# 5G—Enabling the future economy

October 2017

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# Australia's 5G vision

5G is the next step in the evolution of mobile wireless communications technology, promising improved connectivity, greater network speeds and bandwidth, and very low latency. It is the fifth generation in mobile technology which, at each step, has seen significant developments in communications networks:

- 1G—The first generation of mobile phone networks were deployed in the early 1980s, providing a basic voice service using analogue transmission.
- 2G—In 1991, second generation networks were deployed, making the switch to digital standards with improved voice messaging and the introduction of the short message service (SMS).
- 3G—The third generation launched in 2001 and introduced data services in addition to voice and SMS.
- 4G—In 2009, the fourth generation protocol, Long Term Evolution (LTE), was introduced, supporting improved mobile broadband which saw increased capacity and speed for data.

New capabilities of mobile communications networks enabled by 5G technology will allow for a variety of 'use cases':

- higher quality and more video services provided to multiple users with full mobility, even at high speed
- massive scale automation delivered through widespread sensor networks and multiple connected devices
- delivery of critical communications assured by low latency and ultra-reliable networks, and
- improved productivity assisted by high quality, real time data analytics.

Unlike existing mobile communications networks, 5G networks have the potential to allow tailoring of requirements for each of these different use cases within the same network.

The Government considers that 5G is more than an incremental change for mobile communications. Instead, it provides the underlying architecture that will enable the next wave of productivity and innovation across different sectors of the Australian economy. Efficient rollout of 5G and uptake of the services it supports has the potential to produce far-reaching economic and social benefits and support growth of Australia's digital economy. This will be supported by the rollout of the National Broadband Network (NBN) allowing greater capabilities for the seamless delivery of services across high speed mobile, fixed line and fixed wireless networks.

The Government wants to create an environment that allows Australia's telecommunications industry to be at the forefront of seizing the benefits of 5G across the economy. The communications sector will lead the rollout of 5G networks in Australia. However, the Government can create the policy and regulatory environment to support a more efficient rollout, given its potential benefits to the economy.

The Government's direction will be to support the timely rollout of 5G in Australia to enable the next wave of broad-based industry productivity, and support the growth of Australia's digital economy.

This includes immediate actions by Government that enable the communications market to introduce new 5G technologies in line with international developments. These include:

- making spectrum available in a timely manner
- actively engaging in the international standardisation process
- streamlining arrangements to allow mobile carriers to deploy infrastructure more quickly, and
- reviewing existing telecommunications regulatory arrangements to ensure they are fit-for-purpose.

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The Government recognises that as 5G continues to develop, other issues relating to the technology will likely emerge which may require future Government action. In particular, while there are opportunities for 5G to create economy-wide transformation, this will require a broader examination of sectoral regulatory frameworks.

To that end, the Government will work collaboratively with industry to foster an ongoing dialogue on 5G beyond the launch of this paper to identify and remove sectoral barriers to its successful and timely rollout. Through this dialogue, the Government will also look at opportunities to build on other Government activities, such as the national Digital Economy Strategy which will more broadly focus on building the productivity of sectors across the economy.

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# What is 5G?

The International Telecommunication Union (ITU) is the United Nations specialised agency for information and communications technologies. This body decides global spectrum allocation frameworks and harmonises international spectrum to ensure networks and connected devices can communicate seamlessly. The ITU will undertake the formal, international process to identify bands for 5G by 2020. It has developed draft technical specifications for 5G which include:[1]

- high data rates (1 Gbps for hotspots, 100 Mbps download and 50 Mbps upload for wide-area coverage)
- massive connectivity (1 million connections per square kilometre)
- ultra-low latency (1 millisecond)
- high reliability (99.999% for mission critical 'ultra-reliable' communications), and
- mobility at high speeds (up to 500 km/h i.e. high speed trains).

In working towards these specifications, 5G represents a significant leap from the capabilities of previous generations and introduces a range of new technological possibilities. The success of 5G in delivering new technologies and services will be supported by existing communications infrastructure, including the NBN. This convergence of high-speed fixed-line and mobile services will collectively produce a consistent and ubiquitous user experience.

# The 5G economics case

Unlike early generations of mobile networks, 5G will represent a significant shift in the telecommunications industry's focus away from voice and more towards mobile broadband and increased industrial applications. These new use cases are expected to create benefits across a range of sectors—including transportation, health, manufacturing and agriculture—and have varying networking requirements. These use cases, as identified by the industry, can be divided into the following categories:

- enhanced Mobile Broadband
- massive Machine Type Communications, and
- critical communications.

## Enhanced Mobile Broadband (eMBB)

eMBB will deliver improved capacity to a greater number of devices. This will enable higher rates and volumes of data transmission per device and improve coverage to a broader range of locations. eMBB will likely be the focus of early 5G deployments as it can immediately support the growing communications requirements for the digital economy.

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### An improved mobile experience for consumers

5G networks will give consumers a better mobile experience in more locations. Increased network capacity will support more users, even in crowded areas, such as large public events, and at peak times. Faster network speeds will also enable consumers to view rich content in more places, supporting the streaming of live events and high resolution media.

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[1] ITU, 23 February 2017, 'Press Release: ITU agrees on key 5G performance requirements for IMT-2020'.

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## Massive machine type communications (mMTC)

As 5G networks mature, they will support the widespread and dense deployment of sensors and other network-connected devices by significantly reducing their power requirements and providing flexible coverage across different spectrum bands. This proliferation of the Internet of Things (IoT) across industries is expected to produce significant productivity benefits and support integration between sectors.

### Supporting productivity and innovation

The term Industry 4.0 describes the next step in the advancement of the manufacturing sector (the 'fourth industrial revolution'). Industry 4.0 introduces autonomous systems supported by a combination of technologies such as IoT, artificial intelligence, continued technological improvements and digitalisation in manufacturing.

Australia stands to benefit from Industry 4.0, given our world-class manufacturing sector, which includes several high-value industries such as medical technology and aerospace. Australian manufacturers can improve their productivity and international competitiveness through Industry 4.0 processes by supporting their participation in global value chains. This is of particular benefit to SME manufacturers, opening them up to new markets and opportunities. 5G can support Industry 4.0, by providing communications infrastructure that is more accessible and flexible to suit specific industry needs.

5G can enable innovation in other sectors such as agriculture. A challenge for Australia's agricultural sector is identifying how to improve productivity while balancing environmental and commercial constraints. Precision agriculture, which focuses on improving yields and minimising economic risks, seeks to provide more control in the management of agricultural production. While precision agriculture requires a range of enablers—including data analysis, sensor networks and geographical information systems—5G can provide the supporting infrastructure for these technologies.

## Critical communications

Low latency and 'ultra-reliable' communications networks will support the delivery of critical communications, i.e. to support public safety use and playing role in the technology ecosystem supporting autonomous vehicles. In addition to automation, critical communications will also help to support technological advancement in areas including robotics and artificial intelligence.

### The social benefits from autonomous vehicles

5G networks are expected to play a role in the technology ecosystem supporting the development of autonomous vehicles, which will enable a number of social benefits for transportation. Traffic congestion, which is estimated to cost Australia $53 billion by 2031,[2] could be proactively reduced by smart city traffic management systems that are informed by machine-to-machine communications with autonomous vehicles.

Improved road safety is also expected to be a key outcome of autonomous vehicles, as the majority of car accidents involve human error. In the 12 months to July 2017, there were 1,235 deaths on Australian roads with road trauma costing the Australian community an estimated $27 billion annually.[3] Autonomous vehicles can have a valuable role not just in terms of financial savings, but in saving human lives.

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[2] Infrastructure Australia, 2015, 'Australian Infrastructure Audit'.
[3] Bureau of Infrastructure, Transport and Regional Economics, August 2017, 'Road deaths—monthly bulletins'.

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Figure 1—Outline of the relationship between the technical requirements of 5G and expected services and applications it will deliver
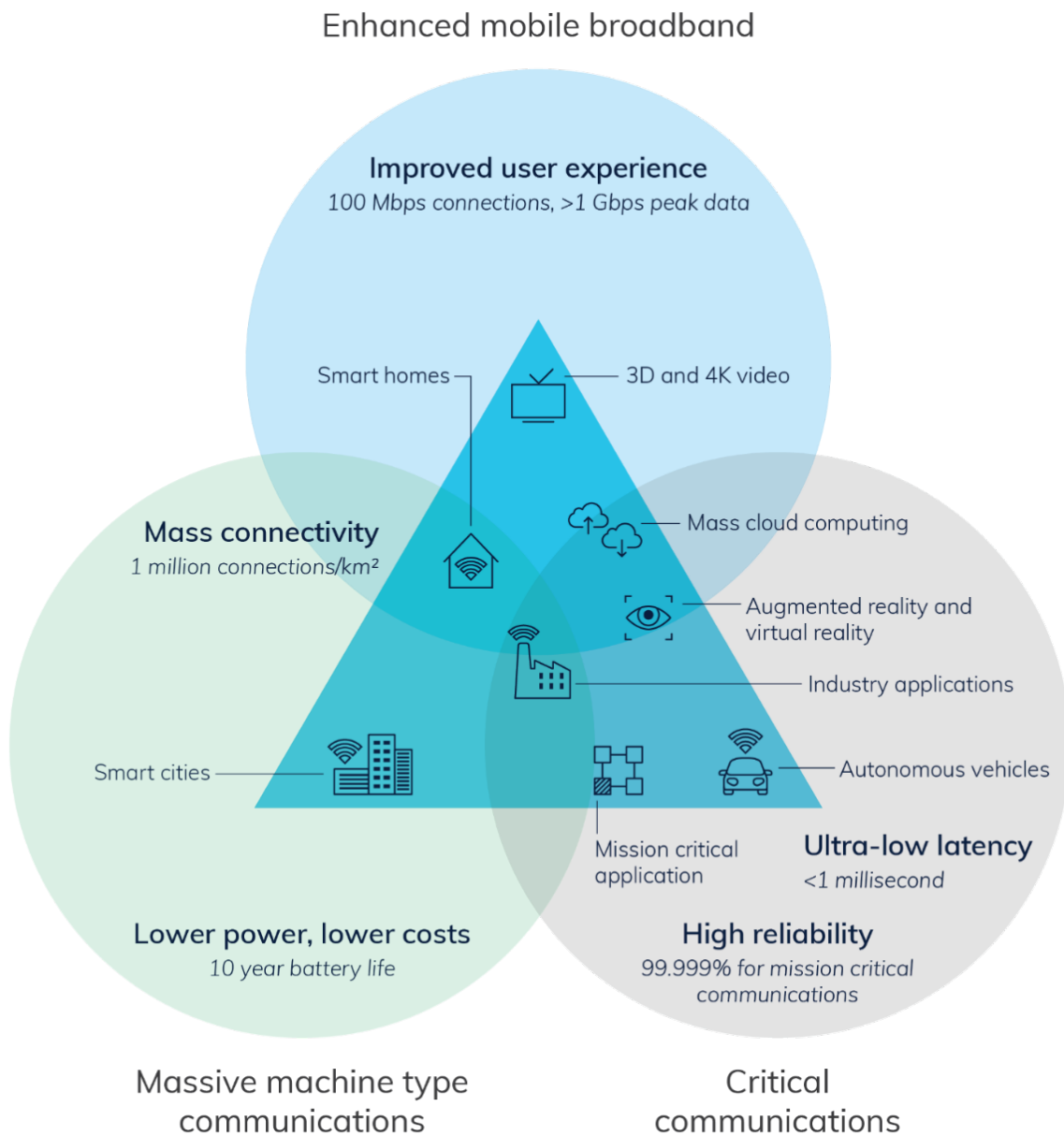


Source: Based on figure 2 from the ITU paper, 'IMT Vision—Framework and overall objectives of the future development of IMT for 2020 and beyond.'

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# What is different about 5G?

5G is expected to enable productivity outcomes across key verticals of the economy as a result of a range of characteristics, such as **network slicing** and **mesh networks**. However, it will need to overcome deployment challenges such as **spectrum acquisition** and **coverage**. This is expected to lead to new approaches for deployment to enable widespread 5G coverage in Australia. The industry will also need to develop a robust **business case** for 5G rollout, which will likely be demand driven, to support the significant capital expenditure required.

## Network slicing

Network slicing allows operators to split their network into separate sub-networks (also referred to as slices), enabling them to dedicate network resources to different users and applications. Sub-networks can 'slice' the infrastructure resources from the physical network to create virtual independent networks. This is a significant development from previous mobile network generations, as it enables an operator to deliver many different capabilities by creating slices that can be tailored for the intended usage. For example, an operator could create a network slice for IoT devices, or alternatively, a network slice for higher security for a higher quality of service for government or public safety uses.

Network slicing also provides a model for infrastructure sharing between network operators. In this case, a single transmitter's network could be shared with more than one operator. Given the capital expenditure that will be associated with 5G rollout, network slicing can provide a cost effective, short-term solution for operators.

Figure 2—5G network slicing enables operators to create separate virtual networks to meet application requirements
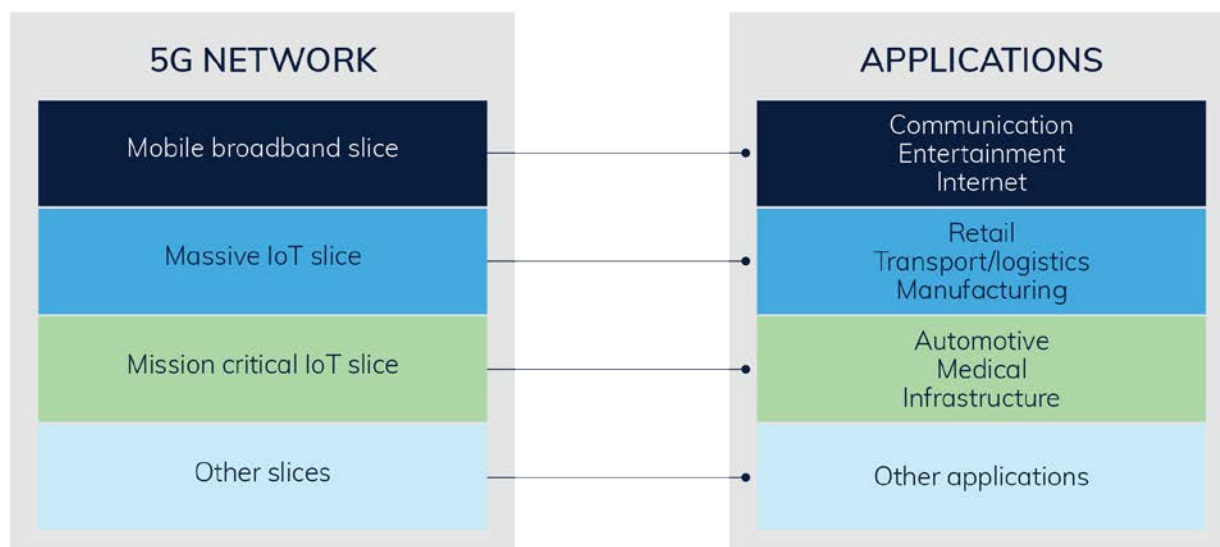


*Source: Based on figure 2 from the ITU article, 'Why end-to-end network slicing will be important for 5G.'*

## Mesh networks

Mesh networks can be utilised to increase the range of coverage, where the 'mesh' is an interconnection among a network of devices. Only one device in the mesh needs to be connected to the network, which can then relay data to other nearby devices.

Mesh networks not only provide the opportunity to support 5G deployment but also have the additional benefit of providing efficient network speeds. Through dynamic routing, devices on a mesh network are able to seek the fastest and most reliable pathway to send and receive data. As such, this architecture can provide a cost effective solution for coverage in more remote areas. For example,

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primary industries would benefit from this network approach by simplifying network connections and costs associated with deploying and managing an IoT sensor network. However, the application of mesh networks is still highly speculative as the industry considers how they will operate in practice and in different environments. This may contribute to the development of new business models for 5G.

## Spectrum sharing

Spectrum is a critical enabler of Australia's current and future communications infrastructure. The specific spectrum bands and quantity of spectrum required for 5G are still being considered. However, 5G will likely require a mix of low, medium and high frequency spectrum to meet different scenarios relating to coverage, connectivity, and latency:

- Low frequency (less than 1GHz)—providing widespread coverage across urban, suburban and rural areas and supporting IoT for low data rate applications.
- Medium frequency (1–6GHz)—providing good coverage and high speeds, and including the expected initial 5G range of 3.3–3.8GHz which has been identified as the most likely band for launching 5G globally.
- High frequency (above 6GHz)—providing ultra-high broadband speeds for advanced mobile broadband applications, and most suitable for applications in dense traffic hotspots.

5G technologies can be expected to deliver improvements in spectral efficiency (the data rate that can be supported per unit of spectrum). However, the use of 5G networks for applications such as widespread industrial applications is likely to require significantly more amounts of contiguous spectrum to be made available.

While some of the potential bands for 5G currently have unused spectrum, other bands would need to be 'refarmed', noting that it is likely that bands currently used for 2G, 3G and 4G in Australia will transition over time to 5G. Refarming enables spectrum to be transitioned to the highest value use as required. The refarming of spectrum already held by mobile broadband operators is a commercial decision for those operators. 5G is also expected to provide the opportunity for 'soft-refarming' where 4G and 5G technologies can both be supported simultaneously, minimising the impact to legacy devices during transition periods.

Spectrum sharing, that is spectrum accessed by numerous users on a shared basis, has also been identified as an option for 5G technology. Spectrum sharing encompasses a range of different aspects of spectrum management. Spectrum can be shared by geography, time, economic priority schemes, code modulation, polarisation, directionality or power. Access to spectrum is divided between users so it can be used without interference issues.

5G opens up new opportunities for increased spectrum sharing, through mechanisms such as network slicing. 5G technology is also designed to support shared arrangements, and allows for the sharing of the same spectrum ('unlicensed Wi-Fi' spectrum) with other technologies. Operators can augment their holdings in situations where existing exclusive holdings are insufficient to meet customer needs. Spectrum sharing in the 5G context is also supported by the expected use of highly directional antenna technology which would enable operators to operate in closer proximity without interference.

## Antenna technology and network topology

5G will require radically different structures of networks if it is to achieve successful deployment in Australia. As 5G will likely utilise different frequencies, new equipment will be necessary. Additionally, the higher frequency 5G spectrum can only travel a small distance and will need more cells to ensure adequate coverage. However, antennas and equipment will be smaller, making it easier to attach these cells to existing infrastructure such as street lights and buildings.

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The more dense deployment of cells will also give rise to other approaches that improve the reliability of data transmission across a 5G network. Data may be divided into individual streams and transmitted through multiple antenna segments in a process called Multiple Input Multiple Output (MIMO) which allows for more information to be transmitted simultaneously. This technique is further empowered by 'beamforming' which allows base stations to direct focused beams of energy to a specific area rather than dissipate the available power of a larger area. These developments will enable more efficient transmission and increase overall throughput.

5G is also expected to assist the adoption of IoT by further reducing power consumption through extended discontinuous reception. In this scenario, IoT devices shift between active and inactive cycles, transmitting only when required. This will allow connected devices to operate for extended periods on a single charge, reducing operational costs.

5G will also increase the support for a greater density of devices that would have otherwise been limited by the capacity on 3G and 4G networks. They will also enhance IoT deployment through the use of network slicing to create virtual network configurations that are optimised for the low power and coverage requirements of IoT networks.

## Business case

For Australians to experience the benefits of 5G, the communications sector will need to explore and develop new business cases to attract investment and support the rollout of 5G services. As 5G becomes an integral part of the communications ecosystem, the sector will need to be agile to respond to the needs and expectations of other sectors which will be seeking to take advantage of these next generation networks.

While residential consumers will inevitably be attracted to the enhanced mobile broadband services offered by 5G, it is the industrial applications for 5G where industry expects to see the greatest opportunity for new business models.

Compelling industrial applications are still to be developed. For example, industry sectors can be expected to seek tailored solutions for their business needs such as enhancing their local area network or enabling autonomous systems, and small businesses will look for low cost deployments of IoT.

It is therefore expected that the model for 5G will be demand driven and will require the communications industry to foster new business opportunities.

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# How are countries preparing for 5G?

In preparation for 5G, many countries have been taking steps to test the technology and review their spectrum arrangements.

Examples of 5G work being undertaken by other countries

The United States is clearing the 600MHz band through an incentive auction for the potential early deployment of 5G. The United States has also identified reforms to infrastructure deployment as a priority for 5G rollout. Mobile network operators are also conducting trials of low-band spectrum for use in 5G services.

The Asia-Pacific Telecommunity (APT), the regional arm of the ITU, approved a recommendation for the use of the 700MHz band for 5G, with 26 countries in the Asia-Pacific region identifying this band for this use, including Australia, Japan, South Korea and New Zealand.

Korea and Japan have stated their intention to use some or all of the 26.5 to 29.5GHz range to trial enhanced mobile broadband applications ahead of the 2018 Winter and 2020 Summer Olympics respectively. It is expected that these trials will lead to commercial availability of 5G services.

The European Communications Commission (ECC) identified the 3.4–3.8 GHz and 26GHz band (from 24.25 to 27.5GHz) bands for the deployment of 5G in Europe. All European countries are expected to select at least part of this range to launch 5G by 2020.

In the United Kingdom, the government launched its 5G strategy in March 2017. It is funding testbeds to understand the different deployment requirements and security considerations for 5G. The United Kingdom is also working to make suitable spectrum available in the high (24.25 GHz–27.5 GHz, and other bands above 30 GHz), medium (3.4–3.8 GHz) and low frequency (700 MHz) bands.

## Industry 5G preparations in Australia

Australia is well positioned to harness the opportunities of 5G. Australia has an effective and competitive mobile communications market, with voice and data coverage available to more than 99 per cent of the population.[4] It is the top performer internationally in terms of having in place effective enablers—infrastructure, affordability, consumer readiness and content availability—to support mobile internet adoption.[5]

5G trials have already commenced in Australia, with each of the main carriers working with mobile equipment suppliers in testing the application and limits of the technology. These trials will continue and will inform the communications sector on how 5G can be effectively deployed for the Australian environment.

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[4] Department of Communications and the Arts, accessed 1 September 2017, 'Mobile phone towers'.
[5] GSM Association, 24 June 2016, 'Global Mobile Connectivity Index'.

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# The Government's direction for 5G

The Government has made significant investments to improve telecommunications infrastructure in Australia, through the NBN and the Mobile Black Spot Program. The Government is also working to create a policy and regulatory environment that supports a competitive and innovative communications market.

The Government recognises that 5G will enable innovation and productivity across industry sectors and can significantly contribute to Australian's growth and future prosperity. Therefore, the Government will focus on enabling the early deployment of this new generation of mobile networks in Australia and encourage its use in delivering new services and applications.

The Government will support the timely rollout of 5G in Australia to enable the next wave of broad-based industry productivity, and support the growth of Australia's digital economy.

Industry expects and needs to lead the deployment of 5G. However, the Government has a role in supporting network rollout by modernising policy and regulatory frameworks and removing barriers that would delay rollout and adoption unnecessarily.

In the first instance, the Government will support the early deployment of 5G in Australia by:

- making spectrum available in a timely manner
- actively engaging in international spectrum harmonisation activities
- streamlining arrangements to allow mobile carriers to deploy infrastructure more quickly, and
- reviewing existing telecommunications regulatory arrangements to ensure they are fit-for-purpose.

## Making spectrum available in a timely manner

A clear, efficient and flexible regulatory framework governing spectrum access will be essential to support the timely deployment of 5G networks in Australia.

The Government is currently undertaking work to modernise Australia's spectrum management framework to ensure it remains fit-for-purpose. In May 2017, it outlined its proposed reforms to the framework which are designed to simplify and streamline the processes for spectrum allocation and provide a transparent, efficient and flexible spectrum management framework. This will be the most significant change to the Australian spectrum management framework in the last 25 years.

The reforms will remove barriers between licence types, and enable flexible licensing issue and allocation processes. This strategic approach will remove outdated processes and support the Australian Communications and Media Authority (the ACMA) to more effectively respond to market demands and new technologies, such as 5G. This will help Australia remain internationally competitive with a modern, innovative economy over the coming decades.

**The Government will put in place its new spectrum management framework by 2019.**

In addition, the ACMA will continue to work on making spectrum available for 5G. The ACMA has been investigating the use of 1.5GHz and 3.6GHz and high frequency mmWave bands in considering additional spectrum for mobile broadband services. The ACMA has decided to prioritise refarming of the 3.6GHz band over the 1.5GHz band, citing industry submissions noting this band is likely to be a pioneer band for early 5G deployments and the need to provide greater clarity and investment certainty for incumbents and potential new band entrants alike. The ACMA is currently engaging with industry on which parts of the 3.6GHz band should be reallocated and on what terms. This approach also follows international trends which have seen the 3.6GHz band commonly used for 5G trials.

**The ACMA will work to bring 3.6GHz spectrum to auction in 2018.**

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## Actively engaging in international spectrum harmonisation activities

There is already significant work underway globally with several countries trialling 5G, but standards for this new generation technology are yet to be finalised. The formal, international process to define 5G is led by the ITU. The ITU's Working Party 5D is responsible for shaping the standard for "futuristic mobile technologies" to support International Mobile Telecommunications (IMT) for 2020 and beyond.[6] This process is known as IMT-2020.

Stakeholders such as regulatory and policy setting bodies, hardware manufacturers and governments of countries in which they are based will be seeking to influence the international dialogue. A key body is the industry-driven 3GPP which undertakes technology standardisation. Collectively, the ITU and 3GPP will drive spectrum harmonisation activities: the ITU, led by administrations, will focus on the spectrum requirements; and the 3GPP, led by industry, will concentrate on equipment and device standards.

Industry is well-placed to lead the standardisation process particularly given its role identifying the application of 5G technologies. However, there is also an important role for the Government in these processes. This is particularly the case in the harmonisation of international spectrum arrangements which will have significant impact on the availability and cost of 5G devices in Australia and can be strongly contested.

In the past, Australia and the Asia-Pacific region have been influential in contributing to standards and spectrum plans that have been adopted across the world. This ensured that Australia was able to adopt new technologies quickly and that the Australian market could take advantage of the economies of scale and have a greater choice of mobile handset equipment.

**The Government will ensure strong participation by Australian in domestic and international discussions about 5G spectrum harmonisation.** Our continued involvement provides the opportunity to contribute to this dialogue and secure outcomes that will benefit the adoption of 5G in Australia.

## Streamlining arrangements to allow mobile carriers to deploy infrastructure more quickly

The design and deployment of mobile networks will be radically different from those of today. 5G is expected to require additional infrastructure in new forms, including smaller cells and more densely-located antennas, particularly in the use of high-band spectrum.

Carriers have specific powers and immunities relating to telecommunications infrastructure deployment and installation. These laws help carriers to rollout telecommunications infrastructure quickly in a nationally-uniform way, rather than having to follow state, territory and local government requirements. These laws have existed in their current form since 1997.

The Government has recently consulted on proposed new arrangements that take account of technology developments and changes in operating practices as well as identifying opportunities to streamline deployment processes. Under these new proposed arrangements, mobile carriers would be able to rollout new communications technologies such as 5G more efficiently.

The Government understands that some members of the community have expressed concerns about the impact on public amenity from increased telecommunications infrastructure. The Government considers that telecommunications providers should work with local communities to address concerns about their infrastructure plans and is encouraging industry to consider consultation requirements for future 5G networks.

**The Government continues to work with stakeholders and will implement the first tranche of changes to carrier powers and immunities following the conclusion of the consultation process.**

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[6] ITU, accessed 1 September, ITU towards "IMT for 2020 and beyond."

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## Reviewing existing telecommunications regulatory arrangements to ensure they are fit-for-purpose

The pace of change in the communications sector is impacting on the effectiveness of the existing telecommunications regulatory framework. In response, the Government is progressively working to modernise the regulatory architecture to ensure that the regulatory and policy settings flexibly respond to the current and future needs of the communications sector.

In undertaking reform, the Government is cognisant that the communications regulatory framework will need to be sufficiently flexible to address the emergence of new technologies and business models.

5G deployment will benefit from the Government's reform efforts, including updates to the regulatory framework for telecommunications and radio spectrum and modernising the ACMA. In these cases, the Government has been revising regulation to shift it away from the traditional vertical telecommunications sectors to principles based, flexible arrangements. This will provide the versatility necessary to account for 5G developments and services.

**The Government will continue to work with industry to modernise current telecommunications regulatory arrangements to ensure they encourage competition and innovation in the sector.**

As with previous mobile networks, cybersecurity will be a critical consideration as 5G is deployed. Security will be even more so a challenge for 5G, as the reliability of communications will be pivotal in the technology's ability to deliver benefits, particularly in the case of critical communications.

Additionally, in providing the architecture for automation, 5G networks will trigger an ever-increasing volume of data. While the bulk of data will be machine-to-machine communications, users will want assurance that their personal information is protected. User consent will be an area of growing complexity due to the intersection between autonomous systems and the individual.

Industry has strong incentives to address cybersecurity risks in 5G's new types of network deployments and systems. However, **the Government will continue to assess cybersecurity and privacy issues as they evolve to ensure Australians have confidence in using 5G.**

## Next steps

The Government recognises the opportunities presented by 5G for economy-wide transformation, creating productivity benefits in sectors such as transportation, health, manufacturing and agriculture. However, realising the benefits of 5G in sectors other than communications will need the right sectoral regulatory settings.

**The Government will work to ensure that sectoral regulatory frameworks are updated to take advantage of 5G.** The communications portfolio is well-placed to facilitate an ongoing strategic dialogue on 5G that will support sectors to identify and work towards unlocking the potential benefits of the technology. This dialogue would provide a starting point for greater engagement across Government and with industry and the community.

To that end, **the Government will establish a 5G working group that will bring together representatives from across Government and industry.** The working group will create a platform for this strategic dialogue with a mandate to seek out opportunities and emerging issues on 5G. This will provide better coverage across Government of the evolving policy and regulatory challenges associated with 5G.

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