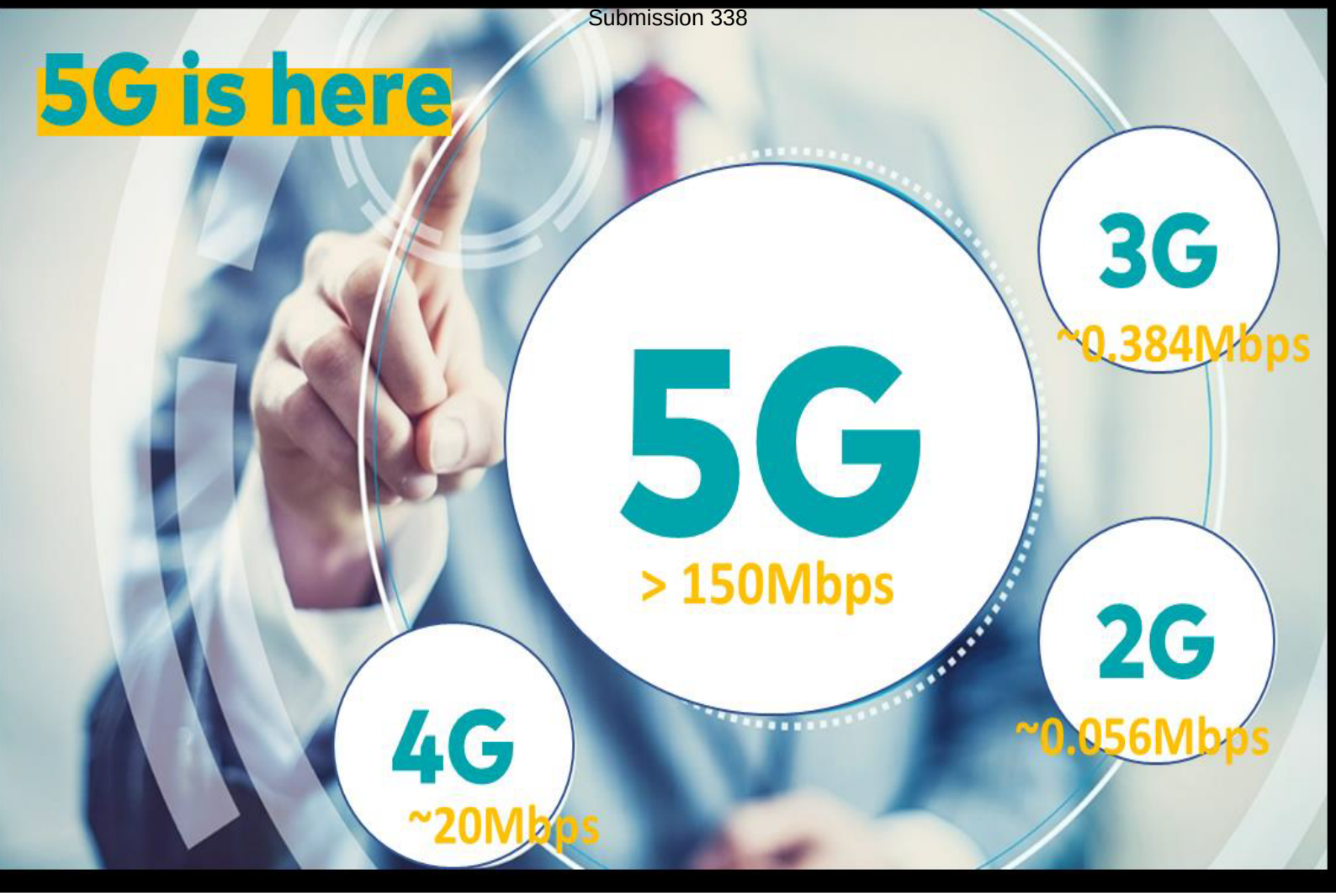

OPTU5G

Submission to House of Representatives Standing Committee on Communications and the Arts

Inquiry into 5G in Australia

Public Version

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Section 1. EXECUTIVE SUMMARY

1.1 Optus welcomes the opportunity to provide input to the House of Representatives Standing Committee on Communications and the Arts (Committee) inquiry into 5G in Australia.

1.2 5G technology has the potential to be truly transformative: changing the way Australians communicate, consume entertainment, and conduct business. Studies have predicted that the economy-wide benefits of mobile technology are likely to be huge, with productivity estimates of $65 billion by 2023.[1] 5G will play a large part in delivering these future productivity gains.

1.3 Australia is at the forefront of the transition to 5G with mobile operators, such as Optus, already delivering advanced services over 5G networks. Australia has the opportunity to build on this early-mover advantage, to unlock the predicted benefits of the new technology and to enhance our global competitiveness.

1.4 However, whilst 5G networks are already being deployed, we should not assume that the benefits of the technology are assured. Many of the truly transformative services will depend on the deployment of a radically different network architecture and new spectrum. This will require significant investment in network infrastructure, systems and technology in circumstances where future revenue streams are unclear.

1.5 There are also policy challenges that need to be addressed to help unlock the potential that could flow from 5G technology. These include:

(a) Ensuring sufficient spectrum is made available to unleash the potential of 5G;

(b) Removing roadblocks to the deployment of new small cell technologies, where cost and speed of deployment is central to the business case of 5G investment;

(c) Countering the misinformation on social media and within small but vocal parts of the community regarding the health impacts of mobile networks and 5G; and

(d) Ensuring competition and investment in nationwide infrastructure.

What is 5G?

1.6 To enable a full understanding of the opportunities unlocked by new 5G networks, it is first necessary to understand how 5G changes existing mobile architecture; and second, the timeframe and stages over which these changes are expected to occur.

1.7 Much focus has been on deployment of 5G base stations, specifically small cells. 5G New Radio (NR) allows materially more efficient use of spectrum, and the use of smart antennas both of which result in greater bandwidth well beyond 1 Gbps. In fact, Australia is in the unique position of utilising many of these '5G' changes within existing 4G networks. Optus is already utilising small cells and smart antennas for our 4G network, allowing Australian customers to experience some of the world's fastest 4G speeds. Optus' current 5G network uses 5G NR in conjunction with 4G radio and core networks.

[1] Deloitte, 2019, Mobile Nation 2019, p.17

1.8 The largest change comes with the second phase in the roll-out of 5G: the deployment of the 5G Next Generation Core, which allows greater flexibility, use of automation and secure APIs allowing customisation of core functions, without having to deploy and manage dedicated hardware. In addition, computing power will move closer to the customer with Multi-Access Edge Computing.

1.9 These changes allow for network slicing, where customers and services can be provided through dedicated slices of the mobile network to meet the required quality of service; and will materially decrease latency. In fact, 5G is capable of providing latency of less than 3ms end-to-end.

These changes give rise to new use-cases

1.10 The combination of enhanced mobile broadband speeds, ultra-low end-to-end latency, and software-based architecture opens up a range of new use-cases that are not possible over current mobile networks.

1.11 While there has been some media on far off future possibilities like autonomous cars or drone deliveries, these are speculative, and this submission will focus on use-cases that can both be delivered in the near term and achieve real change to the lives of our customers and businesses. We see some simple yet highly impactful future use cases for consumers, for example optimised mobile e-gaming, enabling Australia to be at the forefront of the global industry already worth around $240 billion in 2019 and growing each year.

1.12 In addition, the use of software defined functions, edge computing and ultra-fast bandwidth means that 5G networks will be a real alternative to fixed networks to deliver key consumer products like Ultra HD 4K & 8K live and on-demand video and e-gaming. 5G will represent a viable alternative to some fixed access networks in both terms of services provided as well as the economics of network deployment. Efficient utilisation of privately funded 5G fixed wireless networks could also help the NBN deliver ultra-fast broadband to premises that currently cannot access it over the NBN due to technology constraints.

1.13 In the enterprise space, Optus is collaborating with Australian businesses to develop practical use cases across a range of industries. Furthermore, as a part of the global Singtel Group, we are in the unique and advantageous position of gaining insights and learnings from Singtel's partnerships. One such example is Singtel's 5G trials of use cases at the Pasir Panjang Terminal. Awarded the 5G Technology Call by the Port of Singapore Authority (PSA) and the IMDA (Singapore's regulator of Communications) in June 2019, these 5G trials will support PSA's mission-critical, all-weather maritime operations such as its connectivity needs, the use of drones, remote tele-operations of port equipment, crane automation and enhancements to operations. The trials are a test-bed to develop state of the art technologies to operate what will be the largest fully automated container terminal in the world. This facility will truly take the internet of logistics to levels beyond anything that currently exists.

1.14 Optus is working with its partners on practical opportunities that can inform and enhance our ability to deliver real 5G networks and services to Australian consumers.

Barriers must be addressed to allow efficient deployment of 5G

1.15 The productivity benefits that are estimated to flow from mobile networks, including 5G, could be larger than the benefits that flowed from previous major economic reforms, like

the National Competition Policy.[2] But there are barriers to achieving the future made possible by this technology change. These include:

(a) **Access to spectrum** — Realising the full benefits of 5G requires deployment of massive channels of up to 400 MHz compared to the current use of 10-20 MHz channels across a broad range of spectrum frequencies, including high band for urban capacity and low band for national coverage. While the Government has fast-tracked the issuing of 26 GHz spectrum, similar urgency should be taken to reforming existing bands to enable them to be used for 5G networks, including both low and mid band spectrum.

(b) **Deployment of sites** — 5G requires the deployment of many more sites than current networks. Deployment rules that worked well for large macro sites do not work so well for small, low powered cells that fit on power poles or similar structures (small cells). These rules need to be examined and reformed to ensure they continue to be proportionate to the lower environmental impact of small cells.

(c) **Addressing EME safety concerns** — Decades of reliable, independent scientific research demonstrate that mobile technology, including 5G, is safe. EME in the home from mobile networks is typically below those emitted by standard household devices such as a microwave oven or baby monitor. However, there is genuine concern within the community about safety issues. Some of these concerns are being fuelled by false and alarmist claims from unreliable sources. Both industry and government need to work harder to counter any misinformation and ensure that the community is armed with the facts to enable it to embrace the technology that will bring so many benefits to people's lives.

(d) **Significant upfront investment requirements** — The future 5G services will require an overhaul of existing network architecture, which will necessitate significant capital investment in new infrastructure, systems and technology. These investments will need to be made in circumstances where future use cases and revenue streams are unclear. Optus recommends that Government considers whether additional policy measures are required to support a sustainable and competitive 5G market across the nation, recognising that competition and access are important for all Australians.

[2] Deloitte, 2019, Mobile Nation 2019, p.17.

Section 2. 5G IS A FUNDAMENTAL CHANGE

2.1 Much has been made about the potential for 5G, with claims that it represents a revolution in mobile networks. The description of 5G's capabilities matches these claims, as it is designed to provide:

(a) Enhanced mobile broadband, with speeds in excess of 1 Gbps;

(b) Ultra-reliable machine communication, with latency less than 3ms; and

(c) Support of massive machine-type communication.

2.2 The next generation 5G mobile network technology has the potential to create an age of boundless connectivity and intelligent automation, changing the nature of communications for consumers, businesses and governments alike. It will be faster, more flexible, with more computing power. 5G will connect devices, sensors and machines to one another – and to people – leading to significant growth in the industrial IoT and transforming how we interact with the world.

2.3 There is a growing body of evidence that estimates the economic and social potential of 5G technologies. These include:

(a) The European Commission estimates that in 2025 benefits from the introduction of 5G capabilities could reach €113.1 billion per year, flowing from investments of approximately €56.6 billion, creating 2.3 million jobs in Europe.[3]

(b) Accenture predicts that 5G networks could create 3 million new jobs, $275 billion in new investments and $500 billion in economic growth across the USA.[4]

(c) The Australian Department of Communications estimates that 5G is likely to drive an additional $1,300 to $2,000 in GDP per person after the first decade of rollout.[5]

(d) A Deloitte Economics study estimates that mobile technology will add an additional $65 billion (real GDP, in 2016-17 dollars) in 2023 to the Australian economy, representing over 3% of the economy. This is double the contribution the industry made to the economy in 2014, representing the increasing influence of modern mobile networks. [6]

2.4 Deloitte Economics states in a report for the Australian Mobile Telecommunications Association (AMTA) that 5G is more than just the next mobile upgrade, it will facilitate the continued growth of the digital economy beyond 2020. Deloitte observes that while "consumers are set to continue to benefit, much of 5G's value will come from how it can be used by businesses – from automating business processes to enabling seamless connectivity for Internet of Things (IoT) devices."[7]

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[3] https://ec.europa.eu/digital-single-market/en/news/5g-deployment-could-bring-millions-jobs-and-billions-euros-benefits-study-finds
[4] Accenture, 2018, Smart Cities; How 5G can help municipalities become vibrants smart cities
[5] DoCA, 2018, Impacts of 5G on productivity and economic growth, Working Paper, April.
[6] Deloitte, 2019, Mobile Nation 2019, p.17
[7] Deloitte, 2017, 5G mobile – enabling businesses and economic growth.

2.5 The productivity benefits that are estimated to flow from the deployment and use of mobile networks in 2023, including 5G, are larger than the benefits that flowed from previous major economic reforms, such as the National Competition Policy.[8]

2.6 The capabilities of 5G networks, together with the potential use-cases it will support, has led to many claiming that 5G will result in the 4th industrial revolution.

2.7 This section outlines how mobile architecture has evolved from 2G voice to 4G high speed broadband networks; and provides the necessary historical knowledge to understand how and why the new 5G architecture represents a revolutionary break from the principles that underpinned the network architecture of previous generations.

Current generation mobile networks provide the connectivity and bandwidth to all end-users

2.8 The fundamental concept common across current and previous generations of mobile networks was the provision of wide access connectivity through the radio access network, transported back to core locations, which provided connectivity to other voice and data networks.

2.9 Digital mobile networks (GSM) were first deployed with a focus on voice services. These second generation (2G) mobile networks, at a broad level, comprised of base stations (BTS) connected to Base Station Controllers (BSC), which were in turn connected back to a Mobile Switching Centre (MSC) located in centralised core network locations. Each of these different physical nodes had specified and specialised functions.

2.10 For example, the BSC controlled a number of base stations and provided the interface between the cell sites and the MSC. The BSC could only control a defined maximum number of sites, and once this capacity was reached the mobile network would need to invest in additional BSCs. Similarly, the MSC – which switched voice calls across the mobile network and to other mobile and fixed voice networks – could deal with a given maximum number of calls or connected users. Once this maximum was reached, further investment in MSC hardware was required.

2.11 These core nodes were centrally located, and Australian mobile networks typically had five core locations to cover the whole country. Investment in these core nodes were dictated by the need to have a minimum of five (one in each core location), and capacity needs at each location. For instance, core capacity in the Perth exchange may have been at 10%, but Sydney traffic required more than one node. Rather than utilising the unused capacity in the hardware located in Perth, mobile networks had to invest in additional hardware in the Sydney core location. This hardware-based design resulted in high costs and clunky investment profiles.

2.12 Modern 3G and 4G networks still comprise the same point-to-point architecture principles that were used in earlier generations, with functions residing in specific specialised nodes with dedicated interfaces. The distinction between centralised core functions and localised radio functions remain – albeit with more functionality moving towards base stations. While there have been many advances in processing power and capabilities of the various nodes, the move to 4G has been an evolution with many of the new IP-based nodes performing similar, or the same, function as the corresponding earlier generation node.

2.13 The key design concepts have not changed from 2G through 3G and to 4G. The architecture is still based on dedicated nodes and interfaces, which in turn requires

[8] Ibid., n.6

specialised development and investment for any new service or function. In other words, mobile networks still provide a given service (namely bandwidth), which is largely common across all end-users attached to the network. In effect, mobile end-users had to adjust their requirements to the feature and capability presented by the network.

2.14 It is the change in this concept that marks the difference between 5G and previous generation.

5G architecture represents a fundamental change

2.15 This section explains in greater detail how 5G architecture and standards differ from those in earlier mobile generations. Understanding how 5G architecture enables new features and services is important in order to grasp the future potential use-cases enabled by these new networks.

2.16 The architecture and standards of 5G have been designed with no backwards compatibility with existing 3G or LTE specifications. It represents a breakthrough in the 30 year pattern of network design. Network nodes no longer form the basis of the network architecture, decoupling hardware and software.

2.17 Previous generations of mobile networks placed all end-users as the focus of the network, providing network-wide features which all end-users could access. The architecture of 5G flips this on its head – 5G enables dedicated services for individual or groups of end-users and industries, such as energy, government, healthcare, automotive, manufacturing. Not only will 5G provide increased capacity but it enables each end-user to have access to a network designed specifically for their needs.

2.18 Almost all aspects of the new 5G architecture differ from the corresponding 4G architecture – including changes in the radio access, use of Multi-Access Edge Computing, service-based architecture and network slicing.

2.19 While the end design of 5G represents a revolutionary break in the design ethos of mobile networks there is a migration path from the current 4G networks, allowing operators to deploy 5G more quickly.

2.20 The migration to 5G comprises two stages:

(a) Deployment of a 5G access network together with existing 4G access and core networks, known as 5G non-standalone (NSA);

(b) Deployment of a dedicated 5G core, with 5G access nodes directly connected, known as 5G standalone (SA).

5G New Radio (NR)

2.21 5G NR refers to the new standards for the 5G radio access network. The new standards, consistent with the objectives of 5G, allow greater flexibility of use, support of multiple different radio coding, and allow sufficient space for yet unknown future changes. 5G NR has the following major advances over existing LTE access technology.

2.22 First, 5G NR is frequency agnostic and supports significantly more spectrum from low band spectrum below 1 GHz, to millimetre wave (mmWave) spectrum above 6 GHz. Each of these two ranges have different specifications.

2.23 5G NR standards and access to mmWave frequencies allow for very large bandwidths,[9] which means that NR is ideal for keeping everyone connected in busy environments. The use of large maximum bandwidth channels is a material improvement on the maximum bandwidth available in LTE,[10] enabling higher spectral efficiency – in effect getting more throughput from any given amount of spectrum.

2.24 But making this work efficiently depends on new antenna technology such as Massive multiple-input multiple-output (MIMO) and beamforming. While these new antenna technologies are available for use in 4G LTE networks, 5G NR makes greater and more efficient use of the technology.

2.25 Not all devices on 5G NR have to support all bandwidths, which is a change from LTE. Furthermore, 5G NR supports adaptive bandwidth, letting devices move to a low-bandwidth, low-power configuration when appropriate, and gearing up to higher bandwidths only when necessary.

2.26 Also, 5G NR is forward rather than backward compatible, by maximizing the amount of time and frequency resources left blank for future new types of transmission. This flexibility (like what will be available in the 5G core) is a critical component of a 5G network. Rather than making users and applications operate within and adapt to the fixed requirements of the radio network, the radio network is able to flexibly change to suit the requirements of the user and application.

5G radio network will require many more base stations and a much denser design

2.27 The use of higher frequencies combined with the need to support massive multiple connections results in a radio network design that is materially denser than seen in previous generations. The use of small cells will work in conjunction with larger 5G base stations that utilise the advanced antennas described above.

2.28 While 4G LTE relies upon relatively few large masts that are built kilometres apart, 5G radio design will make significant use of small cells, which are able to be placed onto existing fixtures such as light posts, street signs, and utility poles. Australia is currently deploying 5G networks in the 3.5 GHz band, with 26 GHz spectrum to be made available in the near future. While much of this technology is still developing, Australia is at the bleeding edge of 5G. What we do know is that 5G will require many more sites than current networks. Ericsson, for example, has shown that to offer 1 Gbps speeds, cells would have to be around 200 to 300 metres apart.[11]

2.29 Small cells use less power and produce less electromagnetic energy (EME). Even when they operate at maximum power, small cell emissions are well within safe levels.[12]

5G non-standalone and standalone architecture

2.30 The deployment of 5G NR will be incremental, with 5G NR first being deployed alongside existing LTE radio or core nodes – known as 5G non-standalone – before full standalone 5G NR once networks have deployed standalone 5G core networks.

2.31 5G non-standalone refers to mode of 5G NR that utilises the control plane of existing LTE networks while deploying 5G NR to focus exclusively on the user plane. The use of

[9] For example, in sub-6 GHz, the maximum bandwidth is 100 MHz and in the mmWave range the maximum bandwidth is 400 Mhz.
[10] 20 MHz
[11] https://www.ericsson.com/assets/local/publications/conference-papers/5g_nr_sub6_coverage.pdf
[12] Deloitte, 2019, Mobile Nation, p.7

5G non-standalone enables accelerated deployment by enabling support for 5G bearers in the existing 4G-LTE infrastructure.

2.32 5G mobile broadband services will be available to users in a primarily 4G network via mobile terminals that support dual connectivity to 4G LTE and 5G NR base stations at the same time.

2.33 5G standalone refers to the ecosystem where 5G NR utilises the 5G core network for both control and user plane functions. This will enable the full 5G experience to be delivered to end-users, with the functionality of the 5G core flowing through the radio network to the end-user.

New 5G Core

2.34 The core is where the largest changes in network design are to occur. At the most basic level, the major change is that 5G core uses a service-based architecture framework that focuses on network functions compared to the hardware-based architecture used in previous generations.

2.35 In this section, we outline the main changes in the core:

(a) Separation of user and control planes;

(b) Service-based architecture;

(c) Multi-access edge computing; and

(d) Network slicing.

Separation of user and control planes

2.36 While separation of control and user planes is not a new concept, and is an option in 4G, it is a fundamental concept in the 5G architecture.

2.37 The control plane refers to functions that relate to access and mobility management, subscriber verification, session and mobility management, and data session control. In other words, it refers to the functions that connect the end-user to the mobile network and maintains that connection as the end-user traverses across multiple cells.

2.38 The user plane refers to functions that control the applications used, and data required, by the end-user, including traffic flowing from the internet to the end-user.

2.39 The separation of the control and user planes enables networks to deploy centralised control planes, in existing mobile exchanges for example, and deploy the user plane closer to the applications supported and customers using it. Locating the user plane closer to the application (for example, the data centre in which it is located), results in material reductions in latency. It also enables more effective management of high bandwidth applications, like Ultra-HD streaming video and cloud based e-gaming, because networks avoid large backhaul requirements.

Service-Based Architecture

2.40 The 5G standards define a Service-Based Architecture (SBA), whereby the control plane functionality and common data repositories of a 5G network are delivered by way of a set of interconnected Network Functions (NFs), each with authorisation to access each other's services.

2.41 Rather than having physical nodes dedicated to certain network functions, requiring point-to-point interfaces, a 5G core network will utilise common applications to provide

those functions. These platforms are programmable, and allow many different functions to be built, configured, connected, and deployed at the scale that is needed at the given time. In pre-5G networks, should a network want to introduce a new node or function, it would need to design new standardised interfaces between the new and old nodes and create new protocols. In the 5G core with SBA, the network only needs to standardise the API of the new functions.

2.42 The use of SBA allows greater virtualisation of functions in the core, as well as providing increased use of automation and self-healing processes. In other words, mobile operators are able to utilise predictive computing power to identify, predict and prevent network congestion or other issues.

Multi-Access Edge Computing

2.43 The separation of the control and user functions allows the use of Multi-Access Edge Computing (MEC). MEC is an evolution of cloud architecture that enables applications to be moved from centralised core nodes to the edge of the network closer to the end-user and the radio access network. By placing application data (including content distribution nodes) closer to the end-user, networks can avoid the need for long backhaul links and create a short cut in the delivery of content and applications to end-users.

2.44 5G architecture together with hardware developments will result in ‘mini-data centres’ located very close to end-users. Collecting and processing data closer to the customer reduces latency and brings real-time performance to high-bandwidth applications. This enables data from sensors, for example, to be collected, processed and analysed at the RAN edge thus avoiding the extra latency incurred by sending the data back to centralised processing. It is this short-cutting which delivers ultra-low latency and the ability to deliver high bandwidth to the RAN.

Network slicing

2.45 The use of SBA, together with edge computing and cloud-based network virtualisation, makes it possible to create dedicated service environments. This is formed by service specific control and user plane NFs, supported by dedicated core virtual network and customised 5G NR bearers. This dedicated environment is known as a 5G slice.

2.46 Each slice would group the needed NFs for a particular service to offer a dedicated network. This allows fast build-up of a network for a new service without impacting necessarily the existing services, reducing time-to-market and improving operational efficiency. The use of network slicing, with the other features of the 5G core, enables each network slice to be configured for either end-user or application requirements or both. For example, a dedicated e-gaming slice could utilise a high-capacity radio bearer in the 5G NR, together with dedicated NFs in a mini-data centre located at the edge of the network. This would enable ultra-low latency together with super-fast bandwidth. Similarly, low bandwidth IOT use-cases, like sensors, could have a dedicated network slice with low-capacity radio bearers and dedicated NFs left in the centralised core. This would minimise costs while providing the required throughput. Alternatively, vehicular 5G use cases require super low latency requiring both control and user functions move to the edge to enable low latency, as well as fast computing power to enable vehicular sensors.

2.47 5G networks enable network services to be designed to serve the specific needs of each dedicated use case, in addition to having end-users fit into the standard capabilities of the network. This will typically be of benefit to enterprise customers, providing similar dedicated capacity over wireless to what they receive over direct fibre connections today.

Section 3. USE CASES ENABLED BY 5G

3.1 This section outlines some key uses cases that are, or could be, enabled by 5G. Some commentary has focused on the far-off potential of 5G, including driverless autonomous cars or automatic drone delivery services, most remain concepts at this stage.

3.2 The use cases discussed below are broken into:

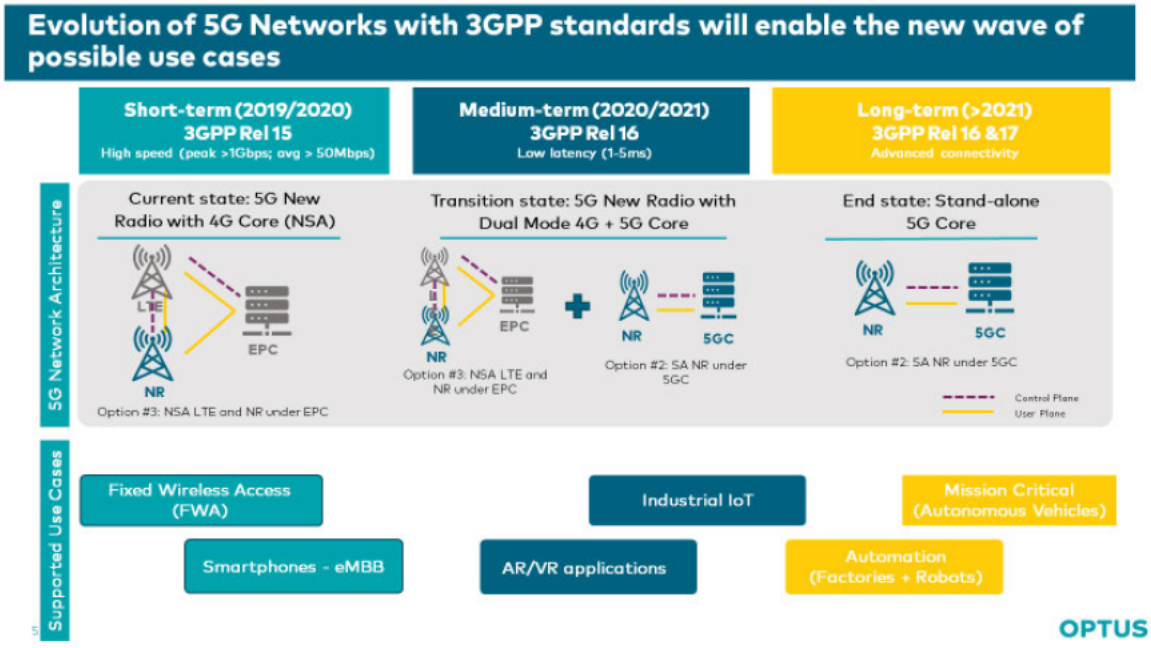
(a) Near-term use cases, which are enabled by the current deployment of 5G NR with a 4G LTE Core;

(b) Medium-term cases, which are enabled using 5G NR with dual mode 4G and 5G Core; and

(c) Longer-term cases, which are enabled by a fully deployed stand-alone 5G NR and 5G Core.

3.3 Figure 1 below shows Optus' expectation on the roll-out of 5G networks in Australia, including likely timeframe and the broad use-cases enabled at each stage.

Figure 1 Network transition and use case



Source: Optus

Near-term use cases

3.4 Optus is deploying a 5G NR network to work with our existing 4G core network. Optus has a target of 1,200 5G sites by March 2020, with a mix of sites across Australia including in Sydney, Perth, Brisbane, Melbourne, Canberra and Adelaide. Key regional cities and town centres will also benefit, like Bunbury and Busselton in WA, Geelong, Newcastle and the Gold Coast.

3.5 Optus offers both 5G in the home, with Optus 5G Home, as well as 5G Mobile with a range of 5G compatible smartphones.

3.6 Optus 5G Home is designed specifically for use in the home/indoors and provides customers in select areas with access to minimum guaranteed speeds of 50 Mbps as part of a Satisfaction Guarantee. Optus' current Optus 5G Home customers are experiencing an average peak time speed of 164 Mbps with maximum speeds hitting 400 Mbps. Optus 5G Home is a simple to use and easy to install product which allows end-users to connect multiple devices simultaneously with good data streaming capability.

3.7 Optus sees potential for Optus 5G Home to work with existing fixed line networks, such as the NBN. This early work suggests that Optus' 5G network could provide a viable upgrade path, or even alternative access network, for those premises that have speed-limited lines, or which otherwise prove difficult to connect to high speeds through fixed connections.

What use cases lie ahead in the medium to long term?

3.8 Beyond this initial consumer use lies the real benefits of the new 5G network. As explained above, these industry benefits occur with the deployment of the full standalone 5G architecture. That is some years away at the earliest.

3.9 The multi-billion dollar and economy changing benefits listed above flow from the new applications and uses that are possible from the second wave of 5G technology; a standalone 5G network that enables:

(a) Enhanced speeds;

(b) Low latency;

(c) Mass connectivity; and

(d) High availability.

3.10 A 5G network that is virtualized, automated, with software defined backhaul and with network and service orchestration will support an explosion of new technology development. These ultra-reliable, low latency wireless connections will allow AI, IOT, big data, machine learning, blockchain and autonomous vehicles to reach their potential.

3.11 Optus is constantly engaged in investigating new use cases that can utilise the new features that will be deployed with 5G networks. We have already identified some large potential use cases in the consumer space such as:

(a) 5G and Cloud Gaming, which has the potential to deliver low-latency, virtual and augmented reality, to an already multi-billion dollar industry; and

(b) 5G and delivery of Unicast, Multicast and Broadcast live and on-demand Streaming Video Ultra HD 4K & 8K video content, which has the potential to more efficiently deliver video content.

3.12 We discuss these cases in more detail below.

5G mobile gaming and Cloud Gaming

3.13 The global gaming market is worth an estimated $240 billion in 2019, with expected annual growth of 5% to 2022. Most of this growth is due to mobile gaming. In Australia, it

is estimated the gaming market is worth $4 billion, of which mobile gaming makes up one quarter.[13]

3.14 Venture Consulting notes that mobile gaming is the dominant form of gaming, accounting for more revenue than console and PC combined and represents the majority of all gaming growth. Importantly for mobile operators and 5G business cases, research shows around one third of gamers would be willing to pay more for 5G gaming services, with another third undecided. Venture Consulting highlights that:

> *5G is set to fundamentally alter the gaming landscape with ultra-fast data speeds, minimal latencies driving lag-free performance, next-gen AR gaming and cloud enabled VR gaming. 5G is also expected to enable responsive and immersive Ultra HD and 4K gaming experiences at 90 fps.*[14]

3.15 This market research indicates that gamers are aware of 5G and its potential and are likely to experience 5G when it is made available. It is likely that gamers will be early adopters of this new technology, which will help drive acceptance and delivery of 5G networks.

3.16 Venture's research also indicates that gamers who prefer online action genres, such as Fortnite, sports and other action games, were particularly interested in 5G. This reflects the benefits that flow from 5G networks – low latency and high bandwidth, both of which are vitally important to effectively participate on these types of games.

3.17 The deployment of standalone 5G networks has the potential to make Australia one of the leading gaming markets globally, embracing the massive growth of this market.

5G and Streaming Video content delivery

3.18 Delivery of video content is the driver of consumer broadband demand – this is true for both fixed and mobile networks. Australia has seen massive growth in streaming video traffic over broadband networks over the last few years, with the presence of content providers such as Fetch, Netflix, Stan, Apple TV+ and the soon to be launched Disney+.

3.19 Optus has been the leader in delivering both live and on-demand sporting content through the Optus Sport channels and application. Optus Sport is Australia's premier football channel, including exclusive live games from the Premier League and UEFA Champions League.

3.20 Optus streamed more than 1,100 live matches across 2018-19, representing over 3,000 hours of live streaming football. Optus Sport audiences increased 60% year on year. The 2018-19 UEFA Champions League final achieved record audience numbers, breaking Optus Sport live streaming records to deliver the highest ever viewership, increasing almost 20% versus the previous record. The final delivered 16.5 million live streamed minutes, making it Australia's second highest streamed sporting event, behind only the Melbourne Cup.[15]

3.21 In addition, Optus Sport delivered the most comprehensive coverage of a FIFA Women's World Cup ever seen in this country, with all 52 matches shown live and on-demand and supported by more than 100 live shows.

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[13] Venture Consulting, 2019, Gaming Market Trends
[14] Venture Consulting, 2019, Gaming Market Trends, p.2
[15] https://www.optus.com.au/about/media-centre/media-releases/2019/06/OPTUS-SPORT-HITS-NEW-AUDIENCE-HIGH

3.22 We are bringing live streaming to 5G. This year's Premier League on Optus Sport was the first time globally that a 5G mobile network was used to stream a live Premier League match to football fans. From June 2020 Optus will launch 4K Ultra HD Live Football content on Optus Sport which will mean that Optus 5G Home customers can enjoy selected games from the Euro 2020 tournament, the 2020/21 Champions League and the 2020/21 Premier League in 4K Ultra HD Streaming quality.

3.23 Optus is also working closely with OTT Video content partners 7plus, Amazon Prime Video, Netflix, Fetch and Stan with others to follow to ensure that their 2020 4K Ultra HD Streaming Video content line-up is optimised for the Optus 5G network.

3.24 The network challenge for live sport, like e-gaming, is managing high bandwidth and low latency demand. 5G addresses both these challenges. Importantly, the deployment of edge computing and micro data centres enables mobile networks to place CDNs closer to the end-user, reducing latency and minimising backhaul bandwidth demands.

3.25 Edge computing, combined with software defined networks and predictive intelligence, could result in mobile networks being able to anticipate the demand for content within specific locations, and being able to allocate capacity, content and bandwidth close to that location. Moreover, there may be opportunities to off-load live content at the micro-data centres onto satellite networks, even further reducing bandwidth demand and latency. From an end-users' perspective they will be able to experience live streaming on their device utilising the mobile network with little or no latency and without capacity issues.

3.26 In summary, with 5G standalone networks it can no longer be assumed that fixed networks are required to do the 'heavy lifting' of bandwidth heavy applications like live streaming Ultra HD 4K & 8K Video content.

5G & our enterprise customers

3.27 5G ultimately will deliver transformative technology and networks to enable various enterprise use cases. It is often stated that 5G is one enabler for the fourth industrial revolution. While 4G can support many IOT uses cases today, the advancements offered by 5G networks will expand these exponentially and in time will support services that require the massive connectivity and low latency offered by 5G.

3.28 There are numerous studies looking at the potential benefits of 5G in the enterprise space. For example, European and American studies have examined four industries that would likely benefit from 5G – automotive, healthcare, transport and utilities. The use cases for these studies of industry sectors all come from the second wave of 5G investments and networks, requiring dense small cells, using beam forming antenna and milli-metre wave spectrum. For example:

(a) **Transportation** – 5G technology will power self-driving cars, which in turn may reduce emissions by up to 90 percent and cut travel time by 40 percent. Across the USA, 5G is estimated to save $450 billion annually in transportation costs.[16] Across Europe, connected vehicles are predicted to deliver €42.2 billion in direct benefits annually, with an additional €8.3 billion coming from transportation industry efficiencies.[17]

[16] https://www.ctia.org/the-wireless-industry/the-race-to-5g
[17] "Identification and quantification of key socio-economic data to support strategic planning for the introduction of 5G in Europe (SMART 2014/0008)

(b) **Smart Cities** – Sensors will monitor the health and safety of critical infrastructure like buildings, roads, and bridges, while connected trash cans, bus stops, light poles and more will help cities operate more efficiently. Across the USA, it is estimated smart city solutions will deliver US$160 billion in benefits and savings.[18] In Europe, it is predicted the annual benefits of smart cities could amount to €8.1 billion in 2025.[19]

(c) **Healthcare** – 5G technology will enable services such as remote patient monitoring and even remote surgery through connected healthcare devices. In the USA, it could generate US$305 billion in healthcare cost savings every year.[20] Across Europe, it is estimated the annual healthcare benefits could amount to €5.53 billion.[21]

3.29 Optus is focused on delivering real outcomes. In an effort to help our enterprise customers prepare their business for a hyper-connected future, Optus created a 5G advisory panel made of representatives from Government, and companies in various sectors including Utilities, Travel, Manufacturing, Property, Healthcare, Retail, Transport and Education.

3.30 Participating businesses embarked on an 8-week co-creation program which kicked off in July 2019. Participants had access to our engineering and networks teams, and a facilitator helped explore future business models and which technologies would underpin identified opportunity. A broad set of enterprise use cases have been identified along with the 5G characteristics. The insights Optus has gained during this interactions has been invaluable, and we have learned from participants to guide our own Optus 5G roadmap. These insights include:

(a) **Use of remote operations** – Today, heavy industry (e.g. mining) mainly operates in a manually operated and decentralised model; where control systems, processes and expertise are located close to the site of operations. The deployment of low-latency, high bandwidth 5G radio coverage with mobile edge processing power in remote locations will enable site operators to centralise significant parts of their control environment. This will maximise the productivity of scarce specialist (e.g. quality, health and safety, maintenance) resources who can monitor and intervene in multiple sites simultaneously while automating many other elements of site operations.

(b) **Rapid deployment of high bandwidth** – high quality, ultra-reliable “last mile” connectivity (public safety, emergency services, broadcast, etc). Major incidents can happen anywhere, often where high quality fixed connectivity is unavailable. The on-demand provision of connectivity can be a determining factor in the speed and quality of the early response. For example, the ability of paramedics (or even drones) to transmit high and near real-time images of casualties and hazards to medical and public safety experts can improve survival rates and reduce risk. Network slicing can guarantee the reliability and performance of these critical connections where they are required. Broadcast services can also take advantage of similar capabilities to upload high-resolution images with guaranteed bandwidth on demand.

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[18] https://www.ctia.org/the-wireless-industry/the-race-to-5g
[19] "Identification and quantification of key socio-economic data to support strategic planning for the introduction of 5G in Europe (SMART 2014/0008)
[20] https://www.ctia.org/the-wireless-industry/the-race-to-5g
[21] "Identification and quantification of key socio-economic data to support strategic planning for the introduction of 5G in Europe (SMART 2014/0008)

(c) **Ultra-reliable high-density healthcare solutions** – A number of healthcare solutions today require frequent and reliable connectivity to a nearby base station in order to work effectively (e.g. pacemaker devices and neurotransmitter regulating devices). 5G can enable quality of life improvements for patients by untethering them from a fixed base station allowing them to move within a broad 5G radio environment while maintaining a reliable and low latency connection to base station functionality hosted in the edge cloud without being constrained by capacity or available channels on the network.

Optus will leverage its unique global exposure

3.31 Optus is also in the very advantageous position of learning from our parent company, Singtel. Singtel is actively participating in enterprise tests and trials of 5G. These trials are collaborative efforts with business partners – vendors, government, and academia joining up to push the limits of what is available now and moving from trial to implementation.

3.32 One such example involves Singtel and the Port of Singapore Authority (PSA) for the first phase of Tuas Port, which will begin operations on Singapore's western seaboard in 2021. Singtel and PSA have been trialling state of the art technologies which will be deployed to operate what will be the largest fully automated container terminal in the world. This facility will truly take the internet of logistics to levels beyond anything that currently exists.

3.33 Whether wired or wireless, hyper-connectivity will be essential to achieve the desired high level of automation for Tuas Port. The Singtel-PSA collaboration is using 5G to test a number of use cases. Central to this testing is validating 5G capabilities against PSA's operating environment, its challenges and the requirements. Some key innovations will include container handling equipment such as AGVs, automated yard and cranes, tele-operated or autonomous horizontal transports. There is also a need to ensure safety of staff working in various zones for necessary works – this tracing must be done in real-time with a high degree of accuracy.

3.34 These trials are providing Singtel – and Optus – invaluable insights into the traits of 5G network, including:

(a) 5G Radio coverage and propagation characteristics;

(b) 5G network slicing functions to ensure the latency and bandwidth requirements are met; and

(c) 5G security, resiliency, and high accuracy network-based positioning.

3.35 Optus is also taking insights from:

(a) Singtel's 5G Garage, Singapore's first live 5G facility, at Singapore Polytechnic. The facility serves as a training centre, test bed and ideation lab to develop Singapore's 5G ecosystem and drive the adoption of 5G by enterprises in their digital transformations; and

(b) Singtel's partnership with the Agency for Science, Technology and Research's (A*STAR) Advanced Remanufacturing and Technology Centre (ARTC), and JTC to deploy 5G at the ARTC Model Factory to explore how 5G can be combined with Internet of Things, artificial intelligence and robotics to create manufacturing solutions for factories of the future.

Section 4. IDENTIFYING BARRIERS TO 5G DEPLOYMENT

4.1 Economy-wide benefits and innovative consumer and enterprise use-cases flow from investment in new 5G technologies. While Australia and Optus have been the forefront of the global 5G technology curve to date, the next step involves material investment in physical infrastructure, technology and spectrum. The barriers that will delay or prevent the realisation of these 5G benefits relate to operators' ability to invest and build the required new network elements.

4.2 Australia has an opportunity to be at the forefront of technology and to improve its global competitiveness over the next 5 years, but we must first address these barriers:

(a) **Pro investment and competition reforms** – The deployment of mmWave 5G networks will require a significant level of investment greater than those seen by previous technology waves. These substantial investments will need to be made in circumstances where future use cases and revenue streams are unclear and unevenly distributed. We need to ensure that the policy levers are set appropriately to ensure investment can be made and that competition is actively promoted.

(b) **Spectrum** – this new generation of technology provides an opportunity for disruptive competition, which is critical to driving productivity gains. The current approach to spectrum allocations presents risks to future 5G competition and creates uncertainty about investments in mobile networks.

(c) **Deployment** – 5G NR is based on the deployment of small cells, low powered antenna with limited range. The architecture requires a dense mesh radio network, with antennas on every other light or electricity pole due to use of high frequency spectrum. This places the economics of antenna deployment at the forefront of network viability. Current deployment rules remain based on large monopole base stations that provide coverage over many square kilometres. These rules need to change to embrace and promote the new radio architecture and make deployment at scale possible.

(d) **EME Community Concerns** — Recently there has been increased focus on the safety of mobile technology (4G and 5G) and EME concerns led by a section of the community. These safety fears are unfounded. We can confidently say this based on decades of reliable scientific research. However, it is clear that in this social media age, both industry and government need to actively engage in the public debate to counter the misinformation that is propagated over social media and at a grassroots level.

Pro investment and competition reforms

4.3 5G requires the deployment of a new network – including deployment of many more sites; and investment in brand new core capabilities. This is not just an upgrade of existing assets.

4.4 Such an investment profile is made even more challenging with the uncertainty surrounding future incremental revenue that could be generated through 5G, in both the consumer and enterprise markets. The added challenge in the enterprise and government market is that it is simply not as competitive as it should be.

4.5 To that end, Optus suggests the Committee considers the following actions that will help promote investment and competition in 5G networks.

Pro-investment policies and strategies

4.6 Network sharing and joint-ventures are a common feature globally in many current 4G LTE networks. It is anticipated that there is likely to be increased focus on network sharing and joint ventures with the deployment of 5G.

4.7 Network sharing arrangements for 5G networks are already in place in the UK, and Italy. In addition, China Unicom and China Telecom have agreed to jointly build the 5G network in China.[22]

4.8 McKinsey estimates the economics of 5G joint ventures is very strong, noting "the cost of small-cell deployment can be reduced by up to 50 percent if three players share the same network".[23] They continue to note that benefits extend beyond commercial, with material improvements in visual amenity and decrease in urban disruption due to excessive fibre and antenna installations.

4.9 Optus sees merit in further enquiries into the nature of the Australian market and barriers that limit the effective adoption of such practices here. Key questions include:

(a) Scope to which barriers exist for existing private entities to engage in cost-minimising network sharing arrangements.

(b) Scope to which government entities could be better utilised to facilitate sharing with private companies to promote increased private investment.

(c) Structural barriers to increased sharing, including whether current market structure with one large dominant player in the enterprise market is an impediment to commercial sharing.

4.10 It is important to note that network sharing is not a form of free-riding such as roaming. It requires joint investment by mobile operators in infrastructure and technology, some on a stand-alone basis and some of which can be shared.

Inquiry into the enterprise and government communications market

4.11 Current market expectation is for incremental 5G revenue to be focused in the enterprise market. Optus notes recent comments from Government highlighting the lack of competition in the enterprise and the continual dominance of Telstra[24] – and whilst these comments are made in the context of NBN entering the enterprise market, the same comments equally apply to enterprise and mobility.

4.12 However, this communications market has never been subject to a review by competition regulators or policy makers. For example, the 2018 ACCC Communications Sector Market Study, explicitly excluded enterprise market issues from the study.[25] Telstra remains dominant in the Government sector. For example, Optus understands Telstra hold approximately 90% market share across several State Governments.

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[22] https://www.fiercewireless.com/5g/china-s-carriers-to-build-a-shared-5g-network
[23] Mackinsey, 2018, Network sharing and 5G: A turning point for lone riders, https://www.mckinsey.com/industries/technology-media-and-telecommunications/our-insights/network-sharing-and-5g-a-turning-point-for-lone-riders
[24] Minister Fletcher, Speech to CEDA's 40th State of the Nation - The NBN and Productivity, 19 September.
[25] ACCC, 2018 Communications Sector Market Study, p.14

4.13 Over the years, Optus has called for a greater focus on competition in enterprise and government markets. We see a more pressing need for such a review with the transition to the new technology that is predicted to underpin the 4th industrial revolution.

Spectrum use must be a focus

4.14 5G requires substantial amounts of spectrum. In early 2021 Australia will see the initial mmWave auction offering over 2.4 GHz of 26 GHz spectrum to the market. Access and use of this spectrum will enable the deployment of 5G networks, which in turn enables the provision of beneficial services. The economic activity and benefits associated with retail services in mobile markets enabled by spectrum use "are about 240 times as large as those associated with license revenues".[26]

4.15 It would be an error for any Government to view spectrum as a revenue stream – ultimately every dollar a mobile operator spends on spectrum is a dollar that cannot be spent investing in other network assets. Critically, in order to achieve the coverage and deployment required, 5G networks will require significant amounts of spectrum. Government risks stifling the deployment of 5G networks – utilising 100 MHz or 400 MHz channels – if it focuses too heavily on the money obtained through allocations rather than on the economic (not to mention social) value created by the use of the spectrum.

4.16 Spectrum auctions should be designed to ensure the maximise amount of spectrum is used in the market at the lowest possible price. The economic benefits that flow from use of spectrum in a competitive market should result in a policy preference of Government to issue spectrum licences at the lower end of prices, recognising that Government gains more value from the efficient use of the spectrum.

Spectrum reform and allocations

4.17 Spectrum is the fundamental input into the production of mobile services and is a key driver of competition in the mobile market. There is a direct trade-off between the amount of spectrum allocated to an operator, the cost of deploying network assets, and the available capacity on the network.

4.18 As outlined above, the 5G NR enables advanced connectivity and bandwidth largely in part due to its ability to utilise very large channel bandwidths – 100 MHz for sub-6 GHz spectrum, and 400 MHz for mmWave spectrum.

4.19 The industry needs more spectrum sooner, allocated in larger bandwidths, and all in a way that promotes competition and guards against asset hoarding.

4.20 The Government has done this for mmWave compatible 26 GHz spectrum – placing 2.4 GHz of spectrum up for allocation. Optus observes that this allocation is occurring before the technology is available for use in the market.

4.21 The Government should take a similarly aggressive approach to reforming existing bands to enable them to be used for 5G networks. We see three main priorities:

(a) Fast track allocation of 5G low band spectrum and reform to licence conditions that limit the use of mid-band spectrum for 5G;

(b) Allocations need to focus on competition and use of spectrum and not on auction revenue raising; and

[26] Thomas W. Hazlett, Roberto E. Muñoz, and Diego B. Avanzini, What Really Matters in Spectrum Allocation Design, 10 Nw. J. Tech. & Intell. Prop. 93 (2012).

(c) Licences should be issued with a presumption of renewal.

Fast track allocation of low and mid band 5G spectrum

4.22 5G networks are being deployed now across mid and low band spectrum bands. These bands offer optimal propagation characteristics for the delivery of both national and metro 5G networks.

4.23 However, we face issues with being able to utilise these bands for 5G. First, there is insufficient low band spectrum (this is spectrum below 1 GHz, which provides ideal propagation for national and regional coverage) currently available to all providers. There is also a material imbalance in current holdings. Allocation of the remaining low band spectrum assets is essential to facilitate operators to provide a seamless transition from 3G and 4G to 5G networks.

4.24 Optus recommends finalisation of 900 MHz to be a high priority for the ACMA. Spectrum certainty in low band (sub-1 GHz) spectrum is required to ensure national service continuity and to support future competitive growth of 4G and 5G national networks.

4.25 With regards to mid-band spectrum, the technology exists for 5G networks to be deployed across the three 2 GHz bands, 2.1 GHz, 2.3 GHz and 2.6 GHz. In total these bands represent over 350 MHz of spectrum that could be used for 5G.

4.26 However, the current technical rules of the licences prevent licence holders from being able to deploy 5G networks. Optus seeks harmonisation of 5G-enabling licence conditions in existing spectrum bands (2.1 – 2.6 GHz bands) to support 5G arrangements, starting with the 2.3 GHz band. Licence conditions for these bands were established in a pre-5G environment and should be updated.

4.27 Both of these auctions should occur as a priority over the coming twelve to eighteen months, and before the ACMA looks at allocating other 5G spectrum bands which are not yet technically able to be utilised.

Spectrum allocations must promote competition

4.28 Competition in retail mobile markets is important to ensure the economy can achieve the full benefits from new networks and new spectrum allocations. To that end, we support the continual use of allocation limits to ensure no one MNO is able to acquire spectrum assets to the detriment of competition.

4.29 This approach is vital in a 5G environment, which utilises spectrum agnostic radio technology, where 5G can be deployed across almost all mobile bands. An operator's decision on which band to utilise now depends on the propagation features of the band and not the overarching mobile technology.

4.30 The history of the Australian mobile market demonstrates that new technology disrupts the incumbent operators and brings the potential of new competition. But success in the market ultimately depends on access to spectrum – and in particular low band spectrum. In the period prior to 2010, the deployment of 3G disrupted the market and Telstra's market share fell to less than 40%. However, Telstra was subsequently able to refarm its 850 MHz assets (which it was granted prior to privatisation) from 2G to 3G and it regained these losses.

4.31 Optus remains concerned that low band spectrum is concentrated in too few operators. There is a total of 210 MHz of spectrum available for use across all sub-1 GHz bands. Currently 130 MHz is licenced for use; of which Telstra owns 60 MHz; VHA-TPG own 50 MHz and Optus own just 20 MHz.

4.32 The ACMA has flagged in its future work programme plans to re-allocate the 900 MHz as well as release additional 850 MHz spectrum – a total of 80 MHz to be allocated.

4.33 Access to low band spectrum has proven to be a key driver of competition in the Australian market. While the roll-out of 5G presents a new opportunity to disrupt incumbent operators, the ability to do so will be hampered by a concentration of ownership in low band spectrum.

4.34 Optus supports the use of low band competition limits, which take into account spectrum holdings in across the 700 MHz, 850 MHz, and 900 MHz bands. This is increasingly important as MNOs look at deploying national 5G networks, as the propagation characteristics of low band spectrum enable wide coverage areas.

4.35 Optus recommends that the Committee notes that strong allocation limits across all sub-1 GHz band are needed to ensure future competition across 5G services is realised.

Spectrum licences should be issued with presumption for renewal

4.36 Efficient investments require certainty of tenure. It is no different with investment in spectrum; and investment in networks that utilise spectrum as an input.

4.37 While the current *Radiocommunications Act 1992* does contain a pathway to licence re-issue,[27] the issue has been the absence of a clear entitlement to renewal, as well as uncertainty about the policy guidance for the criteria and mechanism for evaluation of spectrum licence re-issue eligibility and the determination of the re-issue price.

4.38 Failure to re-issue existing spectrum licences, particularly where the spectrum asset forms a core network input into the business, would have negative consequences for infrastructure investment. This is because a failure to re-issue would cause significant business uncertainty, which would cause a suspension of existing investment planning. Perhaps more importantly, is the adverse consumer experience impacts that would result. Given the significance of spectrum as a key underlying network input for the provision of a mobile service – commonly considered an essential service in modern day life – any significant reduction in an operator's core spectrum holding could result in customers losing all access to the service.

4.39 New Zealand provides a good example of an appropriate approach to the renewal of spectrum licences where:

(a) Commercial spectrum rights are reallocated to existing licensees, five years before expiry, subject to review on a case-by-case basis to ensure consistency with New Zealand's international obligations and the general objective of maximising the value of the spectrum to society as a whole.

(b) Spectrum rights are reallocated for a price to be determined by a price-setting formula that estimates the market value of the rights.

(c) If existing licensees do not wish to pay this price, the respective rights will be reallocated by way of auction.

4.40 Making such decisions any closer to the licence expiry would reduce incentives for investment and secondary trading during the later years of the licence term and, if reallocation is required, may not leave sufficient time for the completion a reallocation

[27] Section 82

process before the expiry of the existing licences and potentially leaving the spectrum unused for a period of time.

4.41 Optus supports reform of the *Radiocommunications Act 1992* that provides a clear entitlement to renewal, and certainty over the criteria and mechanism for evaluation of spectrum licence re-issue eligibility and the determination of the re-issue price.

Deployment reform needs to recognise communications as a utility that enables core social and economic functions

4.42 The services that will deliver the 4th industrial revolution – that fuels the economic benefits quoted above – depend on the deployment of a new type of radio network. As previously mentioned, the 5G world enabled by gigabyte speeds and low latency requires a fundamental re-design of existing radio networks.

4.43 Next generation 5G radio networks require a network of dense small cells, using beam forming antenna and milli-metre wave (mmWave) spectrum. For example:

(a) The final report on the introduction of 5G in Europe state that many of the use cases of 5G "involve short range, dense and high capacity networks".[28]

(b) The FCC Chair highlights that tomorrow's 5G networks will rely heavily on small cells more densely deployed and operating at much lower power. The FCC predicts the USA will require 800,000 new small cell sites by 2025 – four times what is deployed now.[29]

4.44 Reflecting the changing economics of radio deployment – where the administrative time and cost of deployment have a more central impact – several international markets have begun the process of reviewing decades-old rules around site deployment.

4.45 The United States, for example, is well advanced in its review of local, state and federal rules that prevent or unnecessarily delay the deployment of small cells. Further, the FCC is actively writing rules that promote and enable the deployment of small cells.

4.46 The FCC has adopted its "5G FAST Plan", aimed at making the USA the leading market for 5G technology.[30] The plan has three key components:

(a) Pushing more spectrum into the market;

(b) Updating infrastructure policy; and

(c) Modernising outdated regulations.

4.47 The FCC has prioritised reforms to its infrastructure deployment policies. The FCC has adopted new rules that will reduce federal regulatory impediments to deploying the small-cell infrastructure critical for 5G (as opposed to large cell sites). The FCC has also reformed local and state deployment rules designed to accommodate small cells. The reforms outlaw rules that have the effect of prohibiting deployment of 5G and give states and localities a reasonable deadline to approve or disapprove small-cell siting applications.

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[28] Identification and quantification of key socio-economic data to support strategic planning for the introduction of 5G in Europe (SMART 2014/0008), p.106
[29] Remarks of FCC Chairman Ajit Pai at the Federalist Society 2018 National Lawyers Convention, "The current landscape of telecommunications law", November 2018.
[30] https://www.fcc.gov/document/fccs-5g-fast-plan

4.48 Optus submits a similar focus is required for the Australian market.

4.49 As outlined above, 5G NR using mid band spectrum, and the future deployment of mmWave, requires investment in materially greater number of antennas than currently deployed. These small cells are much smaller in size and lower in power than existing traditional macro base stations. While 5G NR takes advantage of these small cells, small cell technology is deployed currently within Australian 4G networks. Despite their much smaller size, the deployment of small cells in Australia has been problematic and often has faced challenges with local and state planning processes given the current deployment regulations.

4.50 In particular, Optus recommends reform of federal legislation aimed at aligning the rights of the communications industry to deploy assets to the rights of other essential services – utility companies (i.e., water, gas, electricity) – in order to more efficiently deploy assets. Communications is regarded as the fourth utility; it is no longer a luxury but a key utility for all businesses and consumers. Indeed, telecommunications is viewed as being a critical and essential service by and for consumers and indeed governments that increasingly fund or co-fund mobile infrastructure projects. However, there are no corresponding rights of deployment. Too many companies and too many local and state bodies see communications assets as a potential income stream rather than a facilitator of vital community services. Optus submits that telecommunications should be treated in a manner consistent with the other utilities with regard to access to property, just as we are seen as vital infrastructure in national security matters and by consumers and businesses alike.

4.51 Optus, and other MNOs, have found it difficult to deploy small cells utilising the current planning framework across the States and Territories. While there are federal powers and immunities which give certain rights to deploy infrastructure, often these rights do not apply or apply in a restricted manner. In Optus' experience, inconsistent application of the rules combined with uncertainty of interpretation of key terms increases the time and cost of deployment.

4.52 Such difficulties could have material implications on the ability of MNOs to deploy 5G networks.

4.53 Optus is calling for reforms to ensure consistent application of land access rights for small cell (and associated) infrastructure in transport corridors, reflecting the small environmental impact and footprint of small cells.

4.54 Current network design expectations plan for most, if not all, standalone small cells to lie within the boundary of public road areas (i.e. road reservation, in between property boundary to property boundary) and transport corridors. In other words, the same locations where all the other utilities are located. These are primarily either light posts or electricity poles.

4.55 However, currently councils are unable to lease out or grant tenure rights for public roads (a) without lengthy public consultation; or (b) for a period longer than 5 years. There are also tenure rights issues between pole and land owner in some instances. This limited or unsure tenure impacts on the ability of operators to invest in the required number of sites.

4.56 Given the major usage of 5G (both from a consumer and enterprise perspective) will rely on roads and transport areas being covered, Optus believes there is an opportunity to introduce a new 'land category' in federal legislation to reflect this. Given the general rights already provided to other utility owners / operators (i.e. road and rail authorities, NBN, Electricity Companies) we believe similar access and just terms are appropriate.

4.57 We acknowledge that at the principle level this sounds relatively simple but will no doubt encounter issues and challenges at a practical level. Optus encourages the Government to engage in this process as soon as practical to ensure operators have a viable planning environment to deploy 5G small cell antennas

EME safety misinformation

4.58 Over recent months, there has been a level of concern across some section of the community and social media in relation to deployment of 5G and small cells and the impact on health through electromagnetic energy (EME).

4.59 EME refers to the energy waves emitted from telecommunications facilities and devices needed to operate our mobile phones, Wi-Fi devices and computers. The energy connects your devices to your local telecommunications infrastructure over the radio network (or air interface).

4.60 At the outset it is important to state that mobile technology is non-ionizing EME (compared with ionizing EME from sunlight, UV rays, x-rays or radiation sources). There are many sources of natural or human-made EME that exist in our daily environment, including the sun, lightning, power lines, electrical appliances (hair dryers, electric shavers, vacuum cleaners, refrigerators, microwave ovens, power tools, electric blankets), radio communication devices (AM/FM radio and television, cordless phones, remote controls, Wi-Fi modems) as well as personal devices such as mobile phones, baby monitors and Blu-tooth systems in our cars. 5G devices are of a similar electromagnetic energy output to current 3G/4G devices.

4.61 The research into radio frequency exposure and possible impacts on health is extensive and spans many decades. This research has been conducted by numerous health authorities and experts – including the World Health Organisation (WHO), Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) and the International Commission on Non-Ionizing Radiation Protection (ICNIRP). The WHO have stated that:

> *Despite extensive research, to date there is no evidence to conclude that exposure to low level electromagnetic fields is harmful to human health.*

4.62 The WHO have also concluded that:

> *Studies to date provide no indication that environmental exposure to radiofrequency (RF) fields, such as from base stations, increases the risk of cancer or any other disease.*

4.63 It is important that a sufficient body of information and succinct and clear messaging regarding the safety of mobile technology and 5G is provided to communities to counter the misinformation that can be found online or at a grassroots level. Optus notes that all mobile network operators, as well as the Australian Mobile Telecommunications Association (AMTA) have stepped up their public material addressing these issues, as have key regulators such as the Australian Communications and Media Authority (ACMA) and ARPANSA.

4.64 To that end, Optus provides below information regarding 5G technology, small cells and EME.

EME testing and regulatory processes

4.65 Optus complies with strict regulations set by the Government regulator, the ACMA, which are in alignment with science-based international standards.

4.66 Optus complies with all Australian EME regulations:

(a) All Optus communications facilities are licensed and recorded with the ACMA.

(b) Optus complies with the industry deployment code process which includes the publishing the environmental EME levels around the new or upgraded facility. This is reported on the ARPANSA template and published on the RFNSA web site.

(c) Optus has strict design processes to ensure all facilities meet the minimum EME standards as set by ARPANSA and our license conditions.

(d) Independent National Association of Testing Authority (NATA) accredited assessors are engaged to ensure that Optus facilities comply with the ARPANSA EME exposure limits.

(e) If ACMA finds that a carrier has failed to meet their licence conditions, the carrier could lose their spectrum licence, be subject to court proceedings and face penalties of up to $315,000 or two years' imprisonment.

4.67 EME emitted from our sites and equipment is well under independently-set safe levels.

4.68 5G is an enhancement of current technology. It is the next step in the evolution of mobile radio technology, just like 2G to 3G and 3G to 4G. Extensive independent research has been conducted both in Australia and internationally on the numerous frequencies and technologies used in mobile networks, including 5G.

4.69 Optus has undertaken EME measurements of new Massive MIMO antennas that utilise beam forming technology. These antennas will be deployed in our 5G network. Results demonstrated that 5G networks will be compliant with Australian EME Standards. Environmental EME levels with 4G and 5G systems are expected to be similar to current levels.

4.70 Singtel also recently conducted EME measurements of a 5G base station (utilising 3.5 GHz spectrum) in Singapore and found that EME levels were very low and well within the guidelines set by the International Commission on Non-Ionising Radiation Protection (ICNIRP).

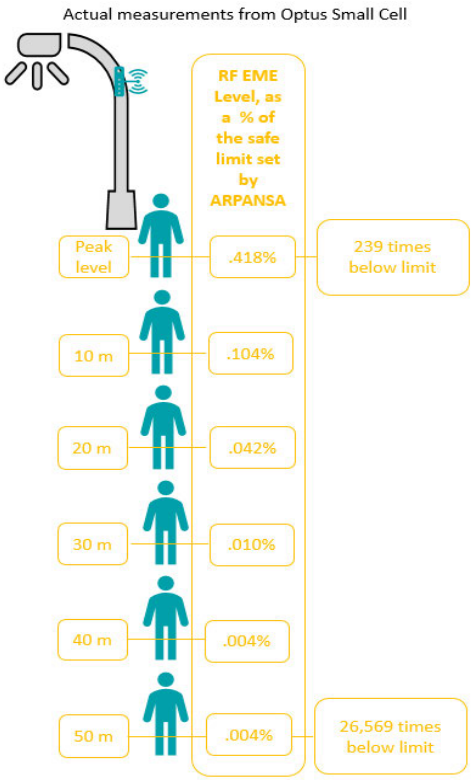
Are small cells safe?

4.71 Small cells operate at lower power than a traditional mobile phone base station and can be deployed with minimal visual impact, even co-locating on existing infrastructure such as a light pole. Small cells emit very low levels of radio frequency electromagnetic energy, making them suitable for residential areas.

4.72 All Optus communications facilities are licensed and recorded with the ACMA. As with all our equipment, our small cells comply with the ARPANSA EME standards. In fact, typical EME levels around small cells can be less than 1% of the limits set by ARPANSA.

4.73 Assessments conducted by technicians accredited by the independent National Association of Testing Authority (NATA) ensure our compliance. These reports are publicly available.

4.74 When selecting an appropriate site, Optus carefully considers environmental constraints, planning, community, property, engineering and RF coverage objectives are all taken into careful consideration when selecting an appropriate site. Under our deployment code obligation, we always notify the community when installing a small cell.



Source: Total Radiation Solutions RF Survey Report, Turramurrasc_3 NSA No,2074034

4.75 The diagram above demonstrates actual radio frequency electromagnetic energy test results conducted from a live small cell in the Sydney suburb of Turramurra in December 2018. These results are typical and reflect measurements of other small cell locations.

Is 5G safe?

4.76 We understand that some people have concerns about EME exposure and 5G's impact on human health. While we talk about 5G being a new mobile technology, with regards to EME it is no different from previous generations of mobile technology. As outlined above, 5G standards allow greater flexibility and larger bandwidths — none of which alter the fundamental nature of EME and radio waves.

4.77 The safety fears that have been expressed are unfounded. We can confidently say this because of the decades of reliable scientific research that back the claim. As noted above, the world's most respected scientific bodies have released public statements which oppose the claims of negative health impacts.

4.78 Closer to home, the independent Australian authority on the matter, ARPANSA, has stated:

> *Contrary to some claims, there are no established health effects from the radio waves that the 5G network uses.*

4.79 Indeed, ARPANSA has urged the community to be cautious of anti-5G campaigns, noting they are:

> *Generating unfounded fear and concern within the community. We have seen increasing misinformation about health effects, [ARPANSA's] role, and 5G or radio waves generally.*

4.80 When we build or use a facility, we follow formal processes to ensure that we comply with strict EME standards set by ARPANSA and license conditions set by the ACMA, our regulator. All of our equipment operates within safe limits and complies with Standards and Licence Conditions.

4.81 Furthermore, every mobile base station and small cell must operate according to strict Australian electromagnetic radio wave standards, which are set by the independent regulator, ARPANSA.

4.82 It is known that 5G signals will use higher spectrum frequencies than previous technologies, however ARPANSA notes that:

> *Higher frequencies do not mean higher or more intense exposure. Higher frequency radio waves are already used in security screening units at airports, police radar guns to check speed, remote sensors and in medicine and these uses have been thoroughly tested and found to have no negative impacts on human health.*

4.83 5G will produce similar electromagnetic fields to the current 3G and 4G base stations. Importantly though, whilst 3G and 4G antennas typically send signals in all directions, 5G will focus the signal only to where they are needed and only when they are needed. This makes 5G a more efficient form of technology.

4.84 While we expect to continue to see alarming rhetoric, the overwhelming conclusion of decades of research should provide the community with the reassurance that 5G is safe.

4.85 To increase community awareness and education on this issue, Optus has prepared Community Information materials which have been provided to all Members of Parliament and Senators and which are made available to communities where we are deploying 5G. An example of materials is extracted below for reference.