquisition will be at least of this order of magnitude, and significant annual investments will continue for some years beyond that as we build out 5G across our metropolitan and regional mobile coverage footprint.

However, at the same time as industry capital expenditure is substantially increasing, returns on invested capital are reducing and ultimately this could compromise investment capacity within the industry, with flow on effects to the quality of experience we can offer customers on our networks.

Given these challenges it is critical that the regulatory framework associated with 5G is fit for purpose and encourages the required investments in this new technology.

The key opportunities for government to help ensure the benefits of 5G can be realised are summarised below.

- *Spectrum access*: Timely access to suitable radio frequency spectrum is essential for any mobile network. There is limited opportunity for 5G to be deployed within existing spectrum holdings as these are already utilised for 4G and 3G services. 5G also requires larger blocks of spectrum than either 3G or 4G. The spectrum that will be freed up after turning 3G off can be used to supplement other 5G spectrum but is insufficient on its own. So, it is important that suitable new spectrum is

[8] National Association of Testing Authorities. https://www.nata.com.au/

released for 5G. We were pleased to participate in the Government's auction of 5G spectrum in the 3.6 GHz band at the end of 2018 and welcome Government plans to auction 26 GHz 5G spectrum in early 2021. The 26 GHz spectrum is critical for enabling the next phase of 5G in Australia to deliver the very fastest speeds. There is also a need to identify additional spectrum in other bands before we can realise the full potential of 5G. Freeing up spectrum in the 3.7-4.2 GHz band for 5G should be the next priority. We also welcome the Minister's recent announcement to progress a series of staged reforms to the *Radiocommunications Act 1992*. This is an important opportunity to enable spectrum to be repurposed for new uses (such as 5G) in a more timely and efficient fashion, as well creating more certainty about tenure to promote longer term investments involving spectrum.

- *Deployment framework improvements*: Further regulatory reform is required to ensure deployment rules are efficient and effective, including removing unnecessary administrative burdens impeding timely deployment of 5G. Through the Australian Mobile Telecommunications Association (AMTA), Telstra and the other mobile carriers have identified a number of short and longer term opportunities for a more effective legislative framework in the deployment of future mobile networks. The opportunities range from simple administrative updates to the *Telecommunications (Low-impact Facilities) Determination 2018* (LIFD) to new capabilities such as the ability to install short poles under the LIFD in certain areas where it is not feasible to use existing infrastructure.

- *Government engagement with 5G*: Appreciation of the opportunities and potential economic benefits that 5G presents, especially within federal and state government departments, remains an area for further attention. The Department of Communications and the Arts (DoCA) established a cross-portfolio, industry-government 5G Working Group (5GWG) in late 2017. We encourage the government to continue using the 5GWG and other mechanisms to explore the opportunities for government organisations to leverage 5G, both for the delivery of government services and in the various industry sectors that government is engaging with.

- *EME research and education*: The level of misinformation without sound scientific basis or medical evidence circulating in the community about 5G EME and health is on a scale we have not seen with the rollout of previous generations of mobile technology. Much of it appears to be driven largely by social media campaigns, and there is evidence to suggest that messaging in these campaigns is being influenced by foreign actors[9]. We also observe that claims are often made that 5G hasn't been tested, when in fact we have conducted considerable testing to confirm our network complies with EME standards. While only a small percentage of the community is engaging, the misinformation is gaining momentum and the fears being raised need to be quickly and respectfully addressed. We have been very active in presenting information to the community based on existing research to show the safety limits are appropriate for 5G. However, is not surprising that some sections of the public lack confidence in industry messaging on this issue. Telstra would like to see a broad-based government communications campaign explaining that 5G technology is safe and there are robust government settings in place, including the monitoring of EME safety standards. Ideally this campaign should incorporate the research from relevant government health experts such as the Australian Health Department and Chief Medical Officer. This should be coupled with a program of EME information/training developed for the medical community so that practitioners are better informed about EME science and therefore able to better inform patients who present with concerns about EME and their health.

[9] https://www.nytimes.com/2019/05/12/science/5g-phone-safety-health-russia.html

- *Regional co-investment opportunities*: Australia's sparsely populated, large landmass, makes the economics of mobile network deployment challenging in regional areas. Regional investment schemes such as the Federal Government's Mobile Black Spot Program (MBSP) have been a resounding success through Government and industry jointly tackling this challenge. A hallmark of the 5G era is higher speeds, which will require augmentation of backhaul transmission capacity to carry the additional traffic. We propose that future rounds of the MBSP would do well to consider backhaul capabilities in regional and remote locations where the upgrade costs to a carrier are uneconomic. Another opportunity for improving the usefulness of the program is to expand the criteria to not only focus on residences, but also strategic locations, such as social and economic hubs, roads and facilities that will be increasingly dependent on 5G technology in the future for the connection of various type of IoT devices such as vehicles and agricultural sensors. We also suggest the program be expanded to include the subsidisation of coverage enhancing devices such as smart mobile repeaters (approved for use by the carriers) and Yagi antennas to boost the performance of existing and future mobile services (including 5G) in marginal coverage areas.

Further engagement

We would be pleased to assist the Standing Committee in any way appropriate, including answering further questions or demonstrating 5G.

01 Introduction

We welcome the opportunity to respond to the House of Representatives Standing Committee on Communications and the Arts inquiry into the deployment, adoption and application of 5G in Australia. This inquiry is timely. We approach what many are forecasting to be the fourth industrial revolution, built on key technologies such as cloud networks, Artificial Intelligence (AI), network edge computing and software defined networks. State-of-the-art wireless connectivity based on the fifth generation of mobile networks (5G) mobile technology will be at the centre of this revolution and is therefore critical to ensuring Australia's future. 5G will be at the heart of our ability to retain Australia's place as a global technology leader and innovator. Innovation enabled by the higher bandwidth, lower latency and massive machine-type communications of 5G will underpin Australia's competitiveness on the global stage.

Our submission is structured as follows:

- Section 2 provides a high-level overview of what 5G is and how it differs from 4G;
- Section 3 considers use-cases illustrating the benefits we anticipate 5G will bring to the community, government and enterprises;
- Section 4 provides insight into how 5G is being deployed and what this means for the community;
- Section 5 addresses EME health concerns and explains why 5G is safe; and
- Section 6 outlines the opportunities for government to help ensure Australia maintains a leading technology innovation position globally through supporting the rollout of 5G services.

02 What is 5G?

5G stands for the fifth generation of mobile network technology. It is internationally harmonised under a set of international standards developed by the Third Generation Partnership Project (3GPP) forum. Unlike the transition from 3G to 4G, the transition to 5G will do a great deal more than just improve data rates. In addition to an order of magnitude increase in speed, 5G will usher in new and ultra-reliable low latency communications (URLLC) and will facilitate the connection of billions of devices.

This section of our submission outlines the architecture and capabilities of a mobile network and how these change in the transition from 4G to 5G.

2.1. The architecture of a Mobile Network

A mobile network has three major components:

- The Radio Access Network (RAN);
- The transmission (also called backhaul) network; and
- The core network.

The RAN uses radiofrequency (RF) spectrum (through the air) to connect to mobile phones and other user devices, and the transmission (or backhaul) network connects the RAN to the core network which manages all the mobile voice, data and internet users and their connections to other users.

The RAN is the most obvious and visible part of a mobile network. The RAN consists of base stations which are cabled to antennas that transmit and receive signals to and from mobile devices such as smartphones, data dongles, tablets and Internet of Things (IoT) devices.

Each base station in the RAN delivers one or more cells of coverage and there are different types of base station for different purposes; Macro base stations, small cells and in-building coverage (IBC) systems, as shown in Figure 2 below

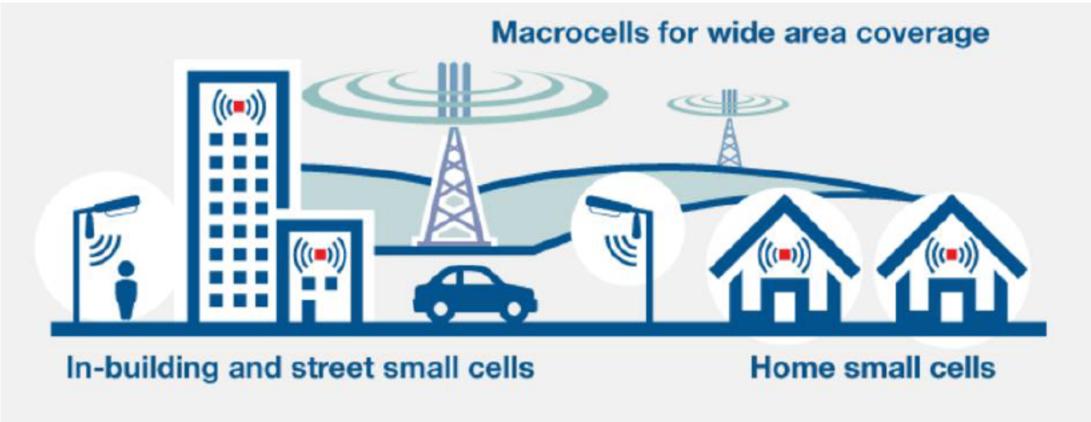

Figure 2: Macro and small cell deployment.

Macro base stations typically provide the wider area coverage and include an equipment hut for the radio equipment at ground level with cables connecting the equipment to an array of antennas mounted on an adjacent tower, pole or roof.

Small cells are miniature low-powered base stations that provide additional localised coverage and capacity. They often combine the radio equipment and antenna/s into a single small unit that can be mounted on towers, poles, rooftops, or on light poles and other similar structures. They operate at a lower power than a traditional mobile phone base station, have less capacity and use smaller equipment. While our early 5G rollout does not involve small cells (the 5G small cell technology is still in development) we will be using small cells for 5G in the future, and currently use small cells in our 3G and 4G networks.

In-Building Coverage systems provide dedicated coverage and capacity inside specific buildings, and typically use the same radio equipment as macro base stations (albeit at much lower power output). They are often cabled via ceiling space to a number of small ceiling mounted antennas that resemble smoke detectors in size, or sometimes via a length of radiating cable known as a "leaky feeder".

The architecture, including components of a macro base station and a small cell, are shown in Figure 3.

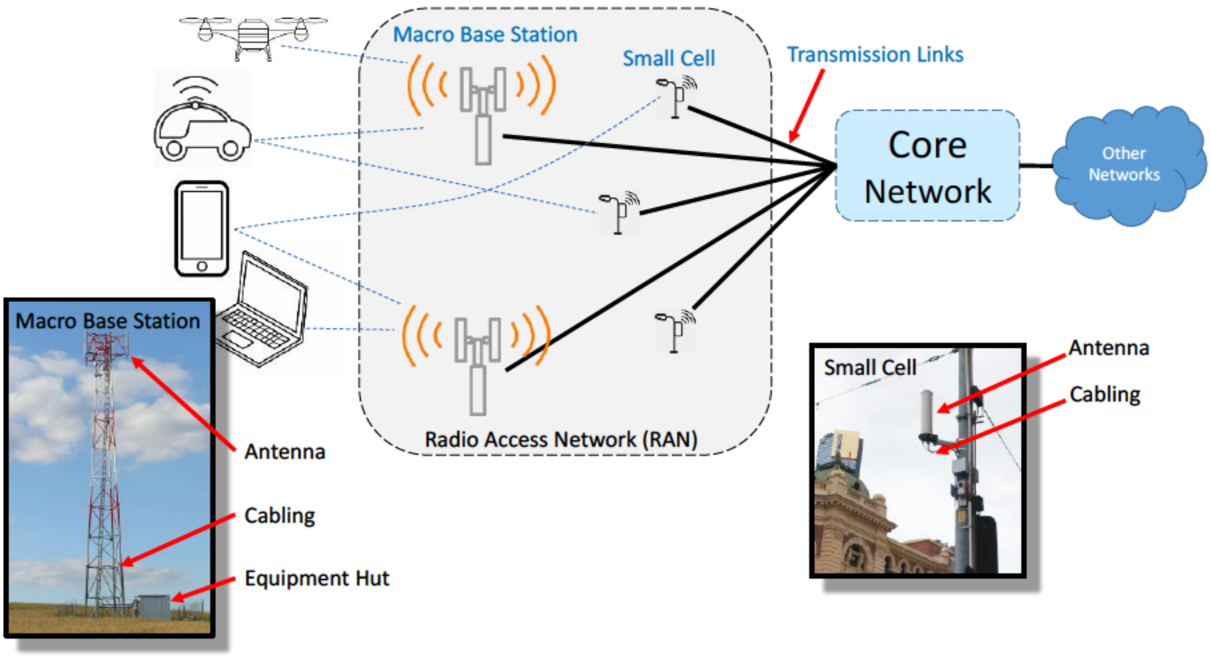

Figure 3: Simplified 5G Architecture.

2.2. How mobile networks work

Mobile devices work by transmitting and receiving low power radio signals. The signals are sent to and received from base station antennas that are attached to radio transmitters and receivers. The base station converts the signals into data which is then transported via the transmission network to other parts of the wider telecommunications network.

A mobile phone base station provides coverage to a geographic area known as a "cell". Cells are aligned next to each other in a similar pattern to a honeycomb, and it is for this reason that mobile networks are sometimes referred to as "cellular" networks.

The location of the base station within the cell is determined by various factors, including topography and other physical constraints such as trees and buildings, the cell 'capacity' (number of calls expected to be made in the cell), the amount of data usage, and the radio frequency used by the base station.

Each base station can only carry a finite amount of phone traffic. In areas of high mobile and data use, such as central business districts and high density population areas, more base stations are required to handle the volume of traffic. Small cells and in-building solutions (designed to give quality coverage within a specific building) are often used for this purpose in these areas.

2.3. What are the capabilities of 5G?

The move from 4G to 5G is in part both an **evolution** and a **revolution**. It is an evolution in that it builds on and refines features and capabilities first released under 4G, and it is also a **revolution** in terms of new capabilities not available on 4G. Broadly, there are three main benefits of 5G over and above 4G: 1) additional speed and capacity; 2) support for the large scale use of machine devices; and 3) ultra-reliable low latency communications. This is illustrated in Figure 4.

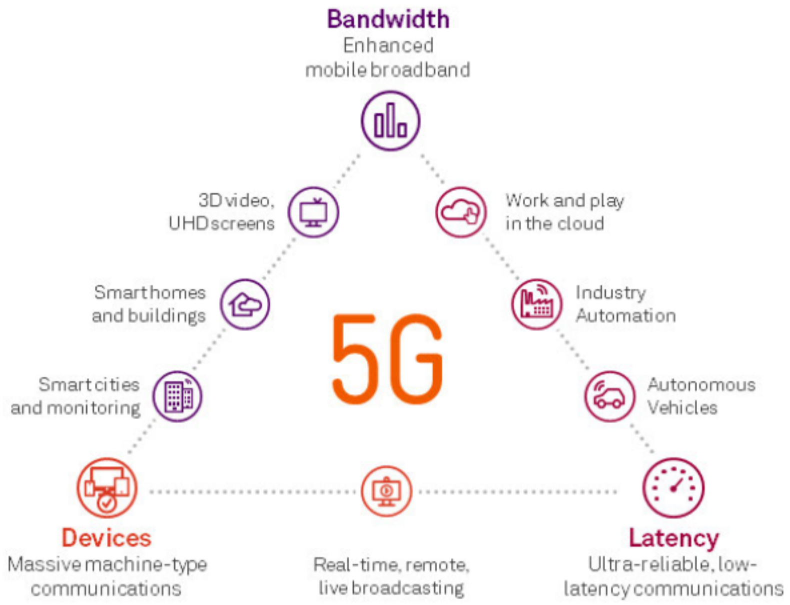

Figure 4: 5G capabilities and high-level use cases.

Additional bandwidth (speed and capacity)

Traffic on our mobile network is growing approximately 40 percent year on year on the back of increased demand for video, driven by the speed available on 4G (mature 4G is easily 10x faster than the fastest 3G). When mature, 5G is expected to be at least 10 times faster than typical 4G (i.e. around 100 times faster than 3G), and better at maintaining those speeds consistently as the much larger spectrum bandwidth that 5G can employ greatly expands the available capacity of the network.

Capacity in a mobile network affects the quantity and speed of data in Mbps that can be processed by each user in a cell. It is determined by the amount of bandwidth deployed (usually quoted in MHz) per site/cell and the number of sites/cells delivering that bandwidth per unit area (site density).

In simple terms, a site transmitting using 40 MHz of bandwidth notionally has twice the capacity of a site transmitting using just 20 MHz of bandwidth. In addition, increasing the number of sites within a given area and reducing the transmission power (so the coverage footprint per site reduces) increases the total capacity available to that area.

More capacity delivers two benefits. Firstly, more customers can do tasks on the network simultaneously (e.g. phone calls, internet browsing, music and video streaming etc.) and secondly, it supports higher speeds for these customers meaning better performance, less buffering when streaming, and faster downloads.

5G's impressive capacity is largely based on an increase in both radio frequency spectrum bandwidth and massive MIMO antennas. While 3G used spectrum bandwidth made up of 5 MHz blocks and 4G used 20 MHz blocks, 5G can currently use blocks of any size ranging up to 400 MHz wide and this will increase in the future. This translates to 5G being able to deliver increased capacity and speed.

Capacity can also be increased by using a higher density of cells as close to the customer demand as possible, and this is where small cells and dedicated antenna systems come into play. For example, a dozen low-power small cells deployed to cover the same area as a single mobile site (with three directional sectors/cells) would deliver a four-fold increase in the capacity available to that area.

An example of where an increase in cell density to support additional capacity is important is a stadium like the MCG. During the AFL Grand Final, the stadium hosts the population of a large regional city in a relatively small space, and unlike typical demand, the stadium attendees' usage is focussed on the brief periods immediately before and after the game, and during quarter time and half time periods. Spreading this load over multiple cells is the only way the demand can be managed without serious degradation of customer experience.

Greater scale

4G can manage several thousand connections per cell. 5G will enable potentially hundreds of thousands of connections in each cell, enabling the future demands of the Internet of Things (IoT). As technology evolves, virtually everything that can be connected will be. Ericsson's latest IoT Connection Outlook[10] (as of June 2019) is 22.3 billion connected IoT devices world-wide by 2024.

Ultra-reliable low latency

Latency is the amount of time it takes between a request for data being sent from a device until the time the requested data is returned, i.e. it is the transit time for packets of data to flow across the network. 5G will provide very low latency with very high reliability for specific use cases. While the latency of 4G is typically tens of milliseconds, the latency of 5G can be as short as a few milliseconds. Low latency will be a key component in future cooperative intelligent transport communications systems using vehicle to everything (V2X) communications, along with other applications such as augmented and virtual reality (AR/VR) and gaming.

[10] Ericsson IoT Connection Outlook, June 2019. https://www.ericsson.com/en/mobility-report/reports/june-2019/iot-connections-outlook

2.4. Real-world 5G deployment - What does 5G look like?

As with past generations of mobile network technology, Telstra's initial rollout of 5G focused on upgrading existing base stations in densely populated areas, including regional cities such as Toowoomba. Telstra began its 5G implementation on the Gold Coast in 2018, with the first 5G call being made in July 2018.

In terms of the scale of our rollout, at the end of FY19 we had rolled out 5G to selected sites within 10 major and regional cities. Over FY20, we expect to increase our 5G coverage area almost five-fold with 5G coverage to be present within 35 Australian cities across metropolitan and regional Australia. Initially the rollout is focused on CBD areas in these cities where high numbers of our customers live, work or pass through on a regular basis, with coverage extending over time into other areas in line with demand.

In terms of physical appearance, 5G antennas are smaller than those used in previous generations. Antennas used in conjunction with 5G macro base stations operating in the 3.6 GHz band typically measure 1.2m x 0.8m, see Figure 5 below.

Figure 5: Typical 5G upgrade to existing base station.

Deployment will be even smaller again for future small cells. Figure 6 below illustrates a current 4G small cell deployment on a street light pole, and Figure 7 provides examples of future 5G small cells.[11]

Figure 6: Current 4G small cell deployment on a street light pole

Figure 7: Future 5G small cell deployments,
Top – antenna on street light pole; Bottom – base station equipment in access hole
Courtesy, Ericsson

Some of the performance improvements of 5G are gained through beam steering antennas which allow the signal to be steered to individual devices as opposed to the broad coverage of previous technology antennas. Directing the radio signal to users and devices (rather than in all directions), increases efficiency as it reduces interference (unwanted radio signals). Greater efficiency, in turn, means lower power and therefore generally lower average EME emissions compared to cells using non-beam steering antennas. This is shown in Figure 8 below.

[11] 5G small cell examples in Figure 7 courtesy Ericsson. Examples shown are indicative of future 5G small cell examples.

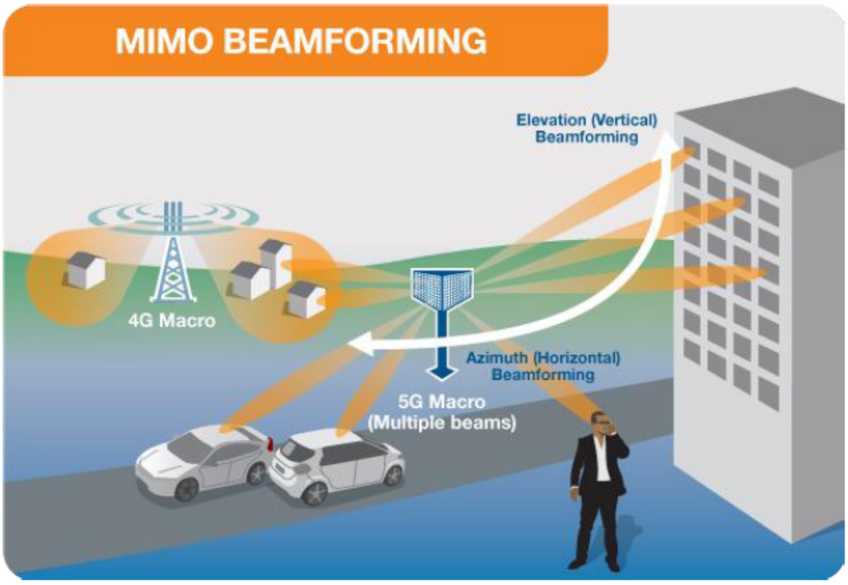

Figure 8: Beam-steering antennas.

2.5. Global Standards

Like previous mobile network technology generations, 5G technology has been developed by the world's leading telecommunications standards body, 3GPP. This forum involves operators, vendors and research institutions from around the globe, and their work is open, transparent, based on consensus and reflects agreement from the input of thousands of global experts. International standardisation gives Australia the world's best technology delivered affordably thanks to the scale of a global standard.

Telstra is leading the way in Australia, having participated in 3GPP since the first 5G discussion in 2015. We have influenced the direction of 5G development to ensure that it meets Australia's unique challenges, including very long-distance coverage, our spectrum requirements and services like public safety. Consideration of bespoke requirements for countries such as Australia are an important part of the 3GPP standardisation process, making the standards broadly applicable yet accommodating of specific country needs, to enable countries like Australia to leverage global deployment scale.

03 Why 5G?

In addition to helping manage the ongoing growth in mobile data traffic, 5G will greatly enhance a future set of technologies such as cooperative autonomous vehicles, virtual and augmented reality, artificial intelligence and machine learning, smart cities, factories and homes, remote surgery and health care. While many of these technologies exist today, through 5G they will become more mainstream and more effective. All these technologies rely on the quality of the underlying telecommunication networks. That is why 5G is so important to the technology innovation we are seeing today.

Although our focus is on the use of 5G for mobile networks, this technology may also be used to enable the next generation of fixed wireless access services. In some cases these will be standalone networks. In other cases 5G mobile networks can be configured to supplement fixed wireless networks or act as a back-up when those networks are unavailable.

3.1. Economic and productivity benefits

The direct and indirect benefits of the mobile sector on the Australian economy are significant. It is a sector in which substantial capital is invested and a very large number of people are employed, and as an enabling technology it stimulates demand for goods and services in other sectors. The Deloitte Access Economics (DAE) report **Mobile Nation 2019: *The 5G Future***[12] observes that the mobile sector supports around 116,100 full time equivalent (FTE) employees and 25,500 FTE staff directly. Directly the sector contributed $8.2 billion to the Australian economy in 2017-18 and indirectly a further $14.7 billion was contributed generating a total value of $22.9 billion added to the Australian economy in 2017-18.

The DAE report also projects an additional $65bn GDP will be added to Australia's economy by 2023 through mobile technology; the equivalent of $2,500 per person. 5G alone is estimated to be worth between $1,300 and $2,000 in additional GDP per person by 2030 according to the Bureau of Communications and Arts Research[13].

Mobile technology achieves this uplift in GDP partly by boosting labour productivity. Today, every sector of our economy (office-based, construction, hospitality, health, agriculture, etc.) operates and relies on data and information, and none of these sectors can function fully or efficiently without access to it. Mobile technology allows workers to realise genuine productivity gains through real-time access to this information no matter where they are. Health workers are able to access patient information while caring for a patient in their own home, construction workers are able to obtain updated plans on site, agricultural workers are able to obtain up to date weather information and professional office-based workers are able to access information at a client's premises allowing them to spend more time with their customers. This is in addition to benefits such as teleworking and being able to work while commuting.

With advancements in mobile technology, infrastructure and the roll out of 5G, new use cases will be discovered and developed, opening up new revenue and productivity opportunities for Australian businesses. Australian businesses are ready: a survey of 550 businesses reported around 80 percent

[12] https://www2.deloitte.com/content/dam/Deloitte/au/Documents/Economics/deloitte-au-economics-mobile-nation-2019-080419.pdf

[13] Impacts of 5G on Productivity and Economic Growth, April 2018. https://www.communications.gov.au/publications/impacts-5g-productivity-and-economic-growth

have already implemented at least one emerging technology in their business, or that they expect to do so in the next three years[14].

3.2. Community benefits

The Australian community will benefit from 5G in many ways. This section outlines some of the predicted benefits for key sectors such a health, education, transport and public safety.

Health Care

5G will enhance today's telemedicine capabilities as a result of its reduced latency and faster speeds to provide an even wider range of expert consultation and treatment without either the practitioner or patient having to travel large distances.

Remote diagnostics through health monitoring and sensory devices are becoming increasingly sophisticated. It will be possible for a specialist to consult and diagnose with real time and historical data about a patient's condition aided by a 4K high-resolution close-up video camera and 4K resolution video conferencing. Connected health monitoring devices are already transforming the lives of patients suffering from serious or chronic health issues, such as cardiovascular disease or diabetes.

The 5G latency improvements will underpin 5G assisted or remote surgery to remote or regional health centres using remote (robotic) control surgery and the remote transfer of haptic, tactile, audio and visual feedback. Robotic surgery is already happening today in operating theatres, but with the surgeon standing next to the robot rather than remotely. Remote procedures like robotic surgery will improve resource efficiency and provide greater convenience and freedom of choice for patients. Robots connected over 5G technology will be able to provide quick access to medical assistance. For example, a drone can deliver a defibrillator four times faster than an ambulance.

5G will also facilitate better outpatient monitoring by alerting consumers and their clinicians about early warning signs. Remote monitoring enables a patient and their care team to make proactive interventions, improving the patient's quality of life and helping to reduce the risk of emergency situations or hospitalisation.

In addition, 5G will support remote Virtual Reality (VR) training in medical and surgical procedures for teaching and training hospitals. VR training gives healthcare professionals the practice they need before working with patients. VR simulations provide highly efficient and cost-effective training methods and will alleviate the need for health professionals in more remote locations to travel to major cities for training.

Education

Borderless classrooms where students are not bound to a classroom or books will be enabled by 5G's faster speeds and low latency. Students, teachers, educators and parents will have easy and quick access to data-rich textbooks, syllabus and e-resources including audios, videos, augmented reality (AR), VR, unified communication (UC) collaboration, debate and discussion forums and boards for all classes. 5G will help students continue their education outside the classroom, delivering the same data

[14] Impacts of 5G on Productivity and Economic Growth, April 2018. https://www.communications.gov.au/publications/impacts-5g-productivity-and-economic-growth

speeds and responsiveness in the classroom to their phone, tablet or laptop. Regardless of distance or location, 5G will empower students to access the same information and exercises as their peers.

VR and AR enables educators and students access to immersive learning. Mixed-reality content and video require high bandwidth and low latency to perform optimally. 4G can struggle to maintain the data traffic throughput and low latency required for true AR and VR experiences. 5G experiences will be seamless. Students can explore the solar system, the human body or visit other countries in VR. With AR, students can explore concepts through touch, pinching and zooming through digital elements added to a live view, often by using the camera on a smartphone or tablet device.

Transport

Several community benefits are expected for next-generation transport in a 5G future. Firstly, traffic congestion could be reduced by low-latency smart city traffic management systems that are informed in near real time by roadside sensors, vehicle telemetry and sensor data from autonomous vehicles. Reducing congestion not only leads to improved commute times, it also reduces pollution as a result of shorter transit times. Using 5G technology alleviates the need to deploy wired (fixed) connectivity to roadside infrastructure and will provide the bandwidth to enable a wide range of telemetry including video.

Secondly, we see 5G underpinning the transition to automated and connected vehicles, both on the roads and in low altitude airspace (drones). This transition will deliver potential for significant benefits in the areas of social equity, access and inclusion. We see benefits for people who cannot drive or readily access public transport such as elderly people, people with disabilities, children, unlicensed or those for whom car ownership and licensing is economically unviable. Models such as Mobility-as-a-Service[15] will bring benefits in terms of increased empowerment for these people as they are able to plan and control their transport and journey options and an increased sense of independence that comes from not being reliant on others for transport.

Finally, we see potential for the application of machine learning analytics to the data gathered from roadside sensors and vehicle telemetry to continuously predict asset failure times (e.g. road, bridge, tunnel maintenance) and to optimise public transport operations in real time including during weather or incident related events.

Public Safety

The biggest benefits for public safety centre on rapid access to information. 5G's capabilities will enhance the ability of emergency first responders to access critical information. First responders will have access to more information before they arrive on the scene and during their response. This could include accessing data collected from smart city sensors to information about dangerous chemicals or hazards. Paramedics would have immediate access to patient data while patients are being rushed to the ER. Hospital ERs would have detailed real time vital information on the transported patient and determine what is required before their arrival.

5G will facilitate faster informed decisions through situational awareness. 5G will help enable real-time analytics of CCTV, in-car and body-worn camera streams through the ability to transfer video at extremely high speed for analysis. 5G enabled applications will provide immediate situational awareness to command staff, other responding officers, and other units in the field during an emergency. This will in

[15] Mobility-as-a-Service is characterised by society shifting away from personal ownership of transportation (e.g. cars, motorb kes, etc) to a shared "on-demand" approach.

turn enable safety and security personnel to respond more quickly to provide higher levels of safety to the community.

5G is also expected to assist public safety by enabling the efficient connection of large-scale wireless CCTV security monitoring across public spaces (e.g. shopping centres, train stations, etc.) to cloud based video analytics platforms.

Beyond access to information, we will also see emergency responders using 5G enabled autonomous vehicles or driving assistance to increase their safety when driving in disaster areas or in hazardous terrain during rescue missions. Similarly, 5G will enhance the ability of drones to assist in disaster management scenarios such as fire and search and rescue. 5G will allow operators using this type of technology to run missions end-to-end with a large data uplink capability. This would mean being able to stream large sets of live data (such as high-resolution video) back to operators to be able to use immediately, and to cloud servers for more advanced analytics and decision making.

Figure 9: Wireless 5G CCTV cameras improving public safety

3.3. Government benefits

In many cases, government benefits arise as a result of efficiency gains and cost reductions that mirror the community benefits outlined in the previous section. To the extent the community benefits from improvements to services delivered to them through 5G, so too government reaps the benefits of efficiency, productivity and cost reduction. Australia's ability to implement and harness technological advances such as 5G will enhance our economic growth and raise productivity and living standards for all Australians.

Over recent years Federal, State and Local government agencies have made significant progress in developing their Digital Transformation Strategies and services. 5G's faster speeds, lower latency and greater capacity will assist government agencies to deliver these strategies and services in line with the Digital Transformation Agencies' following strategic priority:

> "*To make government easy to deal with, you need simple and intuitive services that support your needs and life events, while eliminating the need to deal with multiple agencies or layers of government.*" [16]

[16] https://www.dta.gov.au/digital-transformation-strategy/3-strategic-priorities/government-thats-easy-deal

The timely convergence of maturing technologies like software-defined networking, IoT, cloud, edge computing and 5G complements these digital transformation strategies to deliver richer and more informative experiences and interactions.

5G technology will cope better with heavier data loads and will also adapt to reserve capacity for critical services such as emergency services, telehealth and connected transport. They will also be more robust in times of stress, such as crises or natural disasters.

The scenarios below are some of the specific areas where we see 5G contributing benefits for government.

Smart Cities and IoT

5G enablement of massive IoT deployments will bring significant benefits to government, particularly in the implementation of smart cities. Benefits will flow down to communities through the management of city infrastructure, transport systems and energy usage. With future 5G-enabled low-power, low-cost sensors and modules installed in everyday objects and city infrastructure, 5G will enable new services where other solutions were unfeasible or too expensive. For example, real-time traffic, parking and road condition information will be collected on a far larger scale than is possible with today's wireless network to provide more granular, real-time information to commuters.

Driverless Cars and Transport Networks

The practical introduction of driverless cars will greatly benefit from and be greatly enhanced by the critical real-time responsiveness that ultra-low latency 5G can deliver and the higher speeds to support the multiple communication between vehicles, infrastructure and people to ensure safe, effective operation. For enhanced transport services, the introduction of future low-power, low-cost 5G sensors on key public transport infrastructure, such as railway lines and traffic lights, will play a crucial role in helping transport service providers and councils reduce traffic congestion. Commuters will benefit from shorter travel times as traffic authorities ingest and analyse rich real time traffic data to control traffic lights and update car navigation routes to optimise traffic flows during busy periods.

Energy Management

The massive expansion of renewable energy means requirements on the electricity grid are changing fundamentally. The increasing volatility and decentralisation of energy generation increases the complexity and requires higher flexibility of electricity grid management systems. At the same time, connected industrial control systems (SmartFactory) and home automation (SmartHome) introduce the possibility of more granular control of the demand for electricity (demand-side management). As a 2017 paper[17] from the European Utilities Telecom Council (EUTC) notes, "*[Today,] centralized systems have used a few sensors and actuators for forecasting and operation of the grid. In the future decentralized systems at local level with a high degree of networking will determine the architecture. The aim is to optimize the local and regional energy distribution networks by implementing the dynamic control of producers, loads and storage … For this purpose, communication connections in local and regional structures with very low latency (short control time constraints due to the lack of inertia of large machines*

17 Use Cases for the Adoption of 5GTelecommunications within the Operations of Electric Utilities. EUTC. Oct 2017. https://eutc.org/wp-content/uploads/2019/04/EUTC-5G-USE-CASES-31102017.pdf

in the energy system) are necessary." Further research papers corroborate the role[18, 19] future 5G technology is likely to play in the management and synchronisation[20] of future electricity grids characterised by distributed, heterogeneous power generation.

Future low-power, low-cost 5G sensors fitted along the grid will help detect and respond to spikes in demand caused, for example, by the mass charging of electric vehicles (or, indeed, to draw down energy stored in electric vehicles back into the grid to stabilise it, called "Vehicle to Grid" or V2G technology). This will reduce the risk of blackouts (total power failure) and brownouts (voltage reductions, which can damage sensitive equipment). As well as real-time, uninterrupted data collection, this could help drive more dynamic energy pricing based on real-time demand.

Health Care

5G connectivity will enable the wide scale adoption of high-quality telehealth video conferencing, allowing people to conduct GP consultations on their smartphones or devices. It will provide the reliable and secure connectivity that will enable the wide scale adoption of digital health monitoring devices. Low latency 5G networks will also enable remote diagnosis and treatment of more serious conditions that would otherwise require a patient to be moved to a hospital in another area.

Police and Emergency Services

5G's low latency and high data throughput capabilities, along with increased reliability through prioritisation and network slicing, will be especially relevant for real-time communications during police incident handling. Police with body-worn cameras or in-vehicle dash cams can stream video back to the cloud for real-time facial / plate recognition. Information could be displayed via in-vehicle tablets or AR goggles for improved crime solving and prevention. Similarly, drone surveillance capabilities for fire departments utilising video technology streaming back to base over 5G could help them to do their job more safely and more cost effectively.

Ambulance services will also be enhanced by in-vehicle 5G connectivity to facilitate life-saving scenarios by accessing patient records in real time for diagnosing and monitoring patients in the field.

3.4. Enterprise benefits

5G brings immediate benefits to enterprise with faster speeds and lower latency leading to greater work efficiency and lower operating costs and ability to communicate more effectively with people, plant and equipment than previously possible with 4G. As the full feature set of 5G is introduced, specific industries can start to take advantage of ultra-low latency for equipment and machinery control in factories and industrial campuses across the nation. Other enterprises involved in media and journalism will enjoy the very high data throughput for streaming video and media downloads.

The scenarios below are a few of the areas where we see 5G contributing benefits to businesses and enterprises.

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18 Future Generation 5G Wireless Networks for Smart Grid: A Comprehensive Review. Multidisciplinary Digital Publishing Institute MDPI. 4 June 2019. https://www.mdpi.com/1996-1073/12/11/2140/pdf

19 Intelligent Micro Energy Grid in 5G Era: Platforms, Business Cases, Testbeds, and Next Generation Applications. Multidisciplinary Digital Publishing Institute MDPI. 23 April 2019. https://www.mdpi.com/2079-9292/8/4/468/pdf-vor

20 Smart Grid: A demanding use case for 5G technologies. Helen C. Leligou, Theodore Zahariadis, Lambros Sarakis, Eleftherios Tsampasis, July 2018.http://www.nrg5.eu/wp-content/uploads/2018/07/PerCom.pdf

5G Office / Branch of the Future / Enterprise Wireless

5G will enable corporate / branch offices to establish 'day one' connectivity for new sites, and expand, contract, adapt, move and evolve as modern agile businesses do. It will facilitate temporary connectivity for events and conferences or enable a mobile workforce to be connected to central office systems as if they were in the office in person, providing faster and better digital customer and employee experiences.

5G will enable new use cases such as artificial intelligence, video analytics and robotics supported by a range of software defined networking solutions.

AR / VR Assisted Worker

Augmented and virtual reality solutions will enable workers in areas such as plant maintenance, operations, and equipment training to perform their jobs more efficiently and effectively. AR / VR will also deliver health and safety benefits, including removing staff from hostile and dangerous environments by using robotics and drones, and enabling highly skilled staff to provide remote assistance to more junior staff regardless of where the parties are.

Customer Interaction

5G will enable automated customer interaction technology especially where fixed line connectivity is not available. In conjunction with UBTECH[21], (a Telstra Venture[22]), we recently demonstrated a Cruzr robot named "Sandy". Sandy is a customer interaction humanoid, and while this generation is still Wi-Fi based, Sandy is already ideal for enterprises with receptions, concierge or point-of-sale (POS) retail environments. Humanoids such as Sandy offer features such as communicating with customers in different languages or providing assistance to customers by responding to natural language questions.

Sandy is equipped with Bluetooth and cameras for facial recognition and can be integrated into the organisation's customer portal applications to welcome existing customers.

Figure 10: Sandy, the Customer Interaction humanoid.

Indoor 5G for Enterprise Public Space

5G will ultimately have the capability to provide high performance communications within buildings such as shopping centres, airports, stadiums and venues without the need to rely on Wi-Fi networks that are becoming increasingly congested. This improved indoor experience will drive new revenue opportunities and differentiate services between competitors.

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21 https://ubtrobot.com
22 https://pressroom.ubtrobot.com/2018/05/07/ubtech-robotics-announces-largest-artificial-intelligence-funding-in-history/

Banking and edge computing technology

We have been collaborating with Commonwealth Bank of Australia and Ericsson to explore new capabilities based on 5G edge computing[23]. For example, 5G edge computing could be used in the future to verify and confirm your identity based on your face and fingerprints faster and more securely. In the future, it might be possible to walk into a bank, scan your face / finger and immediately withdraw or deposit your money and walk straight out – providing a faster and more secure way to access your money. Other examples could include faster transactions when paying for your groceries at a wireless payment terminal, or a more secure, personalised experience when using an ATM by not having to use your PIN number.

To further expand our 5G edge computing offering for business customers, in October 2019, Telstra and Cradlepoint announced a partnership to develop "5G for Business" solutions for business customers. These are secure, enterprise grade, cloud-based mobility solutions.

Mining and agriculture

5G will also play a significant role in the mining and agriculture sectors by further enhancing the productivity gains and safety delivered by earlier mobile generations. In the mining sector, 4G-LTE private networks are already being deployed to improve safety and deliver automation. For example, by adopting 4G-LTE underground, the Cannington mine[24] will be able to achieve better operating transparency and production improvements for staff, machines and other mining systems, driving safety, productivity and efficiency. 5G private networks will further enhance the safety and automation through the low-latency and higher speed capabilities.

Similarly, in Aitik, just south of Gällivare in northern Sweden, Ericsson are partnering with Boliden[25] to upgrade their existing Wi-Fi network to 4G and 5G technology to enable the automation of drilling rigs and trucks. While 4G can support some automation, only 5G can comfortably handle the demanding requirements of several 3D video streams and automation – bandwidth, quality of service, latency and positioning – to manage highly complex tasks remotely. Ericsson and Boliden expect to be able to increase drilling rig operational time from 5000 hours per year to 7000 hours, in effect enabling Boliden to perform the same amount of blast operations with five of the modified rigs as they could with seven traditional rigs. They also anticipate fuel savings of around 10 percent resulting from smoother transport flow, steadier speed and less movement. An efficiency improvement of this order would reduce Aitik's annual emissions by approximately 9,400 metric tons of carbon dioxide.

In agriculture, the speed and latency improvements 5G technology offers over current 4G networks make the technology ideal for transmitting information from remote sensors and drones and for automating farming processes. In the UK, the 5G Rural First project[26] has been trialling a number of initiatives, including smart 5G collars on cows and full automation of crops from planting to harvesting. The smart collars worn by the cows send data on everything from what they're eating, where they are and even how they're sleeping to an app used by the farmer. The farmer can see and analyse the information instantly, and then pass it on to veterinarians or nutritionists as required.

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[23] Telstra Exchange article: "We're working with CBA and Ericsson to bring 5G to banking". Channa Seneviratne, 25 Feb 2019. https://exchange.telstra.com.au/working-cba-ericsson-bring-5g-banking/

[24] Telstra Exchange, We're building one of the world's largest underground LTE networks for digital mining. 4 Sept, 2019. https://exchange.telstra.com.au/tag/telstra-mining-services/

[25] Ericsson, A case study on automation in mining: 5G business value. https://www.ericsson.com/en/trends-and-insights/consumerlab/consumer-insights/reports/a-case-study-on-automation-in-mining

[26] https://www.5gruralfirst.org/ and https://edition.cnn.com/2019/04/01/business/5g-farming/index.html

In the crop automation scenario, another 5G RuralFirst project called Hands-Free Hectare became the first in the world to successfully plant, tend and harvest a crop without a single human stepping foot in the field. Autonomous tractors sowed the seeds, drones with sensors monitored the crops, and smaller machines took samples to assess what fertilisers and pesticides to apply and where. The project reported another successful harvest in 2018 and is now to looking to further increase the precision and efficiency of crop spraying.

04 How is 5G being deployed?

This section of our submission covers our approach to 5G deployment, including how 5G will evolve within the first few years of its lifetime, the way it will leverage 4G in those early years, the importance of timely access to radio spectrum, small cell deployment, the many challenges and pitfalls of sharing active network infrastructure, our deployment processes, and the role of community consultation.

Further to the above, in section 6.3 we address the importance of regional co-Investment and how the Federal Government's Mobile Black Spot Program (MBSP) has been highly successful in delivering infrastructure to regional Australia. Going forward, the model for co-investment needs to investigate new and innovative ways for governments to partner with industry to deliver improved telecommunications services and outcomes for regional Australia.

4.1. 5G development roadmap

Telstra is leading the way globally with 5G commercialisation, but the technology we are deploying is still evolving and undergoing change. As it evolves, actual and potential use-cases, and deployment challenges will grow.

Current 5G deployments, including Telstra's, are "non-stand-alone" meaning the technology shares its core with 4G and requires an underlying 4G radio access network. Signalling occurs through the 4G layer which is always connected and the 5G layer, where available, is effectively aggregated with the 4G layer for increased data throughput. This has made it possible to roll out 5G rapidly and early, leveraging the very strong capability we already have in our 4G technology.

Our early rollout uses the mid-band (3.6 GHz) spectrum we acquired at auction last year with the major initial benefits for 5G device users being faster speeds (with the potential to be around twice as fast, on average, as 4G for Telstra customers in 5G enabled areas). We already have 5G coverage at selected sites within ten cities and this will be expanded to approximately 35 cities nationally by June 2020. Over FY20, we expect to increase our 5G coverage area almost five-fold with 5G coverage to be present within 35 Australian cities across metropolitan and regional Australia. The geographic focus of our rollout in CBDs of major and larger regional cities is intended to support mobility use cases in areas where large numbers of Australians live, work or pass through on a regular basis. This footprint will grow outward over time responding to geographic demand and new use cases.

Over the next couple of years, major steps upward in 5G speed and capacity will become possible once the larger bandwidths of mm-wave band spectrum (at 26 GHz and in higher frequency bands) become available, while in-building and regional and rural 5G coverage will be improved with the addition of low-band spectrum options – initially by re-purposing 3G spectrum in Telstra's case.

Innovative new products and services will become possible once the new 5G core network is introduced starting in 2020. A 5G core network introduces a new service-based architecture, the most significant change to the core network since 2G. The new capabilities will allow operators to better match network performance to customers' needs using techniques such as network slicing, improved Quality of Service (QoS) control, as well as richer exposure of network capabilities allowing customers to control and optimise the network to suit their own needs.

Early 5G deployments are already providing improved responsiveness by reducing network latency, but as the 5G core network is introduced and the 5G standards continue to evolve, latency will be reduced even further. This will enable new specialised use cases that demand very low latency.

4.2. 5G rollout as an overlay on 4G

Telstra is currently deploying 5G technology on our existing base stations in capital cities and areas of high demand. Our initial 5G rollout is no different to that of earlier mobile technologies; we use existing mobile base station sites (often called macro sites) where we already have 4G and 3G technology deployed and add 5G antennas and equipment. The 5G antennas are smaller than those used by these earlier technologies so the incremental visual impact is small (see Figure 5).

5G radio-access technologies for dedicated in-building coverage systems and small cells (see below) are still in development, so for the near and mid-term deployment of 5G will continue to be focused on macro base stations at existing 3G/4G sites.

As we deploy 5G to these macro sites, we are typically also expanding the 4G capacity and upgrading the transmission backhaul. This not only enhances the experience of 5G device users (noting that early 5G operates in non-stand-alone mode in combination with 4G), but also significantly improves the speed and speed consistency enjoyed by 4G users especially those with high end 4G devices.

Another significant change that we are introducing as part of our 5G rollout is a new radio network architecture known as centralised radio access network (C-RAN) in which we move the base station's "baseband" equipment to a centralised location. The baseband equipment is the brains of a base station, and by moving this from distributed sites to a centralised location – usually a transmission hub – we can realise a number of benefits. These include coordinating the base stations to allow us to deliver more data within the available spectrum, improving the utilisation of our transmission infrastructure, and enabling future technologies such as mobile edge computing (MEC). MEC will allow service providers and enterprises to deploy applications very close to where they are consumed, reducing latency and operating costs.

4.3. Spectrum

There is limited opportunity for 5G to be deployed within existing spectrum holdings as these are already utilised for 4G and 3G services. 5G also requires larger blocks of spectrum than either 3G or 4G. The spectrum that will be freed up after turning 3G off can be used to supplement other 5G spectrum but is insufficient on its own.

One of the major differences between 4G and 5G is the way 5G draws together a diverse range of larger bandwidth blocks of various radio spectrum bands, each with different characteristics to expand the capabilities as outlined in section 2 of our submission. 5G will use radio spectrum from each of three different bands that we can broadly characterise as low-band, mid-band and high-band spectrum.

- **Low band spectrum** (below 1 GHz) provides robust wide area coverage and the ability to reach inside buildings, but there is limited bandwidth so speeds are slower and capacity is limited;
- **High band spectrum** (or mm-wave, above 6 GHz) offers large bandwidths along with fast speeds and high capacity, but only over short distances, thus requiring users to operate close to the base station and the need for more small cells (as described in section 4.4); and
- **Mid band spectrum** (between 1 GHz and 6 GHz) which offers a mix of the capabilities of low band and high band spectrum.

Our early 5G deployment uses spectrum in the mid-band 3.4-3.7 GHz frequency range which provides a reasonable initial balance between coverage, capacity and speed.

That said, one of the key challenges of early 5G using mid-band 3.6 GHz is its limited reach, both in distance from a site and penetration into buildings (exacerbated by current lack of dedicated 5G in-building technology). Mid-band frequencies are unable to match, even with new 5G antenna efficiencies, the reach and penetration that the lower frequencies used in 4G and 3G can achieve.

With this in mind we are planning for the deployment of low-band 5G using 850 MHz spectrum currently used by 3G. When re-purposed to 5G, this will improve the reach of 5G outdoors and in buildings. This will also be deployed at sites where we have 5G on 3.6 GHz and the two bands when aggregated will provide some modest, but useful benefits in 5G speed and capacity over 3.6 GHz alone. Low-band 5G will also underpin future low latency 5G services across the country thanks to its broad coverage.

As 3G traffic is already rapidly declining we will initially be able to share the available 850 MHz bandwidth between 3G and 5G, keeping 3G in operation. Once 3G is closed in June 2024 the remaining bandwidth will be re-purposed to 5G. We are already trialling 5G on 850 MHz and will begin to deploy it once devices enabled for the band become available in 2020.

While our initial 5G service has significant speed advantages over 4G alone, the promise of 5G to reach theoretical peak speeds of around 10Gbps and higher requires more spectrum bandwidth than is available in the mid and low bands alone.

The scale of bandwidth required is only available in the mm-wave spectrum (initially the 26 GHz band for Australia) and once made available via auction this spectrum has the potential to multiply the deployed 5G bandwidth by as much as five or even ten-fold from that possible today along with substantial increases in 5G speed and capacity.

The three bands, mid, low and mm-wave, together with an independent 5G core, ultimately combine to provide the full 5G capability to support the full gamut of future 5G use cases that are anticipated to transform our society.

4.4. Small cell deployment

As already noted in section 2.1, our early 5G rollout does not involve small cells as small cell technology for 5G is still in development. As 5G matures and 5G traffic grows the need for 5G small cells will gradually increase and we will begin small cell deployments in areas where 5G traffic is highest.

Even more so than mid-band spectrum, the mm-wave spectrum is limited in terms of its reach and in-building penetration. The range is more like that delivered by public Wi-Fi hotspots. For this reason, small cell technology is likely to become increasingly important and more numerous in 5G rollouts once mm-wave band spectrum becomes available.

Small cells for mm-wave band 5G will also be physically smaller again than previous generations of small cell technology. Complete cells will approach the size of a briefcase and will be able to be embedded in a range of street furniture making them visually undetectable.

4.5. Infrastructure sharing – the challenges

We are often asked if base station equipment can be shared by multiple mobile operators, to reduce the visual impacts and electromagnetic energy levels. Where it is technically feasible and makes economic sense, mobile network operators often share passive infrastructure (including towers, poles, buildings and housings).

Sharing active infrastructure (electronics including radio transmitters and antennas) is a very different proposition. Techniques for sharing active infrastructure do exist in earlier generations of mobile technology. While 5G allows for similar active infrastructure sharing as in earlier technologies, including Multi-Operator RAN (MORAN), Multi-Operator Core Network (MOCN) and network slicing, there are both technical and economic challenges to sharing infrastructure between peers. First, active sharing technologies currently require the same vendor to be used between operators. This would remove the ability for each operator to make independent vendor decisions. Second, there are other technical constraints. For example, sharing beam steering antennas will be difficult given their unique positioning for each carrier's current traffic levels and locations, which will mean that positioning is unlikely to be suitable for other carriers. Also, some structures may not physically support more than one or two operators' network equipment. Most of the economic gains derived from sharing are made in the sharing of passive infrastructure; the incremental savings realised from sharing active infrastructure are marginal at best after compensating for the increased complexity arising from the need to coordinate between multiple operators. When offset against the yield and market share, reductions arising from the loss of competitive differentiation means there are strong economic incentives against sharing of active infrastructure.

As we move to deploying small cells, an important aspect to also recognise is that for them to be effective their precise placement is critical. It will be rare that the needs of all carriers align for any small cell to the extent that small cell infrastructure sharing is viable. The factors requiring precise small cell site placement include amount and geographic focus of customer demand and location of surrounding network elements (macros and other small cells) and these are unique to each carrier. For this reason, carriers must work primarily with local government to secure suitable locations, rather than an external provider controlling the location and design of the facility.

Neutral hosts

The term "neutral host" refers to a situation where a party other than a carrier provides infrastructure that hosts multiple carriers. This can range from offering passive site sharing of tower/pole and shelter facilities for carriers to install equipment, through to independent network build with carriers hosted on that network via a form of roaming or other virtual partition for each network operator to integrate into their own mobile network. This is different to an existing mobile network operator sharing in that neutral hosts do not offer retail mobile services direct to consumers or businesses.

For the same reasons outlined above around the criticality of cell placement with respect to individual carrier needs and surrounding architecture, such neutral host options are also impractical for introduction in areas with existing competitive networks, and are fundamentally limited, as outlined below.

One form of limitation is the inability to customise the neutral host network's features and capabilities to match those of the carrier's network. This potential limitation manifests in two ways. First, there can be a loss of functionality as a customer moves from the carrier's own network onto the neutral host's infrastructure, resulting in poor, inconsistent user experience. Secondly, if MNOs are concerned about the impact to user experience, they may choose to constrain or de-feature their overall service to avoid impacts to the experience. This has the unintended consequence of removing competitive differentiation between mobile service operators as the operators converge towards the available feature-set of the neutral host. Removal of competitive differentiation is not in the interest of consumers. The lack of competition removes any incentive to upgrade the host infrastructure over time.

A second form of limitation occurs at higher frequencies (mid-band and high-band). At lower frequencies, the deployed bandwidth is low, notionally 5-20 MHz per carrier as evidenced by bands under 1 GHz. It is entirely possible to build a single radio transmitter that spans the aggregate of all MNOs (notionally 25-50 MHz) such that a single radio transmitter can encompass all network operators. However, at higher frequency bands, where carriers are using 60-100 MHz (as is the case in 3.6 GHz) or worse, where MNOs may be using 800-1000 MHz each (as expected in 26 GHz) it is simply not possible to build a single radio system capable of spanning such a wide frequency range. Thus, multiple cells are still required in a 1:1 relationship for each carrier. Here, the economics quickly become unattractive to MNOs, as neutral hosts will need to profit and small cells have a limited coverage requiring multiple cells. MNOs will find using a neutral host uneconomical and will deploy their own infrastructure rather than source from a neutral host.

Competitive differentiation

Australia has been a world leader in delivering mobile network technology for decades. As independently attested by a number of global bench-marking companies (P3, Ookla, Open Signal, Akamai etc.) we already have some of the most advanced and fastest 4G networks in the world, and we continue to push the global technology envelope as one of the leading countries to introduce 5G.

The reason is simple. Since the time when other carriers entered the mobile market, we have had an intensely competitive mobile market, and one where the latest network capabilities and the customer benefits that flow from them are key differentiators.

The converse is also true. If there were now, or in the past, any serious impediments to a carrier's ability to differentiate services then competition would be severely stifled, Australia would be without 5G service and indeed, would likely still be lagging at the low end of 4G services. All Australians would have suffered as a result.

This is of critical importance when considering the topic of infrastructure sharing.

While passive infrastructure sharing (where it makes technical and commercial sense for all parties), has and will continue to play a role in 5G deployments, it is worth observing that carriers do not share every tower or facility. The reason is each carrier has a unique set of evolving constraints ranging from specific spectrum holdings, vendor capabilities (and limitations), engineering expertise, through to unique and changing target markets, customer demands and service offerings. Telstra has experience of active network sharing in the early days of 3G when we shared with Hutchison. It was only when we launched our own Next G network that we fully realised the power of that technology and unleashed our ability to differentiate and provide customers with a far superior experience.

Precise placement of sites in a mobile network is critical in order to efficiently satisfy the carrier's customer demand while also not interfering with other sites in the carrier's network. This is because all sites interact with all surrounding sites so that call traffic can move seamlessly between sites without disruption. It is far more complex than a Wi-Fi network which is simply a number of individual hotspots that have no interaction and can be installed anywhere convenient without concern for customer movements or the placement of other hotspots in the network.

In short, active infrastructure sharing means less service differentiation. There is and always will be a place for passive infrastructure sharing in 5G deployments but, if it is not to stifle investment and the timely delivery of customer benefits, such sharing must be at the discretion of carriers when it makes economic and technical sense for them to do so.

4.6. Deployment process and community consultation

Deployment processes have not changed with the introduction of 5G; however, the community interest in the technology has been significant. Mobile network infrastructure (including 5G) such as towers, antennas, radio transmitters and other network equipment is currently deployed in accordance within a range of legislative instruments. In certain defined circumstances, the *Telecommunications (Low-impact Facilities) Determination 2018* (LIFD) enables carriers to install or upgrade equipment that is considered to have a low visual impact on the community (e.g. adding equipment to an existing facility, or on a rooftop of a building) without development approval.

More commonly seen infrastructure such as poles, towers and masts are subject to Development Approval by state government or more commonly, local councils. Few states and territories have a state-based planning scheme for telecommunications. This results in an inconsistent nationwide approach both within states and nationally. Further to this, there is no ability for a carrier to install a pole of any type for a small cell. In established suburbs there is generally electricity infrastructure that can be used. However, in new estates or areas where an agreement can't be reached with pole owners, Telstra is forced to seek Development Approval for small cell poles. This process is time consuming and costly, does not scale to the infrastructure slated for future 5G, and given the low impact nature, is not justified.

Community consultation for base station deployments (including small cells) is undertaken in accordance with the Mobile Phone Base Station Deployment Code C564:2018[27] (the Code). The Code requires carriers to undertake an approach based on the precautionary principle to the siting, design, and operation of a base station. In practice, this means carriers must consult widely with the community prior to the deployment of mobile base station infrastructure (including small cells) and address any reasonable concerns prior to commencement of a works program. Where community consultation is not already occurring under a state or local council Development Approval, the Code requires carriers to develop and make public a Consultation Plan that identifies interested and affected parties, how they will be notified, and how they can comment on the planned deployment. The Code also prescribes community consultation for between 10 and 15 business days and local council consultation for up to 20 business days for all types of deployments. Notification is provided to the community via methods such as newspaper notices, letterbox drops, or signs on site. Telstra devotes significant resources to consultation, including responding to comments and concerns.

Telstra's experience with 5G deployments to date has been mixed. In many instances, a minority of the community will use online platforms such as social media to encourage opposition to the 5G installation based on misinformation about its health impacts being spread at an international level. There is also an expectation from the community that significant angst during consultation periods will result in Telstra withdrawing the facility. This is not a sustainable approach for necessary infrastructure deployment. Telstra looks forward to working with government and community stakeholders to identify effective ways to address deployment concerns while balancing them against the community's desire for 5G to access the business and social benefits it will bring.

27 https://www.commsalliance.com.au/__data/assets/pdf_file/0018/62208/C564_2018-181206.pdf

Telstra notes that Australia's carriers are subject to far greater deployment transparency requirements, along with more extensive consultation frameworks, than those for other types of radio infrastructure, and in many other countries.

05 EME health considerations

At the outset to this section, it is worth noting that testing, both laboratory and real world, has confirmed that radiofrequency (RF) electromagnetic energy (EME) from 5G is well within the safety limits specified by standards setting organisations and is comparable to previous generations of mobile technology and Wi-Fi.

All mobile handsets and other user devices are designed and tested to ensure that they operate within the safety limits. We also design and install our network base station equipment to operate well within the limits. Testing that we have undertaken[28] in and around our 5G Innovation Centre in a real-world environment shows that the RF EME levels from 5G base stations are typically around 1,000 times below the safety limits set by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA)[29]. This is illustrated in Figure 11 below.

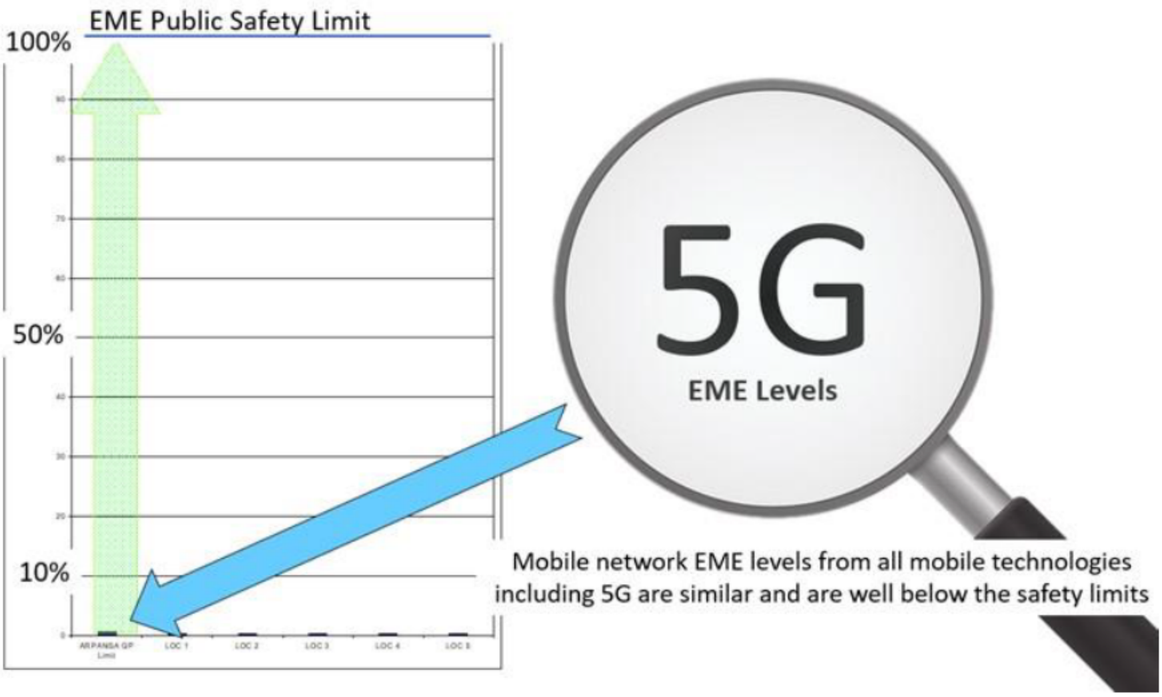
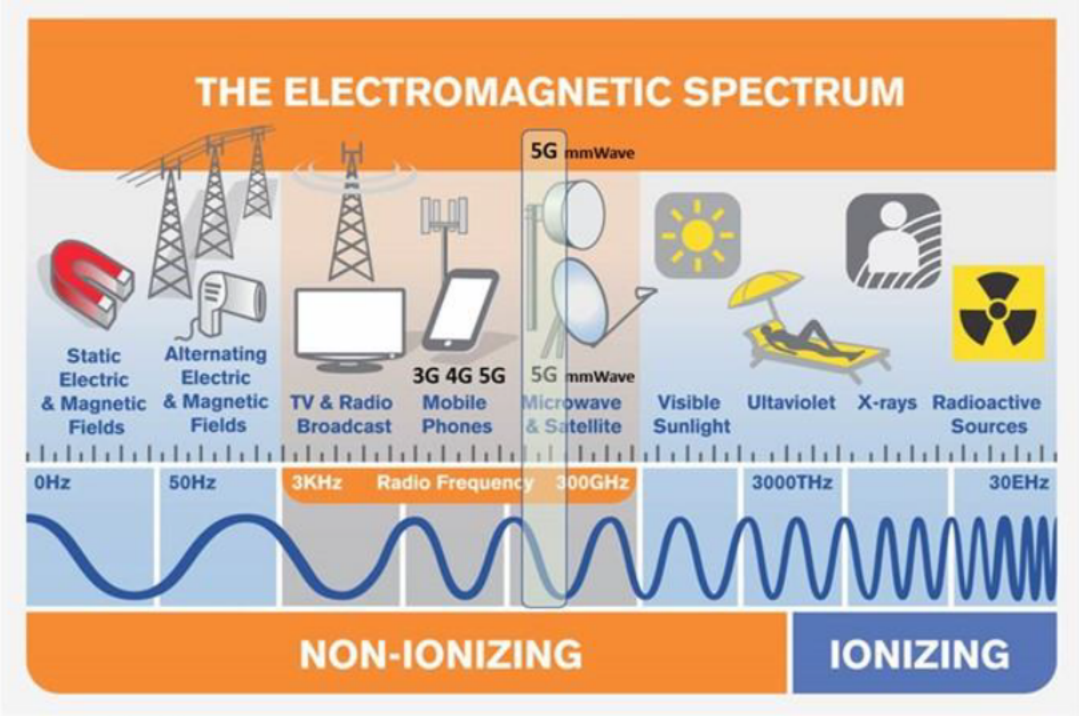


Figure 11: 5G base station EME versus Public Safety Limit.

Ever since Italian inventor Marconi first discovered the ability to modulate radio waves for communication in 1895, we have found ever increasing ways to use radios for communication. 5G, in all the radio bands it uses including 3.6 GHz and mm-wave bands, is a narrow part of the overall radio spectrum, as illustrated in Figure 12 below.

28 For details, see https://www.telstra.com.au/consumer-advice/eme/5g-and-eme
29 https://www.arpansa.gov.au/research/surveys/mobile-phone-base-station-survey/australian-exposure-limits



Source – EMF Guide

Figure 12: The electromagnetic spectrum and EME.

ARPANSA, the agency of the Commonwealth Government tasked with protecting people and the environment from the harmful effects of radiation, says that "*there are no established health effects from the radio waves that the 5G network uses*".[30]

The health and safety of the public and Telstra workers and contractors is critically important for Telstra. We recognise there is some public concern over possible health effects from EME generated by wireless technologies. Telstra applies a range of processes and controls to ensure EME is managed in accordance with the global and domestic regulatory parameters. It is important that all network providers operate in line with community expectations, scientific understanding, safety standards, compliance requirements, and that the public and staff are well informed. This approach also applies to 5G, with EME issues relevant to this technology incorporated into our existing framework.

Scientific research over many decades has enabled national and international health authorities to develop standards and guidelines that take account of biological effects and establish safety limits for exposure to RF EME[31]. Exposure limits incorporate large safety margins for added protection. Telstra takes compliance with the safety standards very seriously.

30 https://www.arpansa.gov.au/news/5g-new-generation-mobile-phone-network-and-health
31 Electromagnetic energy (EME) and electromagnetic fields (EMF) are used interchangeably. 'Radiofrequency' is a term used to define frequencies from around 3 kilohertz (kHz) and up to 300 gigahertz (GHz).

5.1. The science facts

On scientific matters, Telstra is guided by recognised national and international scientific bodies and health agencies including the World Health Organisation (WHO), the International Commission on Non-Ionising Radiation Protection (ICNIRP)[32] and ARPANSA. For each of their given mandates, these organisations conduct reviews of the large body of international scientific research that has been published over the last 50 years or so.

The scientific basis of exposure standards remains sound

The RF exposure limits were developed by ICNIRP and ARPANSA by first identifying a threshold exposure level and then applying a reduction factor to that level. The threshold level chosen is the EME exposure level which can result in a whole-body temperature rise of about 1° Celsius over a sustained period, a rise which is similar to the natural daily body temperature variation[33]. The ICNIRP and ARPANSA general public limits have been set conservatively at fifty (50) times below the threshold exposure level.

In 2014, ARPANSA released a review by its "*RF Expert Panel established to assess the scientific literature to formally determine whether there are any significant changes to the science underpinning the Standard*[34] *and whether it continues to provide adequate protection*." The Panel concluded that "*the underlying basis of the ARPANSA RF exposure Standard remains sound and that the exposure limits in the Standard continue to provide a high degree of protection against the known health effects of RF electromagnetic fields*."[35]

In 2018, the ICNIRP released a draft revision of its EME exposure guidelines for public consultation[36]. It also included an in-depth review[37] of the scientific literature on EME and health from which it concluded that the "*overall evaluation of all the research on HF* [high frequency, 100 kHz - 300 GHz] *fields leads to the conclusion that HF exposure below the thermal threshold is unlikely to be associated with adverse health effects*"[38]. That is, there are no scientifically substantiated adverse health effects associated with exposure to EME at levels below the revised or current[39] ICNIRP guidelines. The ICNIRP's revised guidelines are expected to be published towards the end of 2019.

5G is covered by exposure standards

Current deployment of 5G by Telstra uses a frequency (3.6 GHz) that is close to the frequencies used for previous mobile generations (700 MHz to 2.6 GHz). It is expected that in the future, 5G will also use

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32 ICNIRP is an independent non-profit organization providing scientific advice and guidance on the health and environmental effects of non-ionizing radiation (NIR) to protect people and the environment from detrimental NIR exposure. It is recognized as an official collaborating non-governmental organization (NGO) by the WHO and the International Labour Organization (ILO). ICNIRP publishes EME exposure limits (guidelines) that have been adopted by many countries including Australia.

33 In the frequency range 10 MHz to 300 GHz, heating is the primary established health effect.

34 ARPANSA. 2002. Maximum exposure levels to radiofrequency fields – 3 kHz to 300 GHz, Radiation protection Series No. 3 (RPS3), available at https://www.arpansa.gov.au/regulation-and-licensing/regulatory-publications/radiation-protection-series/codes-and-standards/rps3

35 Report by the ARPANSA Radiofrequency Expert Panel on Review of Radiofrequency Health Effects Research – Scientific Literature 2000–2012 (ARPANSA 2014) https://www.arpansa.gov.au/sites/default/files/legacy/pubs/technicalreports/tr164.doc

36 https://www.icnirp.org/en/activities/public-consultation/consultation-1.html

37 ARPANSA and ICNIRP reviews considered the scientific literature on the relationship between EME and health outcomes including symptoms (headaches, concentration difficulty, sleep quality), cognitive function, cardiovascular effects and brain cancer (in relation to mobile phone use).

38 https://www.icnirp.org/en/frequencies/high-frequency/index.html

39 ICNIRP. 1998. ICNIRP Guidelines For limiting exposure to time-varying electric, magnetic and electromagnetic fields (up to 300 GHz), Health Physics, 74(4):494-522

frequencies just below or within the millimetre wave spectrum (mm-wave, 30–300 GHz[40]). The first mm-wave band to be used for 5G is the 26-28 GHz band. In the future, other mm-wave bands being considered for 5G (subject to decisions at WRC-19[41]) are all below 100 GHz, including 40 GHz, 45-47 GHz, 50-52 GHz, 66-76 GHz and 81-86 GHz. In the future (WRC-23) bands above 100 GHz may be considered but that is some time off. Across these frequencies, the only scientifically substantiated biological effect of low level EME is the heating of human tissue. This is recognised by the international and national standards setting bodies, ICNIRP and ARPANSA, and as mentioned previously, the exposure limits are set such that the effect on the human body from wireless technologies is a very low and non-consequential level of heating. 5G is captured by these safety standards so the addition of this new technology adds no risk.

Exposure limits are conservative and cover people across all ages and populations

It's important to note that the general public exposure limits in both the ICNIRP guidelines and the ARPANSA exposure standard have been developed to protect all people. The ICNIRP notes that its guidelines for the general public took into account all people including "*the frail and/or elderly, infants and young children, and people with diseases or taking medications that compromise thermal tolerance*." ARPANSA states that its standard "*has been specifically devised to protect everybody, including children*."

IARC classification

The WHO's International Agency for Research on Cancer (IARC[42]) classifies agents that humans may be exposed to, based on the strength of evidence of their potential as human cancer hazards. An agent is any chemical, physical, or biological entity or exposure circumstance (e.g. occupation as a painter). To do the classification, IARC establishes Working Groups of specialist scientists to review the existing scientific evidence for any cancer hazard associated with the selected agents. IARC does not consider 'risk' or likelihood of harm to humans. See the IARC Preamble[43] that describes the process and criteria for classifying agents.

In 2011, IARC classified RF electromagnetic fields (EMF) (30 kHz-300 GHz) as Group 2B, i.e. defined as being 'possibly carcinogenic to humans'. This classification was based on limited evidence related to the use of mobile handsets. The IARC Preamble notes that the Group 2B classification comes with the proviso that "*chance, bias or confounding could not be ruled out with reasonable confidence*."

Neither ICNIRP nor ARPANSA changed their exposure limits as a result of the IARC classification. The WHO has written that, in regard to the classification, "*Studies to date provide no indication that environmental exposure to RF fields, such as from base stations, increases the risk of cancer or any*

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40 The band is called mm-wave because the wavelength of electromagnetic waves in free-space varies between 1 mm (at 300 GHz) to 10 mm (at 30 GHz).

41 World Radio Congress 2019 (WRC-19) is the four-yearly conference convened by the International Telecommunications Union. In 2019, it is considering the following spectrum bands for allocation to IMT on a primary basis: 24.25-27.5 GHz, 37-40.5 GHz, 42.5-43.5 GHz, 45.5-47 GHz, 47.2-50.2 GHz, 50.4-52.6 GHz, 66-76 GHz and 81-86 GHz, which have allocations to the mobile service on a primary basis; and 31.8-33.4 GHz, 40.5-42.5 GHz and 47-47.2 GHz, which may require additional allocations to the mobile service on a primary basis.

42 IARC's mission is to co-ordinate and conduct research on the causes of human cancer and to develop scientific strategies for cancer prevention and control.

43 IARC. 2019. Preamble to the IARC Monographs, 2019. https://monographs.iarc.fr/wp-content/uploads/2019/01/Preamble-2019.pdf

other disease."[44] The 2014 ARPANSA and 2018 ICNIRP reviews of the scientific literature on RF EME and health are consistent with the WHO's position.

5.2. Telstra's EME safety activities and support for 5G research

Telstra has maintained a nationally and internationally recognised EME safety capability since the mid-1980s where specialist staff monitor the state of the science and have developed a dedicated compliance and reporting process. Telstra also offers comprehensive information and advice to the public about EME[45] at Telstra.com.

In a world-leading initiative, AMTA has implemented, as part of its RF safety program, a publicly-accessible reporting site called the Radio Frequency National Site Archive (RFNSA[46]). Telstra was commissioned to develop the site and is also responsible for its ongoing management. This web site documents Australian mobile network base stations, provides EME reports, site locations, carrier contact details for existing sites and community consultation information for new sites, including for 5G sites.

In recognition of Telstra's scientific expertise in RF dosimetry[47], a consortium of leading Australian research institutions has also invited Telstra to participate in a research centre of excellence funded by the Federal Government's National Health and Medical Research Council (NHMRC)[48]. The current centre is called the Australian Centre for Electromagnetic Bioeffects Research (ACEBR)[49] which is funded from 2018 to 2022[50].

Involvement in the ACEBR enables Telstra to seek advice on scientific issues as part of our commitment to consider possible health effects from EME, and our expertise in dosimetry enables us to assist fellow researchers conduct accurate experiments[51]. A listing of scientific journal papers published by ACEBR researchers, including Telstra staff, can be viewed at the ACEBR's website[52]. The papers include the research undertaken at Swinburne University of Technology (as part of the ACEBR) to more accurately specify the physical properties of human tissue and the behaviour of EME propagation into the body at 5G and higher frequencies.

44 WHO. 20 Sep 2013. 'What are the health risks associated with mobile phones and their base stations?', available at https://www.who.int/features/qa/30/en/
45 https://www.telstra.com.au/consumer-advice/eme/5g-and-eme
46 https://www.rfnsa.com.au/
47 Dosimetry is the measurement or calculation of electromagnetic fields in biological materials and bodies and is an essential part of studies on health effects of EME.
48 The first was the Australian Centre for Radiofrequency Bioeffects Research (ACRBR) funded from 2004 to 2009; the second was the Australian Centre for Electromagnetic Bioeffects Research (ACEBR) from 2012 to 2016.
49 Partners in the ACEBR include Swinburne University of Technology (SUT), the University of Wollongong, RMIT University, The University of Adelaide, SA Pathology, and the Victor Chang Cardiac Research Institute. Involvement by Telstra is through two staff having Adjunct Research positions at SUT. See https://acebr.uow.edu.au/index.html.
50 The source of the funding provided by the NHMRC is from the Australian Government's levy on radio communication license fees.
51 While Telstra actively participates in EME research providing dosimetry support to studies, it does not conduct the health risk assessments from the research. National and international health agencies such as ARPANSA and the WHO have the responsibility to determine and advise on health risks based on results of research.
52 https://acebr.uow.edu.au/publications/index.html

5.3. International and domestic standards and regulatory frameworks

The Australian Communications and Media Authority (ACMA) is responsible for regulating EME from wireless or mobile enabled consumer devices[53] (such as mobile phones, Wi-Fi) and radiocommunications facilities (such as mobile base stations) through licence conditions[54]. A common feature of the regulations is the reference to the science-based limits published in ARPANSA's human exposure standard (covering the frequency range 3 kHz to 300 GHz, which includes frequencies used by 5G).

In Australia, the ARPANSA standard is based on the ICNIRP guidelines (which covers all frequencies to 300 GHz). In preparing their guidelines, ICNIRP reviews the large body of independent international and domestic scientific research, including the research undertaken by the ACEBR. ICNIRP is expected to publish revised guidelines by the end of 2019 and has emphasised the 'transparency' of the science involved in setting the human exposure limits and the need to readily update the guidelines as new scientific information comes to hand[55].

EME compliance assessment standards[56] for all radio communications networks, systems and devices globally including 5G are developed by the International Electrotechnical Commission (IEC) Technical Committee TC106. The IEC has developed the 5G assessment standards jointly with the IEEE and provides the technical methodology to the ITU for reference in their global recommendations. National governments and standards bodies are members of the IEC and either directly adopt IEC standards or use the technical methodology in their own standards. Standards Australia directly adopts IEC standards and uses a locally developed Australian methodology to ensure harmonisation with other countries in the region and globally. Telstra plays an active role in Standards Australia, the IEC and the ITU. Mike Wood from Telstra is the current Chairman of the IEC Technical Committee TC106.

The AMTA RF safety program also includes EME assessment procedures for mobile base stations to ensure that they meet the requirements of Standards Australia and the IEC. AMTA in association with the National Association of Testing Authorities (NATA) has developed a national accreditation program for EME measurement laboratories and testing officers to ensure the quality and accuracy of EME assessments is maintained. This includes ACMA audits of EME levels at base station sites.

5.4. Compliance with EME standards and regulations

Telstra has a dedicated EME compliance team and ensures compliance with EME standards and regulations through a three-stage process:

(a) Base station site design – all site designs are modelled to ensure compliance with EME standards following set procedures and radio frequency engineering design guidelines.

(b) Environmental EME Assessment - an Environmental EME Report is prepared for all sites. The Environmental Report estimates the maximum cumulative EME emitted from the base station. The estimated levels are conservative and are calculated based on the maximum mobile call and data capacity anticipated for each site. Actual EME levels will generally be significantly less than

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53 Radiocommunications (Compliance Labelling - Electromagnetic Radiation) Notice 2014 and the Radiocommunications (Electromagnetic Radiation-Human Exposure) Standard 2014.
54 Radiocommunications Licence Conditions (Apparatus Licence) Determination 2015.
55 Presentation by Professor Rodney Croft, ICNIRP Commissioner, at BioEM 2019 Montpellier, 23-28 June 2018.
56 Available at https://www.iec.ch/dyn/www/f?p=103:7:0::::FSP_ORG_ID,FSP_LANG_ID:1303,25

predicted, due to path losses and the base station automatically reducing transmitted power to only serve established phone calls and data transmissions.

(c) Site Safety Documentation (SSD) – The SSD comprises the EME Guide (EMEG), a Site Compliance Report (SCR) and a Site Compliance Certificate (SCC). This documentation is prepared by a National Association of Testing Authorities (NATA) Assessor after commissioning, to certify that the site has been assessed and complies with the Radio Frequency Human Exposure Limits as specified by the Australian Communications and Media Authority (ACMA) *Licence Condition (Apparatus Licence) Determination 2015* (LCD) and the requirements of the ARPANSA *Radiation Protection Standard for Maximum Exposure Levels to Radiofrequency Fields - 3 kHz to 300 GHz*[57].

The Environmental EME Report and the SSD is available via the Radio Frequency National Site Archive (RFNSA) at www.rfnsa.com.

The ACMA also checks our compliance by undertaking audits of EME levels at base station sites.

5.5. Worker safety

To promote safe work practices at radiocommunications sites, the industry has developed the RadioWorkSafe mobile application and website[58]. RadioWorkSafe provides the basic safety steps for working on base stations and buildings and other facilities with radio transmitting antennas. RadioWorkSafe also provides building and facility managers with essential information to help provide a safe work place and manage access around mobile and communications antennas.

5.6. 5G measurements

We have completed extensive testing of our 5G network infrastructure in real-world settings using commercially available 5G devices, and our data confirms two things. Firstly, our 5G base stations produce EME levels at around 1,000 times below the safety limits in many cases. Secondly, all our testing has found 5G EME levels to be similar to 3G, 4G and Wi-Fi technology.

It is helpful to have real EME readings from 5G in a live network, in a variety of typical use cases and locations like cafes, residential streets, sports fields, schools and apartments. These are the places that 5G is going to be used in the real world.

We conducted our testing on the Gold Coast and in Brisbane in collaboration with Ericsson, Narda and Total Radiation Solutions, to give a clear and definitive answer to many of the questions people are asking. We used both the HTC 5G Hub mobile broadband hotspot and the Samsung Galaxy S10 5G smartphone for the survey and configured both devices to produce a high level of data traffic over 5G using download speed tests, 4K video streams, and the iPerf[59] network transmission test tool.

As far as we are aware, to date Telstra is the only operator globally to undertake this level of real-world testing. We believe that we have a responsibility to share this data freely and publicly and to explain what it means in the clearest and simplest terms[60].

57 Radiation Protection Standard for Maximum Exposure Levels to Radiofrequency Fields - 3 kHz to 300 GHz
58 https://www.radioworksafe.com.au/
59 iPerf is a software tool for active measurements of the performance of IP (internet protocol) networks.
60 See https://exchange.telstra.com.au/5-surveys-of-5g-show-eme-levels-well-below-safety-limits/

Indoor testing – inside apartments and cafes

In the testing we completed inside apartments and cafes near our 5G Innovation Centre at Southport on the Gold Coast, we measured 5G base station EME levels consistently under 0.02 percent of the limits set in the ARPANSA safety standard – that is, more than 5,000 times below the safety limit.

We undertook our testing in apartments where young families and our own network engineers' partners live. In our apartment testing, we had a room full of network engineers maxing out their devices simultaneously, while still delivering those EME results of more than 1,000 times below safety limits.

Outdoor testing – in the street, at school, at the sports ground

Outside in the street – as well as at a school and at a sports ground in the suburb of Musgrave in Queensland – our testing confirmed that 5G base-station EME levels are well below the safety limits. Our real-world testing using commercial devices and our live 5G network technology showed network EME levels at around 1,000 times below the safety limit in many cases. We are now able to use this real-world data to answer questions from customers (and other stakeholders) and confirm that all our 5G base stations comply with the EME safety limits.

Positive feedback from the scientific community

We presented our findings to the WHO in Geneva, to the IEC, and to the 2019 BioEM Conference at Montpellier, France, in late June. The feedback from scientists, engineers and technical experts was positive – these are currently the globally definitive real-world tests for the EME levels produced by 5G in everyday use conditions, along with our comparison of 5G to the EME produced by existing 4G, 3G and Wi-Fi technology.

Impact as 5G services are expanded

People have asked what 5G will be like when many more devices are connected. To answer this question, we tested mm-wave on our trial network operating at maximum capacity and modelled our test results on the current network at maximum capacity. We observed no significant increase in EME levels. Next year we will undertake further testing on mm-wave frequencies with more spectrum.

Essentially, the many efficiency improvements of 5G over 4G and 3G, including beam forming antennas, mean that when more devices are connected to a network, EME levels remain low on 5G – this is one of the main advantages of the new technology.

Testing shows 5G EME well below safety limits

We have continued the 5G testing program and in October 2019 we conducted a further set of extensive 5G tests at the Gold Coast in real world environments with base stations operating at 160 Watts and with 80 MHz of spectrum bandwidth.

In this series of measurements, we tested the 5G technology in 3 different configurations:

1. Normal 4K Ultra High Definition video streaming (less than 10% full power) - which represents a typical usage from customers;
2. iPerf 200 Mb/s (30-50% full power) which represents a high network utilisation; and
3. iPerf 1500 Mb/s (approximately 100% full power) which represents very high network utilisation and close to maximum capacity.

5G technology is designed to be very efficient and provide high quality service to customers using low power levels, however we wanted to test the network close to maximum power as we are often asked about this. These test configurations enable us to measure the EME levels from 5G at various network loads and close to maximum capacity.

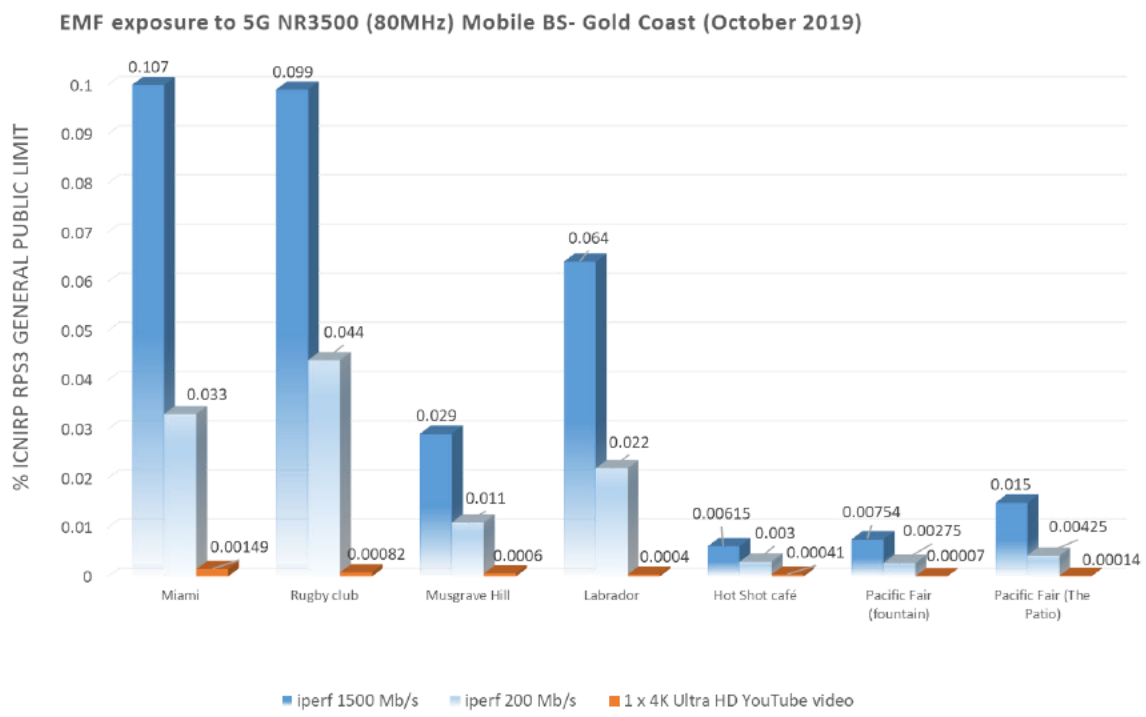

Figure 13: EME test results Gold Coast October 2019 at various network load configurations

In all our testing, the 5G EME levels from base stations were found to be well below the EME safety limit – in many cases, around 1,000 times below the safety limits.

We will continue to undertake further testing on 5G including the advanced antennas and 'beam steering' capability of 5G, which can improve coverage and data transfer speeds using existing antenna hardware and even more efficient transmission methods.

5.7. Flora and fauna

The World Health Organisation (WHO) have investigated the effects of EME on the environment. In their 2005 information sheet the WHO concluded: "*The limited number of published studies addressing the risk of EMF to terrestrial and aquatic ecosystems show little or no evidence of a significant environmental impact, except for some effects near very strong sources. From current information the exposure limits in the ICNIRP guidelines for protection of human health are also protective of the environment.*"[61]

Earlier this year Telstra sought further advice from ARPANSA on the matter who responded: "*There is no established evidence that EME exposure from wireless telecommunications sources is harmful to*

[61] https://www.who.int/peh-emf/publications/facts/envimpactemf_infosheet.pdf

flora or fauna. It should be remembered that many of the studies investigating human health are performed in the laboratory on animals and plant cells". Telstra also welcomes the establishment of EKLIPSE, a European Union funded project, which according to its mandate "… *will set up a sustainable and innovative way of knowing, networking and learning about biodiversity and ecosystem services*."[62]

For animals that are able to use EME for purposes of navigation (e.g. birds and bees), the current scientific understanding is that such animals have biological mechanisms that utilise magnetite particles (or similar) present in some of their cells (that interact with the Earth's magnetic field) and possibly also utilise cryptochrome molecules in the retina (activated by blue light: 610-670 THz). These electromagnetic phenomena are well outside the radiofrequency spectrum. We will continue to follow this important topic with interest.

62 http://www.eklipse-mechanism.eu/about_eklipse

06 How can government help?

Throughout our submission we have provided many examples of the anticipated social and economic benefits 5G technology will provide. The opportunity for Australia is to pave the way for the timely introduction of 5G to enable all Australians to realise this benefit and to ensure we keep pace with other countries.

However, there are economic challenges and other risks to achieving this goal. This final section of our submission explores the potential challenges and risks and how government can assist to address these through policy settings and other measures.

We note that other government administrations overseas are implementing specific programs of work to maximise the opportunity for 5G. For example, the United States Federal Communications Commission (FCC) is pursuing a comprehensive strategy to Facilitate America's Superiority in 5G Technology (the 5G FAST Plan[63]). The strategy includes three key components: (1) pushing more spectrum into the marketplace; (2) updating infrastructure policy; and (3) modernizing outdated regulations.

6.1. Principles for an effective policy and regulatory framework

To maximise the opportunity for Australia to remain a world leader in mobile network technology and to deliver the social and economic benefits 5G is forecast to generate, we need a policy and regulatory framework that creates the right environment for investment and innovation, in the interests of, and inclusive of all, customers – individuals, communities, businesses and governments who will use the connectivity provided by 5G in transformative ways.

Supporting investment

High quality telecommunications networks require substantial capital investment, both in the cost of equipment and the cost of acquiring radio spectrum. Telstra alone spent more than $4 billion in the last 12 months in capital expenditure, and overall, the telecommunications industry spent between $9 and $11 billion per annum for each of the last three years according to the Ovum Communications Provider Revenue and CapEx tracker[64].

Research from PwC[65] shows return on invested capital for telecommunications was just 7 percent in 2016, having declined from 12 percent in 2012. Over time, reducing returns on invested capital leads to the risk of capital investment reducing and a significant decline in network experience for customers. The regulatory and policy framework must enable providers to generate a sufficient rate of return on the services they sell, while still meeting the goal of fostering open and fair competition. This occurs best through service differentiation, which in the 5G era will come from traditional attributes such as network coverage and performance, along with new service differentiation capabilities enabled through new features such as network slicing.

Policies that undermine service differentiation, such as mandated roaming or sharing of active network equipment between carriers reduce incentives for network operators to invest, as any form of competitive

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[63] https://www.fcc.gov/5G
[64] Ovum. Communications Provider Revenue and CapEx Tracker, 2Q19. 2 October 2019. Report ID: GLB007-000301. https://www.ovumkc.com/Products/Service-Provider-Markets/Service-Provider-Strategies/Communications-Provider-Revenue-Capex-Tracker-2Q19/Summary
[65] PwC. Always On Australia – Seizing the opportunity for future generations. July 2018.

differentiation is stifled. It is vital that government policies support investment, delivering true product and service differentiation that underpins healthy investment returns.

Supporting innovation

Australia must build its innovation capital if we are to retain our global reputation and our high living standards as the world enters the fourth industrial revolution. With low levels of manufacturing, Australia is heavily reliant on mining and agriculture to drive export revenue. We need to ensure these industries remain competitive globally by employing the latest technology to reduce cost and overhead, and 5G will usher in new levels of productivity, both at point of production as well as in the transport and logistics associated with these commodities.

Similarly, Australia needs to expand its capabilities as a technology country to reduce our reliance on primary production and to claim our place as an innovative country delivering world leading technology solutions. 5G will play a pivotal role in Australia's transition to global technology innovator, ensuring that future generations of young Australians do not have to move off-shore to develop their careers, but instead can readily find fulfilling jobs in the technology sector at home.

To realise this opportunity, we must systematically review regulations in every industry and every sector, from R&D to immigration visas, to ensure the right incentives exist for technology innovation to happen in every sector.

Supporting customer and inclusion outcomes

It is often the case, that in periods of rapid change, those that are left behind in our communities are those who can least afford to be. The Australian Digital Inclusion Index (ADII)[66] measures the availability of connectivity, the affordability of connectivity and the digital skills of Australians with which to take advantage of connectivity and the technology it delivers.

The report considers these dimensions across different cohorts within our society covering gender, indigenous, ethnicity, income, regional, remote and metro. What it shows is that across the nation, digital inclusion follows some clear economic and social fault lines and that in general, Australians with low levels of income, education, and employment are significantly less digitally included.

There is a substantial gap in digital inclusion between richer and poorer Australians and the so-called 'digital divide' is particularly acute in regional areas. In 2018, every regional centre recorded a lower digital inclusion score than the Australia-wide average for capital cities. The broad point is that too many Australians – and particularly regional and low income Australians - are simply missing out on the opportunities of the digital age. Policy must continue to recognise these divides – the 5G future is for everybody and we cannot have a situation where some Australians are missing out.

6.2. Economic challenges of 5G investment

High quality telecommunications networks require an incredible amount of capital investment. As mentioned in section 6.1, Telstra alone spent more than $4 billion in the last 12 months on capital expenditure.

[66] https://digitalinclusionindex.org.au/the-index-report/report/

Mobile network deployment is especially capital intensive and over the last 5 years to 30 June 2019 Telstra has invested around $8bn in its mobile network including the build and spectrum purchase for our 5G rollout. For our 5G deployment from inception to the end of FY20 we will have invested almost $1b in 5G spectrum and network infrastructure. We anticipate our expenditure over the following two years for rollout and spectrum acquisition will be at least of this order of magnitude, and significant annual investments will continue for some years beyond that as we build out 5G across our mobile coverage footprint.

However, at the same time as industry capex spend is increasing, returns on invested capital are reducing and ultimately this could compromise investment capacity within the industry with flow on effects to the quality of experience we can offer customers on our networks.

If this industry landscape wasn't already challenging enough for the economics of mobile network deployment, the nature of 5G, however, adds new economic challenges for its rollout that were not experienced to the same extent with previous technologies. 5G relies on higher frequency bands such as the 3.6 GHz band that has already been allocated in Australia, and the 26 GHz mm-wave band that is to be auctioned in early 2021, to provide the much larger blocks of spectrum that are required to underpin 5G's capacity and speed advantages over 4G, and these larger blocks come at considerable cost in terms of spectrum purchase.

At the same time, these higher frequencies do not cover as far or as deep into buildings as existing mobile bands and so to cover an equivalent area to an equivalent depth with 5G, with the significant capacity and speed gains people expect from the technology, requires an increase in the number of sites and site density compared to earlier technologies.

While the use of small cells (that are less costly per cell than macro base stations) will help achieve this without seeing costs increase entirely proportional to the increase in number of sites, there will still be an overall increase as each small cell site still incurs costs related to access and lease payments, and regulatory compliance requirements.

To deliver the speed and latency benefits of 5G to our customers also has a ripple effect on investment costs beyond the radio access network, notably for underpinning backhaul (fibre and fibre capacity) especially as we move out into remoter regional and rural areas of the country. While existing backhaul transmission links are generally adequate to deliver the benefits of 3G and 4G to customers in such areas, upgrading of this infrastructure to enable the full 5G experience in these areas will be very costly and may be uneconomic. This is an opportunity for some government co-investment as explained in section 6.3.

6.3. Regional co-investment

The Federal Government's regional Mobile Black Spot Program (MBSP) has been a resounding success for many years. Across four rounds, the Federal Government has successfully leveraged industry, Federal, State and Territory Government contributions of over $760 million to deliver improved mobile coverage through the construction of 1,047 new sites. Through the MBSP, Telstra has invested over $280 million in capital delivering new and improved coverage to over 60,000 premises across an area of around 200,000 km^2.

While the MBSP has been highly successful in delivering infrastructure to regional Australia, the model for co-investment is now starting to face challenges due to the declining number of customers for each new mobile site. We think it is time to investigate new and innovative ways for governments to partner with industry to deliver improved telecommunications services and outcomes for regional Australia.

From a first principles perspective, co-investment supports delivery of new and / or upgraded infrastructure that would otherwise be uneconomic. However, the challenges with economic viability extend beyond just delivering new mobile coverage to remote areas; they apply equally to other enabling infrastructure such as backhaul and transmission networks. This is likely to be even more pertinent in the era of 5G which will bring an order of magnitude increase in data speeds.

We propose that future rounds of the MBSP would do well to consider backhaul capabilities in regional and remote locations where the upgrade costs to a carrier are uneconomic (in terms of the incremental revenue), but the population would benefit from a full 5G experience to foster businesses, remote telehealth services and other innovative products and services that will only be possible under 5G.

Another opportunity for improving the usefulness of the program is to expand the criteria to not only focus on residences or population covered, but also strategic locations such as social and economic hubs, roads and facilities that will be increasingly dependent on 5G technology in the future for the connection of various type of IoT devices, including vehicles and agricultural sensors. We also suggest the program be expanded to include the subsidisation of coverage enhancing devices such as smart mobile repeaters (approved for use by the carriers) and passive Yagi antennas to boost the performance of existing and future mobile services (including 5G) in marginal coverage areas.

6.4. Spectrum access

At the heart of any mobile network is radio spectrum as mobile networks cannot operate without it. So timely and ongoing access to suitable spectrum is critical for investing in and operating mobile networks.

Timely access to suitable radio frequency spectrum is essential for any mobile network. There is limited opportunity for 5G to be deployed within existing spectrum holdings as these are already utilised for 4G and 3G services. 5G also requires larger blocks of spectrum than 3G or 4G. The spectrum that will be freed up after turning 3G off can be used to supplement other 5G spectrum but is insufficient on its own. So, it is important that suitable new spectrum is released for 5G. We were pleased to see the Government auction spectrum in the 3.6 GHz band at the end of 2018 along with the Minister of Communications' recently announced plans to auction 26 GHz spectrum in early 2021. It is important that the latter stays on track as the 26 GHz spectrum is critical for delivering the next phase of 5G in Australia to deliver the very fastest speeds. There is also a need to identify additional spectrum in other bands before we can realise the full potential of 5G. We see freeing up spectrum in the 3.7-4.2 GHz band for 5G being the next priority.

We are also pleased to see the Minister of Communications recently announced plans to progress further reform of the existing radiocommunications legislation, in a staged fashion.

While Telstra appreciates there is due process to follow for the assignment of spectrum, enacted in the *Radiocommunications Act 1992*, we believe more could be done to speed up reallocation of spectrum via auction. Central to this is a simpler spectrum reallocation framework that enables spectrum to move to new uses more rapidly and with less administrative cost. We have previously advocated[67] for

[67] Telstra submission to DoCA Consultation on new Spectrum Legislation, 28 July 2017. https://www.communications.gov.au/sites/default/files/submissions/2017-07-28-miller-brian-telstra-submission-spectrum-review-exposure-draft-2017-07-28.pdf

streamlining of licensing processes by removing the requirement for the Minister to be involved in related decision-making and for the ACMA to further streamline its auction planning and processes.

There is a need for greater certainty about licence tenure to support investment planning, avoid stranding existing investments and services, and to maximise the utilisation of the spectrum resource. While spectrum licences sold at auction can currently have a term of up to 15 years, there is no certainty about the renewal of licences at the expiry of their term. Other licences (e.g. apparatus licences that are assigned on an administrative basis) typically only have a term of one year but they are normally renewed without question. As part of the reforms we are seeking provision for all licences to have a longer maximum term and a default expectation that they can all be renewed subject to certain conditions being met (i.e. there is evidence of substantial investment in the spectrum), along with a defined process for making renewal decisions and setting the renewal price.

Finally, it is important that mobile network operators can continue using spectrum on an exclusive basis. Exclusive spectrum is necessary to support the delivery of a high performing and reliable service. Mandatory sharing of spectrum carries the risk of greatly undermining investment confidence for both the mobile network operator, and the access seeker wishing to share the spectrum, as well as making it more difficult to ensure services are delivered at the required quality. Mobile network operators are concerned that when the time arrives to reclaim spectrum which was subject to forced sharing with an access seeker, the inertia exerted by end-customers of the access seeker service will delay deployment. Similarly, sharing undermines investment for the access seeker, as rollout plans for mobile networks can change based on a variety of factors, and investment return windows for the access seeker can be greatly shortened with little warning.

6.5. Deployment framework improvements

Future 5G technology will require more infrastructure than previous generations. This is partly due to the higher frequencies being deployed, and due to the ever-increasing demand for mobile broadband data. This denser framework will also see an increase in the use of small cells. Currently, Telstra works with existing infrastructure providers such as electricity utilities to deploy small cells. Telstra often has difficulty in providing all types of mobile network infrastructure to new housing estates or commercial developments. In instances where there is no existing infrastructure, Telstra must lodge a Development Application with state government or local council to install even a 'street' pole. The time and cost involved in this process does not scale economically for 5G where a large number of low power and low visual impact small cells will be required.

Through AMTA, carriers have identified the following short and longer term opportunities for a more effective legislative framework in the deployment of future mobile networks.

Short term opportunities range from simple administrative updates to the *Telecommunications (Low-impact Facilities) Determination 2018* (LIFD) to align with changes already made to the *Telecommunications Act 1997* earlier this year, and minor updates to the definition of a Radiocommunications Facility in the LIFD to allow for multiple antennas on the device.

Longer term opportunities include capabilities such as the ability to install poles under the LIFD where it is not feasible to use existing infrastructure, and better process alignment for facilities and locations already managed under other State and Federal legislation such as airports. We also recommend that consideration be given to providing carriers with rights similar to those for other utility operators to deploy telecommunications infrastructure along transport and other existing infrastructure corridors.

We recognise these longer term opportunities require all stakeholders to come together to agree the scope and extent of the changes, and we look forward to working with stakeholders to find effective ways to reduce unnecessary administrative burden in the deployment process while maintaining sufficient governance to ensure amenity standards are met to address community expectations.

6.6. Government support to promote demand for 5G use

DoCA's 5G Work Group (5GWG) was convened in late 2017 on the back of the Department's *5G—Enabling the future economy* paper[68] to foster an ongoing dialogue on 5G issues. One of the goals was to provide a platform for collaboration across Government and industry, and the group has proved to be a useful forum for this purpose.

An ongoing focus for the 5GWG is to ensure relevant government departments such as health, infrastructure transport and cities, and the department of agriculture understand the opportunities and application of 5G to their respective sectors. Understanding the information needs of other portfolios, coupled with an ongoing dialogue with industry bodies for those sectors will help to make sure the respective industries are thinking about the role of 5G within their sectors. This approach is particularly relevant as realising the benefits of 5G may often require new models of engagement and collaboration between industry and government, across different levels of government, and between industry and its business and government customers.

We encourage the Government to continue using the 5GWG and other mechanisms to explore the opportunities for Government organisations to leverage 5G, both for the delivery of government services and in the various industry sectors that government is engaging with.

6.7. Funding for Australian EME research

As we outlined in section 5.1, a large amount of research has been conducted over many decades yet health bodies such as ARPANSA state that while no health effects are expected from radio frequency exposures below the limits set in the ARPANSA standard, "*it is important to continue the research in order to reassure the Australian population.*"[69] We strongly support ongoing funding of EME research in Australia and look to the Australian government to ensure this research is well resourced.

ARPANSA is the primary health body responsible for the development of Australia's EME exposure standard. It is a respected voice in debates concerning the science of EME and plays an important role in ensuring public confidence in the compliance of mobile networks with EME standards through their program of EME surveys of mobile base stations. We support a well-resourced ARPANSA so that it can continue its valuable program of EME activities, particularly as 5G deployment intensifies.

The National Health and Medical Research Council (NHMRC) funded centres of research excellence such as the Australian Centre for Bioeffects Research (ACEBR) deliver valuable contributions to government, industry and the public, and similarly, we look to the Australian government to ensure these institutions are well resourced and funded.

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68 https://www.communications.gov.au/departmental-news/5g-enabling-future-economy
69 https://www.arpansa.gov.au/news/5g-new-generation-mobile-phone-network-and-health

6.8. Community and health professional EME education

The level of what we believe to be misinformation, purported to be based on scientific and medical evidence, circulating in the community about 5G EME and health is on a scale we have not seen with the rollout of previous generations of mobile technology. It appears to be driven largely by social media campaigns and there is evidence to suggest that messaging in these campaigns is being influenced by foreign actors[70]. We also observe that claims are often made that 5G hasn't been tested, when in fact we have conducted considerable testing[71] to confirm our network complies with the standards outlined in section 5.1. While only a small percentage of the community is engaging, the misinformation is gaining traction and the fears being raised need to be quickly and respectfully addressed.

We have also seen a lack of awareness and understanding of EME health related issues among some medical practitioners which is hampering their ability to properly advise patients and the wider community.

Telstra has been very active in presenting its experience and confidence that existing research and safety limits are appropriate for 5G. However, not surprisingly, some members of the public lack confidence in industry messaging on this issue.

Telstra would like to see a broad-based government led communications campaign that seeks to educate the public on the independent global and peer-reviewed research which has found that 5G technology is safe, and that there are robust government settings in place, which include monitoring of EME safety standards. Ideally this campaign should incorporate the research from relevant government health experts such as the Department of Health and Chief Medical Officer.

In addition to campaigns for the general public, we also believe that a program of EME information / training should be developed for the medical community so that practitioners are better informed about EME science and in turn they are able to better inform patients who present with concerns about EME and their health.

70 https://www.nytimes.com/2019/05/12/science/5g-phone-safety-health-russia.html
71 For example, and not limited to, Telstra's testing descr bed at: https://exchange.telstra.com.au/5-surveys-of-5g-show-eme-levels-well-below-safety-limits/