

Market analysis

Communications supply chain market study

From equipment and spectrum
to wholesale services

MARCH 2023

Canberra

Red Building
Benjamin Offices
Chan Street
Belconnen ACT

PO Box 78
Belconnen ACT 2616

T +61 2 6219 5555
F +61 2 6219 5353

Melbourne

Level 32
Melbourne Central Tower
360 Elizabeth Street
Melbourne VIC

PO Box 13112
Law Courts
Melbourne VIC 8010

T +61 3 9963 6800
F +61 3 9963 6899

Sydney

Level 5
The Bay Centre
65 Pirrama Road
Pyrmont NSW

PO Box Q500
Queen Victoria Building
NSW 1230

T +61 2 9334 7700 or 1800 226 667
F +61 2 9334 7799

Copyright notice

<https://creativecommons.org/licenses/by/4.0/>

With the exception of coats of arms, logos, emblems, images, other third-party material or devices protected by a trademark, this content is made available under the terms of the Creative Commons Attribution 4.0 International (CC BY 4.0) licence.

We request attribution as © Commonwealth of Australia (Australian Communications and Media Authority) 2023.

All other rights are reserved.

The Australian Communications and Media Authority has undertaken reasonable enquiries to identify material owned by third parties and secure permission for its reproduction. Permission may need to be obtained from third parties to re-use their material.

Written enquiries may be sent to:

Manager, Editorial Services
PO Box 13112
Law Courts
Melbourne VIC 8010
Email: info@acma.gov.au

Contents

Executive summary	1
Key trends	3
About this study	4
Analytical framework	4
The ACMA and the Australian communications sector	5
Communications supply chains	5
Components, spectrum and equipment	7
Chipsets and semiconductor components	8
Spectrum	8
Equipment	11
Communication networks	16
Fixed-line networks	16
Fixed-line wholesale market	19
Mobile networks	23
Mobile infrastructure	23
Mobile wholesale market	25
Fixed wireless networks	27
Fixed wireless infrastructure	27
Fixed wireless wholesale market	28
Satellite networks	29
Satellite infrastructure	29
Satellite wholesale market	30
Cloud	34
Cloud computing and services	34
Cloud infrastructure	34
Cloud services: Supply chain input	36
Cloud services: Supply chain wholesale service	37
Glossary	39

Executive summary





The Australian Communications and Media Authority (ACMA) contributes to maximising the economic and social benefits of communications infrastructure, content and services for Australia.




This market study looks to identify key trends across the inputs and intermediate elements of the communications supply chain – from components, equipment and spectrum through to wholesale services and access networks. In this study, terrestrial broadcast services and pay TV have been excluded; while private networks will be considered as part of a standalone market study. Please refer to the [ACMA research program](#) for further information.

This market study highlights a sector in transition, with challenges (such as the ongoing impacts of the COVID-19 pandemic, access to finance, interest rate rises and inflation) and opportunities (such as 5G, digitisation and cloud services) emerging.

Across the supply chain, the report identifies the following state of play in the Australian market.

Table 1: Key findings across the communications supply chain

Inputs	Components 	<ul style="list-style-type: none"> > Health and geopolitical events over the past 2 years have disrupted global supply chains for components. > Australia has fared well compared to similar markets. > Microchip shortages have hindered the production for various digital capabilities, with all key suppliers located in Taiwan.
	Spectrum 	<ul style="list-style-type: none"> > Spectrum remains a scarce resource managed by the ACMA. > Demand for certain frequencies continues to evolve with each new technology introduction.
	Equipment 	<ul style="list-style-type: none"> > Australian mobile operators are upgrading from non-standalone to standalone 5G networks. > Manufacturers focus on importing consumer and enterprise networking equipment to Australia. > Devices are constantly keeping up with evolving equipment to ensure compatibility with new network features.
Intermediate (inputs and outputs)*	Fixed-line networks 	<ul style="list-style-type: none"> > Fixed-line networks are experiencing continued consolidation in the market. > Alongside major terrestrial fibre projects, there has been growth in optic-fibre submarine cables connecting Australia to the rest of the globe.

	<p>Mobile and fixed wireless networks</p> 	<ul style="list-style-type: none"> > Mobile operators have divested their passive infrastructure (towers and cell sites) to institutional investors while continuing to seek efficiencies through sharing spectrum and co-location.
	<p>Satellite networks</p> 	<ul style="list-style-type: none"> > Technology is moving towards a greater variety of satellites operating in different orbits and for a broader range of uses. > This market is experiencing growth in smaller satellite deployments. > More telecommunications service providers (telcos) are partnering with satellite operators to provide fibre backhaul in exchange for greater connectivity in remote areas and direct-to-mobile satellite services.
	<p>Cloud</p> 	<ul style="list-style-type: none"> > Australian networks have demonstrated their intention to compete and collaborate in the cloud services market against specialist IT companies and hyperscalers. > Heightened demand for cloud services has subsequently accelerated local data centre infrastructure builds.

** All intermediate services include analysis on their respective wholesale markets. Retail markets will be explored in detail in our upcoming Communications supply chain market study: Services, applications and retail.*

Key trends

Table 2 summarises market trends and their impact on the supply chain. It highlights considerations for the ACMA as the communications sector regulator.

Table 2: Key market trends impact on the supply chain and ACMA role

Market trend	Supply chain impact	The ACMA's role
Equipment manufacturing in semiconductors and microchips continue to experience the ongoing effect of the COVID-19 pandemic, when less equipment was made and exported. There is a global reliance on small markets such as Taiwan as well as a growing demand of chips and semiconductors as technology advances – predominately for industrial IoT platforms and consumer electronics.	Equipment shortages have delayed productions and deployments in various digital capabilities across the communications supply chain. These include network upgrades or maintenance, deployment of private networks, Internet of Things platforms (sensors), ICT infrastructure (data centres), artificial intelligence applications, autonomous vehicles and consumer electronics (gaming, augmented/virtual reality, modems, smartphones).	Industry is responsible for network deployments and maintenance. The ACMA may have a role under telecommunications consumer regulation if there is an impact on service quality obligations not being met.
There has been a shift towards some telcos exploring active network-sharing arrangements. This includes increased interest for Open RAN equipment (as cited by NEC, BAI and Nokia), new trials for neutral host providers (FSG to lead NSW pilot trial) and proposals for mobile network operator sharing agreements.	Networking-sharing arrangements increase infrastructure efficiencies in the telco supply chain. Building and maintenance costs are reduced, power consumption minimised and the risk of overbuild is lowered. This in turn allows telcos to redirect funds towards newer technology and innovation.	The ACMA has no direct role in regulating network sharing, however it can support industry-led trials of non-traditional spectrum-sharing arrangements, such as Automatic Frequency Control or other automated database solutions for spectrum assignments.
Australia is experiencing growing data volumes as consumption in data-intensive applications increase. This is demonstrated through an increased range of use-cases both from industry (Internet of Things, artificial intelligence, private networks) and consumers (video streaming, gaming, smart devices).	Activities to satisfy growing data demand is seen across the telco supply chain: <ul style="list-style-type: none"> > Increase in fibre network builds and market participants. > Transmission route expansions (domestic and international). > Greater satellite-telco partnerships to supply connectivity. > Spectrum planning and allocation. 	The ACMA will seek to facilitate new licence types to support industry network deployments to meet growing demands and innovation (as seen in the introduction of area-wide licences). Amendments to the <i>Radiocommunications Act 1992</i> support additional licensing flexibility.
The Australian market is seeing increasing cloud adoption from a network perspective, greater core network virtualisation and edge computing, as well as wholesale and datacentre services, use of cloud storage, cybersecurity and digital transformation (cloud migration).	The adoption of cloud has several impacts on the supply chain: <ul style="list-style-type: none"> > Infrastructure efficiency (hardware/on-premise equipment is replaced by a cloud core). > Improved network performance > Greater applications available. > Additional data centre builds to support cloud services. 	The ACMA does not have a direct role in regulating cloud services or infrastructure. However, the ACMA does manage device regulation (such as edge-computing nodes and cloud-supported IoT/M2M devices) to ensure technical standards are met.

About this study

The ACMA conducts market analysis that contributes to our understanding of communications and media markets.

As part of the market analysis workstream, this market study was conducted to inform our understanding of developments in the communications sector. The study was developed based on desktop research and intelligence from third-party providers. Information is based on an illustrative sample selected to identify general industry trends and is not intended to be an exhaustive list.

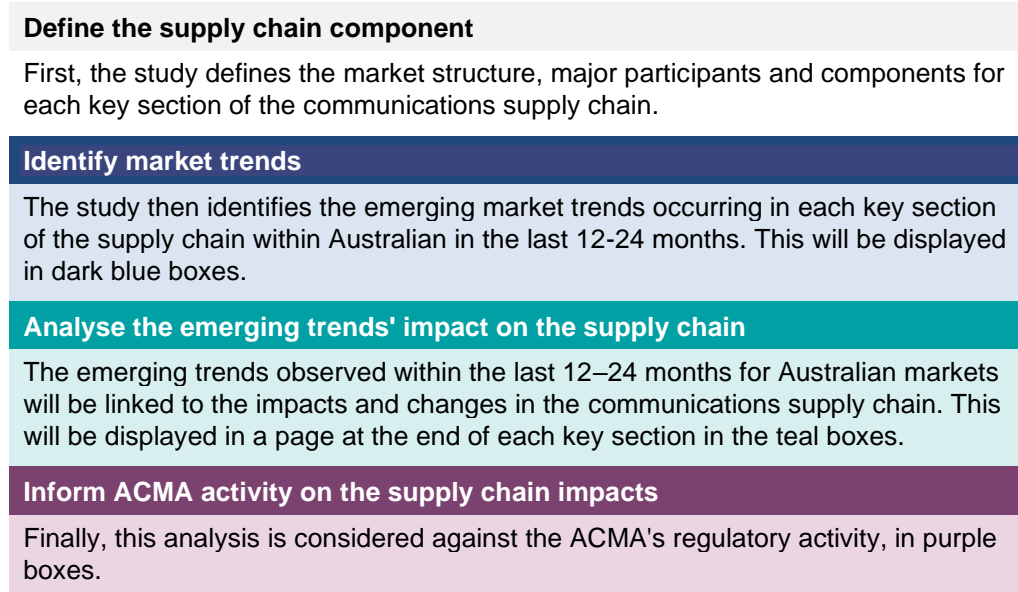
The study includes commissioned research for the components and equipment section provided by GlobalData. This research was commissioned by the ACMA, which involved interviewing leading manufacturers and analysing current supply chain issues. The ACMA would like to thank those who provided feedback and input into the development of this market study.

Our research program makes an important contribution to the ACMA's work as an evidence-based regulator. It informs our strategic policy development, regulatory reviews and investigations, and helps us to support a media and communications environment that works for all Australians. This market study forms part of the [ACMA's 2022-23 research program](#).

Analytical framework

This market study identifies key trends across the inputs and intermediate elements of the communications supply chain, that is, from components, equipment and spectrum through to wholesale services and access networks. The following diagram represents the steps taken to analyse the impact of these trends and identifies the role played by the ACMA to support supply chain activity.

Figure 1: Analytical approach



The ACMA and the Australian communications sector

The ACMA contributes to maximising the economic and social benefits of communications infrastructure, content and services for Australia. We do this by:

- > maintaining, enforcing and improving regulation to drive industry performance and protect consumers
- > managing public resources to enable industry to deliver existing and new services.

The ACMA plays an important role in ensuring Australians have access to the communications services they need and use. Throughout this report, the areas where the ACMA contributes and supports the Australian communications sector across the communications supply chain are identified.

Communication services have proven an essential part of various services and applications offered to Australians. Connectivity has become an integral part of daily life though connecting communities, remote working and providing essential services such as telehealth and education. The services and applications provided to retail consumers represent the final part of the communications supply chain and will be considered as a separate report.

Communications supply chains

Supply chains largely characterise the process of producing a product or service from its inputs through to its outputs, which are either consumed or used. In the context of the communications industry, mapping out a supply chain is a challenging task. There are a number of different approaches, which may be:

- > defined by network layers¹
- > a siloed approach, which identifies individual elements.²

The ACMA acknowledges that there are challenges in analysing communications supply chains from a market perspective:

1. Technological advances have meant that some categories can be blurred for the purpose of supply chain delivery. A good example is cloud services, which could be considered as:
 - > a service/application where people can store data digitally to reduce storage and search costs
 - > part of network infrastructure used to deliver a service (for example, cloud technologies are used to virtualise elements of the core network for a 5G service, which enables mobile network owners to have core elements closer to the edge of the network).

Therefore, cloud simultaneously forms part of an input, intermediate and output in this supply chain.






























2. Competition is not stagnant across any of the communications networks, causing upstream and downstream markets to be constantly evolving.

¹ See, for example, ACCC, [Communications sector market study](#), April 2018.

² See, for example, InterMEDIA, [Reviewing the layered model](#), 1 April 2018, p. 15.

Figure 2 draws upon the various approaches outlined above to develop a model of the communications supply chain, with examples provided within each category.

Figure 2: Communications supply chain model

Inputs		Intermediate (inputs and outputs)		Outputs	Consumption
Equipment, spectrum and infrastructure ³		Wholesale services/networks	Cloud	Services/Apps*	Retail
Servers 	Towers 	White label 	Cloud Service 	Voice, SMS and Emails 	Consumers 
Routers 	Fibre cables 	Mobile virtual network operators (MVNOs) 	Data Centres 	Streaming 	Small business 
Base stations 	Microwave links 	Fixed-line network 		Gaming 	Enterprise 
Chipsets 	Satellite links 	Mobile network 		Online gambling 	Government and Non-for-profit organisations 
Devices 	Earth Stations 	Fixed Wireless 		Internet of Things (IoT) 	
Spectrum 		Satellites 		Digital Twins 	

Source: ACMA analysis.

* Note the list of services and applications supplied by telecommunication services is not exhaustive.

³ The infrastructure analysis has been integrated within the intermediate chapter, by specific network type.

Components, spectrum and equipment

Communications networks rely on a variety of equipment to store and carry information. From chipsets to equipment manufacturing and production, communications networks rely on manufacturers and wholesalers to provide the necessary equipment to operate networks effectively and safely. Communications equipment forms the backbone and foundation of telco networks, and the type of equipment required for operation varies depending on the network type. This section covers the different inputs that can be used to build or access a communications network.⁴

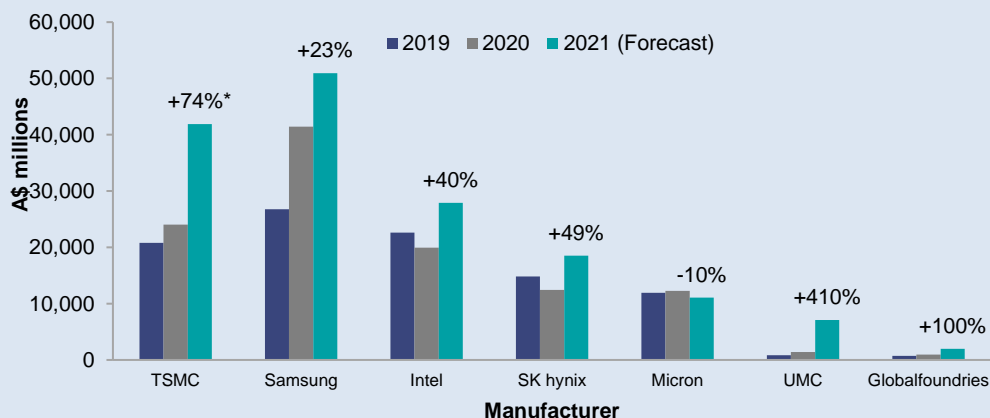


Market trend: Microchips – high demand, low supplies

The impacts of the COVID-19 pandemic disrupted the supply of microchips while, at the same time, created a surge in demand for remote working communication devices, computing products and at-home entertainment.

These supply chain disruptions ranged from shortages in raw materials to delays in manufacturing processes and transport logistics. It highlighted the world's reliance on a small number of suppliers of raw materials like silicon and noble gases, and a handful of large manufacturers mostly located in geopolitically high-risk regions. Australia has fared well, compared to similar markets, in securing supply for components and equipment throughout the pandemic.⁵

Figure 3: Major semiconductor manufacturers' capex



Source: S&P Global Market Intelligence, [Chip shortages stick around while the world waits for more capacity](#), 23 August 2021.

*The % change represents the year-on-year growth from 2020 capex figures.

The sudden demand for consumer electronics during the COVID-19 pandemic, as consumers faced lockdowns and work-from-home orders, coincided with the rapidly evolving Internet of Things (IoT) era that is putting processor chips into more appliances, gadgets, vehicles and even clothing.

⁴ Passive equipment, components and infrastructure has not been included in this supply chain scope. The focus is on active parts of the telco networks which are experiencing supply chain disruptions.

⁵ GlobalData, [Supply Chain Disruption: Thematic Intelligence](#), 23 August 2022.

Chipsets and semiconductor components

Semiconductors are a necessary input into modern technology and form the foundation of many aspects of modern communications technology. These then form the basis of more complex chipsets and electrical components to produce devices such as mobile phones, laptops, tablets and other intricate devices.

Two ongoing challenges are access to raw materials and competing equipment standards. Industry leaders have flagged supply pressures on raw materials used to make microchips with 5G smartphones and edge computing devices using more silicon than 4G smartphones. New cars need more silicon than older cars. Silicon content is expected to grow even if device unit growth is flat.⁶ If 'bifurcation of global technology standards' occurs, it will affect Australia's ability to receive critical equipment, especially given it's scarcely manufactured domestically.⁷



Market trend: Taiwan a key market critical to 5G

About 75% of the global semiconductor supply comes from east Asia. The global market is dependent on Taiwan-based manufacturers such as the Taiwan Semiconductor Manufacturing Company (TSMC) and United Microelectronics Company (UMC).

Geopolitical events tied to Taiwan could cause significant supply chain disruption to all major markets including Australia.⁸ Equipment that requires specialised advanced equipment – such as Application Specific Integrated Circuits (ASICs) or Field Programmable Gate Arrays (FPGA) – will need the advanced fabrication nodes located in Taiwan.

ASICs and FPGAs are used in 5G mobile network equipment as well as satellite terminals and on-board payloads.⁹ However, many of the analog semiconductors used in Radio Frequency Front-Ends (RFFE) might be less impacted as these can be manufactured in the United States and Japan.

Spectrum

The electromagnetic spectrum is the continuous range of electromagnetic waves that extend from the long wavelength (low frequency) radio waves to short wavelength (high frequency) X-rays and gamma rays. The part of the electromagnetic spectrum most useful for communications and sensing is commonly referred to as the 'radiofrequency spectrum', with most communications applications currently using frequencies below 30 GHz. Different frequency ranges have different properties that make them better suited for different applications.

⁶ S&P Global Market Intelligence, [Taiwan Semiconductor Co: Q2 2022 earnings call transcript](#), 14 July 2022.

⁷ Department of Industry, Science and Resource, [2022 List of Critical Technologies in the National Interest](#), 22 August 2022.

⁸ GlobalData, [ACMA Report: Perspective on Telecommunications Supply Chain](#), 14 October 2022, p. 5.

⁹ ASIC are custom designed for each task, which can include microprocessors, flash memory and digital signal processors. They are used on equipment such as IP routers and ethernet switches, satellite digital transparent processors, and massive MIMO antenna units. FPGA are semiconductor devices used in software for aerospace, defence, automotive, broadcast and consumer electronics and more.

Figure 4: Electromagnetic spectrum



Source: ACMA analysis.

Access to spectrum requires licensing which is managed by the ACMA. There are 3 categories of radiocommunication licences in Australia: apparatus, class and spectrum, as described in Table 3.

Table 3: Description of radiocommunication licence types

Licence type	
Class licence	<ul style="list-style-type: none"> > Class licences generally authorise the use of radiocommunications devices in a specified frequency band or range. There is no licence issue or renewal, and therefore no associated licensing costs. > Does not require any application or payment of fees. > Allows operation of common radio equipment on shared frequencies, with a low risk of interference.
Apparatus licence	<ul style="list-style-type: none"> > Applications are processed and largely allocated over-the-counter by the ACMA. These licences can be auctioned where there is high demand.¹⁰ > Costs include taxes, fees and charges. > Can be 'assigned' (allocated a frequency) or 'non-assigned' (sharing a frequency). > Includes area-wide apparatus licences (AWLs).¹¹ > Usually issued for one year but can be issued for up to 20 years.
Spectrum licence	<ul style="list-style-type: none"> > Spectrum licences can be sold or allocated by the ACMA through auction, tender, set price, negotiation or direct allocation. However, most often these licences are initially allocated via auction. > These licences are defined by various conditions depending on the frequency band, including geography, bandwidth and other technical requirements. > Allocation method is determined by market conditions. > Licence terms for up to 20 years. > Costs may include spectrum access charges, tax and service charges for certain services.

¹⁰ In recent years, broadening an apparatus-licensed band to new uses where demand has exceeded supply, the ACMA have used an 'allocation window' approach. This seeks applications in a given time period. See the [26/28 GHz applicant information pack](#).

¹¹ AWLs are a type of apparatus licence introduced by the ACMA in 2020. They are designed to allow flexibility to support a range of wireless broadband and satellite use-cases. AWLs are flexible, aggregable and can be tailored to a particular spectrum user's business case.

The most recent spectrum allocations in Australia are typically optimised for certain use cases but provide flexibility to support a range of uses, including:

- > mobile wireless broadband services
- > fixed wireless access (FWA)
- > private networks operating over limited areas, such as rail corridors, hospitals, education precincts, mines or industrial facilities, either as an 'industry vertical' or as a service by an enterprise provider
- > fixed satellite services (FSS)
- > IoT
- > machine-to-machine (M2M) communications
- > earth transmit and receive (satellite links)
- > microwave links.

Equipment manufacturers and industry are influenced by factors such as the spectrum harmonisation process undertaken by the International Telecommunication Union (ITU) and technology standards-making bodies. While the ITU is a United Nations specialised agency with decisions made by countries, proprietary industry standardisation bodies (such as 3GPP and IEEE) develop detailed specifications and standards for devices. Both these processes assist with enabling international roaming and economies of scale. This is especially important for a nation such as Australia, which has a relatively small population and is generally a technology 'taker', especially in the case of consumer devices.



Market trend: Facilitating innovative spectrum usage

The ACMA's development of AWLs was designed to allow flexibility to support a range of wireless broadband and satellite use-cases. AWLs are flexible, aggregable and can be tailored to a particular spectrum user's business case. Examples of Australian use-cases include:

- > **Mining:** Fortescue Metals Group notes its innovation in developing infrastructure and mining assets – it established a private network to run over 193 autonomous trucks, as part of its 'Autonomous Haulage System', across all iron ore operations. It was issued 2 AWLs in August 2022, which are yet to be in use in the designated Pilbara region.¹²
- > **Satellite:** The rollout of low earth orbit (LEO) satellite constellations to provide broadband has seen new entrants (such as Starlink and Viasat) in the spectrum-licensing market in recent years.

Currently, AWLs are only available in the 26 and 28 GHz bands, within defined geographic areas of Australia. However, the ACMA is planning to issue AWLs in the 3.4–4.0 GHz band across remote and regional Australia in 2023 and 2024.

¹² Fortescue Metals Group, [Fortescue's autonomous haul fleet surpasses 2 billion milestone](#), 13 July 2021.



Spectrum allocations

Spectrum remains an essential input to the communications supply chain. The ACMA monitors emerging market developments within the communications sector to assist in informing future spectrum demand and priorities when planning and managing the supply of spectrum. The ACMA has completed or is currently conducting spectrum allocations in various frequency bands.

Five-year spectrum outlook (FYSO)

The ACMA publishes an annual FYSO report, which provides an overview of the market, technology and policy drivers likely to shape the demand for spectrum and spectrum management priorities over the next 5 years. It is developed in consultation with industry, which helps inform the ACMA's priorities. The most recent FYSO (2022–27) provides an overview of current market trends and the ACMA's detailed work plan.¹³

Equipment

Equipment is required across the supply chain by different users. Telcos require various network equipment to operate different types of networks (fixed line, mobile, fixed wireless and satellite). Equally, end users rely on consumer equipment such as modems, routers and devices (mobile phones, TVs, laptops) to access such networks.

Fixed-line network equipment

Fixed-line equipment such as routing, switching and software-defined wide-area network (SD-WAN) hardware is essential in supporting optic fibre, hybrid fibre coaxial (HFC) and copper networks.

Routers (devices used to link networks) fixed over a network link are used to provide different data paths for fast and reliable transmission. Switches (found inside network connected devices) are used to change these data transmission paths between devices. Changing transmission pathways to send data only to relevant devices allows telcos to reduce the total data load on their networks. SD-WAN uses software to control the connectivity between data centres, remote offices and cloud resources. SD-WAN can include routers, switches or virtualised customer premises equipment.

In Australia, the main suppliers of fixed-line equipment include Nokia, Ericsson, Cisco, Ciena and Infinera.

Mobile and fixed wireless network equipment

Key equipment deployed for wireless communications networks include base stations and core network equipment. Base stations are a part of the radio access network (RAN), which includes transmitters/receivers sitting on top of towers or buildings that support mobile and fixed wireless networks by linking to its core network equipment. The core network offers numerous services (voice, SMS, data) to customers who are interconnected by the RAN.

In Australia, RAN equipment is supplied by Ericsson, NEC Australia, Nokia and Samsung. Core equipment is supplied by Cisco, Dell, Ericsson, Intel and Nokia.

¹³ ACMA, [Five-year spectrum outlook 2022–23](#), 7 September 2022.

Australia's 3 mobile network operators (MNOs) are in the process of upgrading their 5G networks from non-standalone to standalone (SA) networks.¹⁴ All are testing different combinations of equipment and spectrum to optimise customer experience and network performance. Consumers may need to buy new compatible devices take advantage of 5G network features.



Market trend: Open RAN developments

Open Radio Access Networks (Open RAN) is an open, standard-based radio access approach that facilitates a link between user devices and the core network, through interoperability across equipment providers. An open standard allows network operators to pick and choose equipment from different suppliers, allowing greater flexibility (through an expanded ecosystem of equipment) and competition.

Open RAN also allows for less equipment at the radio (cell) site, as this technology adopts virtual RAN principles that replace physical equipment with software.

The adoption of Open RAN can benefit networks through reduced costs, as well as greater diversity, supply chain resilience, energy efficiency and network security.¹⁵

There are multiple use-cases where Open RAN is being deployed in both dense urban and rural environments. Open RAN trials in Australia (deployed in the second half of 2022) continue to demonstrate its ability to overcome scale and performance challenges by taking advantage of advances in silicon processors and accelerators.

Recent trials include:

- > NEC Australia was selected to participate in Phase 1 of the NSW Mobile Coverage Project. NEC will trial active sharing partnerships, leveraging its Open RAN technologies to improve mobile coverage.¹⁶
- > BAI Communications Australia is similarly participating in the trial by leading the program's Open RAN stream. It is responsible for designing, building, and operating shared infrastructure, partnering with NEC Australia and Optus to explore this active sharing model in rural and regional NSW.¹⁷
- > Nokia and Mavenir have been selected as the primary equipment providers by Field Solutions Group (FSG), as part of NSW's Neutral Pilot trial to explore active sharing models, such as Open RAN.¹⁸

Australia, in collaboration with the United States, has committed through the [Quad's Memorandum of Cooperation on 5G Supplier Diversification and Open Radio Access Networks](#), to develop and strengthen practical cooperation in open, interoperable and disaggregated telecommunications approaches, including as pertains to testing-related activities for Open Radio Access Networks.¹⁹

¹⁴ A 5G standalone network refers to networks that independently connect the 5G radio directly to the cloud-native 5G core, whereas 5G non-standalone networks connect the 5G radio to a 4G core (therefore, the 5G service relies on existing 4G networks).

¹⁵ Vodafone, [Open RAN – all you need to know](#), accessed on 22 December 2022.

¹⁶ NEC Australia, [NEC to participate in Open RAN pilot for Regional Mobile Coverage](#), 16 June 2022.

¹⁷ BAI Communications, [BAI partners with Open RAN workgroup to improve mobile coverage across regional NSW](#), 2 August 2022.

¹⁸ Mavenir, [FSG selects Nokia and Mavenir as technology partners for Australia's 4th Mobile Network](#), 20 February 2022.

¹⁹ Australian Department of Home Affairs, [Statement on 5G/Open RAN Information Sharing and Telecommunications Resilience and Security](#), 15 September 2022.

Satellite network equipment

The main components of a satellite system include user terminals (for example, mobile phone and GPS navigation), a satellite network operation centre, gateways (earth stations) and communication equipment on satellites. User terminals, gateways and satellites consist of antennas that transmit and receive communications signals. Gateways transfer data, which is required at every site to enable communication to and from the satellite. These communication signals can then be communicated to a local terrestrial network.

In Australia, the main suppliers of gateway and data hub equipment include Newtec, Gilat, Comtech, Viasat, Teledyne, Thuraya, while suppliers of antennas and payloads are Airbus, Hughes Systems, SSL and ViaSat.



ACMA activity

Base station deployments

Approval of a base station depends on several planning factors, such as the type of base station, the classification/zoning of the land and whether it's considered a low impact facility.²⁰ The ACMA licences all radiocommunications facilities; these are listed on the Register of Radiocommunications Licences (RRL).

The ACMA manages the mobile phone base station deployment code to balance the need for efficient network deployment while meeting community expectations. MNO's continue 5G network upgrades across Australia, with an additional 2,883 5G base stations deployed from July 2021 to May 2022.²¹

Customer equipment

Customers need a range of equipment to connect to communications networks. The type of modem, router or gateway device used will depend on the end user's speed and capacity needs. Modems deliver a broadband connection while routers distribute the connection wirelessly (through wi-fi) around a household or premise. Both fixed and wireless fixed connections require a router. The modem and router are now often combined into a single device called a gateway.

The Australian enterprise and government segments require higher capacity modems, routers and even servers, which are used for storage and networking.



Market trend: Lockdowns driving demand for network equipment

Qualcomm noted the impact of the lockdown in Victoria, Australia.

Consumers increased the demand for wi-fi equipment enhancements (5G, Wi-Fi 6 and Mesh Wi-Fi), and when those stocks depleted, demand began increasing in expensive gaming routers. This scenario was repeated across the Asia-Pacific as communications became essential due to digital transformation, which was accelerated by the pandemic.²²

²⁰ For more detail on what constitutes as a low impact facility see the [Telecommunications \(Low-impact Facilities\) Determination 2018](#) and governing legislative instruments that apply; the [Telecommunications Act 1997](#) and [Mobile Phone Base Station Industry Code](#).

²¹ ACMA, [ACMA compliance priority 2021–22 final report](#), 21 August 2022.

²² GlobalData, [ACMA Report: Perspective on Telecommunications Supply Chain](#), 14 October 2022, p. 18.

Devices

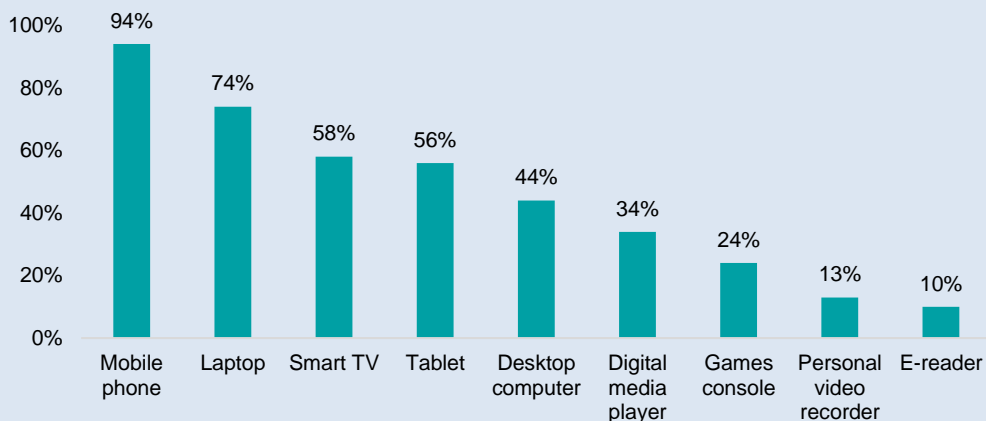
Devices are the connection point for people to access the global communications network and all potential services. The range of devices is enormous, with strong competition in both consumer and enterprise markets. Availability depends on healthy supply chains while compatibility relies on careful international harmonisation of essential inputs like spectrum and software.



Market trend: Impact of device unavailability on network revenues

Australians are using a variety of devices to access the internet in the 6 months ending June 2022.²³

Figure 5: Percentage of Australians connecting to the internet by device type



Source: ACMA, *Annual consumer survey 2022: Communications and media: How we use the internet*, 12 December 2022.

5G device penetration growth is predominately attributed to the rise in machine-to-machine (M2M) and IoT devices.

The proliferation of devices will see total data on Australian networks increase from 5.1 exabytes in 2022 to 17.4 exabytes in 2027, mostly driven by increased video traffic as well as M2M communications.²⁴

However, 2022 continued to be affected by production disruptions in consumer devices such as smartphones, computers and gaming consoles. This is a result of the lingering effect of chip shortages caused by the effects of COVID-19 lockdowns in the second quarter of 2020²⁵, which also led to temporary declines in Australian MNO revenues (due to lower handset sales).²⁶

Recently, capacity is being freed up due to weakness in retail markets, particularly computers, smartphones and consumer electronics, where sales have been falling since March 2022. Taiwan manufacturers are now redistributing their semiconductor capacity to industrial end-markets, which received lower chip stocks due to their increased competition throughout the pandemic.²³

²³ ACMA, [Annual Consumer Survey 2022: Communications and media in Australia: How we use the internet](#), 12 December 2022.

²⁴ GlobalData, [Australia Mobile Broadband Forecast](#), 2 August 2022.

²⁵ J.P. Morgan, [Supply Chain Issues and Autos: When Will the Chip Shortage End?](#), 11 August 2022.

²⁶ ACMA, [Communications and media in Australia: Trends and developments in telecommunications 2020–21](#), 7 December 2021, p. 3.



Supply chain impact: Components, spectrum and equipment

Impact of emerging market trends on the supply chain:

Demand side

More semiconductors and chips are required to support new equipment and devices. For example, wireless networks, optical transport equipment, IoT, M2M, smartphone devices and high-frequency components such as those used in satellite antenna arrays, VSAT (very small aperture terminal) and 5G base station massive 'multiple input multiple output' (MIMO) antennas.

Australia is experiencing ongoing consumer demand for new equipment required for network upgrades (Wi-Fi 6 and 5G). Wi-fi equipment sales spiked as digital transformation was accelerated by the pandemic.

Enterprises are also investing in network equipment, so their operations are compatible with 5G and Wi-Fi 6 technologies. The growth in enterprise cloud storage is creating a surge in data centres construction.

Telcos are upgrading their fixed (for example, fibre networks) and wireless networks (for example, 5G networks).

Innovation in wireless communications products is increasing demand for spectrum.

As 5G continues to rollout, MNOs are upgrading their 5G networks from non-standalone to standalone networks and trialling Open RAN active sharing partnerships.

Supply side

From September 2022, ongoing supply chain disruptions affecting communications equipment manufacturing around the world have been reported. These range from raw materials shortages to manufacturing process and transport logistics delays.

- > In late 2021, semiconductor prices had risen 10% for high-end semiconductors and by 20% for less complex chips.²⁷

The Australian Government has established the Office of Supply Chain Resilience to ensure ongoing access to communications equipment. It has formed deals with India, Japan and the United Kingdom.²⁸

The introduction of AWLs has assisted in expanding spectrum availability to industry, especially within defined areas such as a mining site, factory or agriculture farm. This new licence type has been developed to support industry innovation and application across Australia.

5G RAN and core equipment supply is growing to support more 5G standalone networks and network sharing arrangements. Devices are also being upgraded to support standalone in the consumers and enterprise segments.

²⁷ GlobalData, [ACMA Report: Perspective on Telecommunications Supply Chain](#), 14 October 2022, p. 5.

²⁸ Department of Industry, Science and Resources, [Office of Supply Chain Resilience](#), accessed 20 December 2022.

Communication networks

Any combination of equipment (including hardware and software), spectrum and infrastructure produce access networks, which are the backbone of communications in Australia. Among access networks there are 2 primary types: fixed line and wireless.

Fixed-line networks use cables such as fibre-optics to transmit data. Wireless networks, on the other hand, use spectrum to transmit data to users, via radio signals.

Broadly, wireless communications networks in Australia can be categorised as mobile, fixed wireless and satellite. All rely on radio signals to transmit data, however, each network requires different equipment and infrastructure to supply connectivity to end users. In turn, this creates varying features such as portability, reliability, bandwidth and speed.

Fixed-line networks

Fixed-line networks carry most data traffic in Australia. The 2 primary fixed network wholesale providers are NBN Co, which operates the National Broadband Network (NBN) and Telstra, which operates the Public Switched Telephone Network (PSTN), commonly known as the Telstra copper network. In addition, there are other operators such as Uniti and TPG Telecom (TPG) and Statutory Infrastructure Providers (SIPs)²⁹, which also supply fixed wholesale services.

Fixed-line infrastructure

Domestic transmission fibre cables

Across Australia, transmission (also referred to as backhaul) services are supplied by telcos to access seekers (as well as their own networks) to carry data between 2 locations. The term 'transmission' is generally associated with high capacity, fibre links that carry large volumes of communications traffic, including voice, data, video and other content.³⁰ See [Microwave links](#) for a wireless type of transmission.

Australia's 4 major transmission providers are Optus, Telstra, TPG and Vocus. NBN Co is not considered by the ACCC to have a transmission service. However, it operates its own transmission network for its wholesale service.³¹ Transmission cables do not provide wholesale services, but act as the backbone in transferring large amounts of data for fixed-line network owners. These fixed-line network companies on-sell fixed wholesale access directly to retailers.

²⁹ A SIP is a telecommunications carrier designated for a particular area under the SIP rules. These rules set out key obligations for the SIP to connect and supply services at minimum speed. The NBN is the default SIP for the whole of Australia, except where other carriers have been designated as SIPs for an area.

³⁰ According to the [ACCC](#), transmission links are generally dark/owned fibre (70%), microwave links (20%) and leased lines (10%).

³¹ ACCC, [Domestic Transmission Capacity Service: Final Report on the review of the declaration for the DTCS](#), April 2019, p. 17.

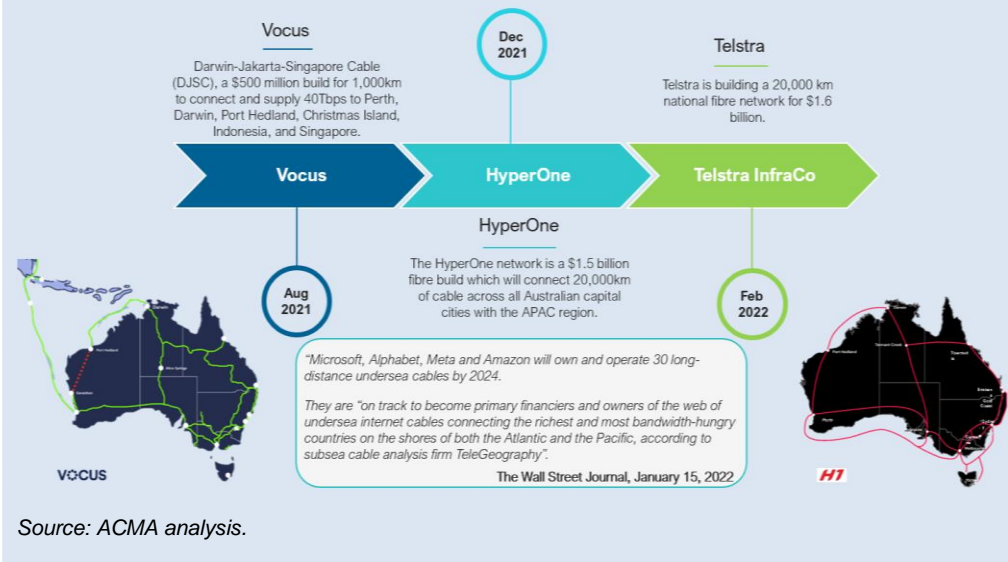


Market trend: National fibre route expansions

A number of competing network builds have emerged across the Australian intercapital fibre market:

- > Telstra unveiled its new project build, establishing dual fibre inter-city paths across Australia³² and subsequently named Microsoft as an anchor tenant on its new ultra-fast intercity fibre network.³³
- > Telstra's build mimics HyperOne's national fibre project, which will connect a similar 20,000 km of new fibre backbone. Both projects estimate total costs of A\$1.5–1.6 billion.³⁴
- > Vocus commenced construction on 'Project Horizon', building its national fibre backbone between all mainland capitals. This initial stage provides the first fibre link between Perth and Port Hedland.³⁵

Figure 6: Major upcoming intercapital fibre projects



International transmission fibre cables

International or 'submarine' transmission connections refer to optic fibre cables covered in armour that are laid on or beneath the seabed and run across the ocean floor between continents. These cables facilitate the transfer of data and provide transmission links between Australia and international locations.

The submarine cable owners providing connections to and from Australia include telcos, utilities, technology companies and Australia's Academic and Research Network (AARNET).

There has been an increase in the number of submarine cables installed in recent years.³⁶ This reflects the increasing demand for higher bandwidth applications and the growing number of internet-enabled devices in Australia.

³² Telstra Exchange, [How we're building the fibre network of the future](#), 2 February 2022.

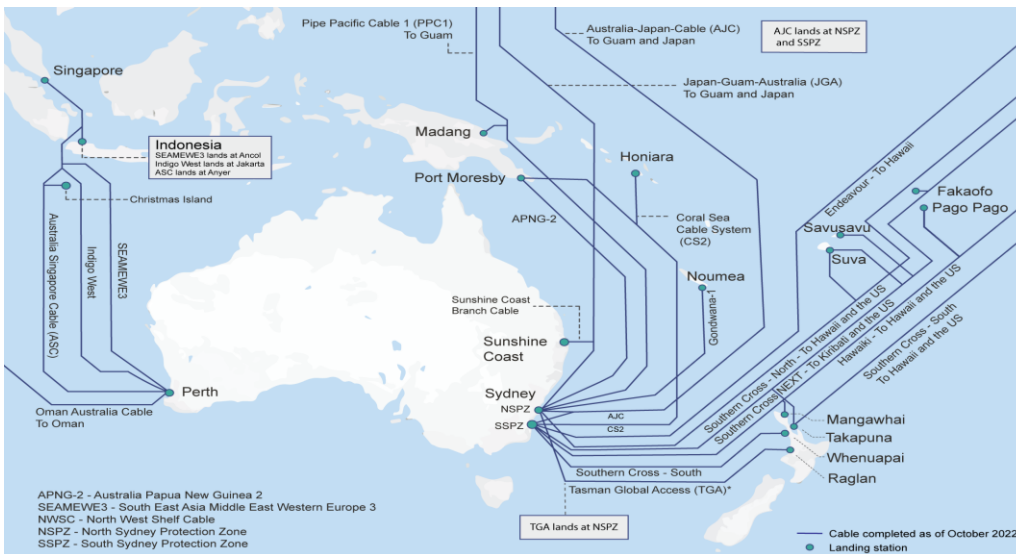
³³ Microsoft, [Telstra and Microsoft sign 5-year agreement to support Australia's digital growth](#), 26 July 2022.

³⁴ HyperOne, [Our new digital highway](#), accessed on 8 June 2022.

³⁵ Vocus, [Vocus begins mobilising for Project Horizon construction](#), 5 October 2022.

³⁶ From 2018 to 2022, the ACMA has permitted the following cables: the Australia Singapore Cable, Indigo Central, Indigo West, the Japan-Guam Australia Cable, the Coral Sea Cable System, the Southern Cross NEXT cable, the Sunshine Coast Branch Cable, the Oman Australia Cable and the Project Highclere cable.

Figure 7: Submarine cables connected to Australia



Source: ACMA, [International submarine cables landing in Australia](#), 31 October 2022.

Market trend: Australian submarine cable investors

In recent years, global tech companies have entered the Australian submarine cable market including Alphabet (parent company for Google) and Amazon Web Services.

While not currently seen as an issue for, or impact on, Australia’s communication supply chain³⁷, international markets have seen issues with net neutrality created by such tech investors as they seek to receive preferential data traffic rates or network prioritisation.

ACMA activity

Approvals for submarine cables

The ACMA is involved in the application process linking submarine cables to Australia:

- > **Permit to install:** The ACMA issues installation permits to telcos seeking to build an international or a domestic submarine cable in a protection zone (domestic cables outside protection zones do not require a permit).
- > **Declaration of protection zones:** The ACMA may declare protection zones around submarine cables may restrict or prohibit certain activity within the zone, such as resource extraction or some commercial fishing.

The ACMA has granted 9 submarine cable installation permits since 2018.

Market trends reveal greater fibre route expansions are addressing growing data consumption in Australia. This is driven by growth in applications such as connecting data centres to support cloud and edge computing, supporting digitalisation of industries (IoT and M2M platforms), video content and gaming.

³⁷ Wall Street Journal, [Google, Amazon, Meta and Microsoft weave a fibre web of power](#), 15 January 2022.

Amendments to the *Telecommunications Act 1997* in 2020 have encouraged more investment in the fixed-line sector in Australia. Fixed-line network owners can now compete in both the wholesale and retail markets by separating their retail and wholesale business functions (that is, a 'functional separation') under an undertaking approved by the ACCC, unless exempt.⁴¹

To date, TPG and Uniti have completed functional separation undertakings, while Vocus is in the process of separating their wholesale and retail businesses.⁴² The most notable participants in the wholesale fixed-line market include NBN Co, TPG, Uniti and established statutory infrastructure providers (SIPs) such as ASN Telecom, Frontier Networks and VostroNet.⁴³



ACMA activity

SIP obligations

The Telecommunications Act sets out connection and supply obligations on the Statutory Infrastructure Provider (SIP) of a service area, which the ACMA manages.

A SIP has 2 main obligations:⁴⁴

- > connect premises to its networks
- > supply an eligible service to consumers.

In cases where it is not reasonable for the SIP to connect premises to a fixed-line network, it must provide fixed-wireless or satellite technology to allow retail service providers to provide customers with voice and broadband services (at the minimum prescribed download and upload speeds of 25 Mbps and 5 Mbps, respectively).

The ACMA manages the SIP register, which details mapping information for each of their service areas. This information is stored on data.gov.au.⁴⁵

As the fibre market is experiencing new entrants and recent consolidation (creating larger NBN-alternatives & competition), it is important for the ACMA to continue to ensure all providers are meeting their SIP obligations. Greater management may be necessary where NBN Co is not the default SIP and newer entrants have won contracts to new development areas (apartment buildings or new estates).

Connection and supply obligations guarantee, allows the ACMA to continue to ensure retail service providers gain wholesale access to superfast broadband infrastructure, regardless of the SIP provider.

⁴¹ ACCC, [Industry guidance on the carrier separation rules](#), April 2022. See section 1.2 to 1.4.

⁴² CommunicationsDay, [Vocus to build new east coast undersea cable](#), 4 May 2022.

⁴³ The ACMA maintains the SIP register, see full list of fibre wholesalers SIPs [here](#).

⁴⁴ ACMA, [Statutory Infrastructure Provider regime - SIP obligations](#), 12 August 2022.

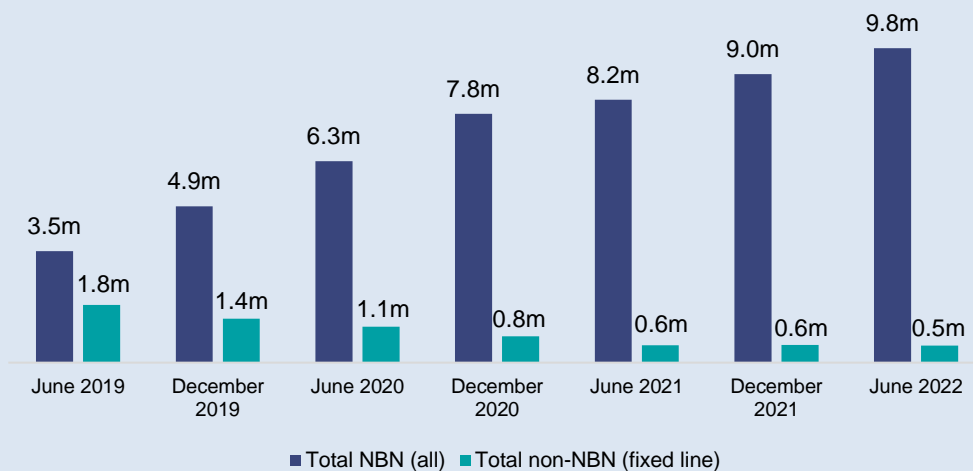
⁴⁵ The ACMA regularly makes changes to the SIP register. New SIPs are added as their networks become fully built and can connect services. Current SIPs may add new service areas or request to be removed as the SIP for certain areas.



Market trend: Consistent data volume growth in Australia

Traffic continues to grow on fixed-line networks as demand increases for data intensive applications. Total data volumes on non-NBN fixed-line wholesale networks, remained steady at just over 0.5 million terabytes (TB) since June 2021. However, data volumes over the NBN network continue to grow, with 9.8 million TB downloaded in Australia for the quarter ending June 2022, up from 8.2 million TB in June 2021.⁴⁶

Figure 9: Total volume of data downloaded per quarter (TB)⁴⁷



Source: ACCC, [Internet activity report for the period ending 30 June 2022](#), 5 December 2022.

There is strong commercial interest in the fixed fibre sector as annual revenue for FTTP and FTTB connections to both residential and business, expected to grow by 21% to A\$7.5 billion by 2026.⁴⁸

In addition to fixed-line network owners offering wholesale access direct to retailers, they can offer wholesale access indirectly through ‘white labellers’.

White label services

‘White label’ services are another type of customer access wholesale service within the telco supply chain.⁴⁹ It refers to a company selling services to a retailer, which is then re-branded as the retailer’s own. Consumers only see information and communications from the reseller, while services such as billing, call centres, and technical support are performed by another company for a fee (see Figure 10).

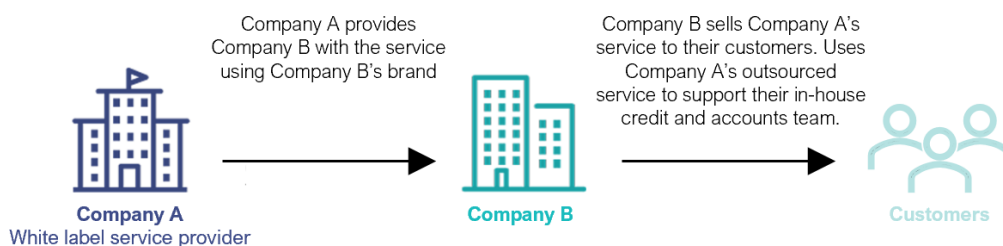
⁴⁶ ACCC, [Internet Activity Report for the period ending 30 June 2022](#), 5 December 2022.

⁴⁷ NBN Co does not split data traffic by technology however as 95% of their connections are fixed-line (the remaining 4% fixed wireless and 1% satellite), it is expected that the majority of its total data downloads are transferred through its fixed-line network.

⁴⁸ GlobalData, [Australia Fixed Communications Forecast](#), 26 July 2022.

⁴⁹ White label services all exist across all types of communication networks – fixed-line, mobile, fixed wireless and satellite.

Figure 10: White label business model



Source: ACMA analysis.

NBN Co notes there are 4 telcos in Australia providing white label services using its fixed-line network⁵⁰:

- > Aussie Broadband (also offers white label services using Uniti's fibre network)⁵¹
- > Building Telco Businesses
- > Superloop
- > Uniti.

In addition to NBN white labellers, other Australian telcos offering white label solutions include Novum Networks, Partner Wholesale Networks, Superloop (using its recently acquired white label platform 'Acurus'), Symbio and 2SG for a range of telco services. See the following networks for additional white labellers.

Dark fibre services

Dark fibre relates to optical fibre without equipment installed, which is unable to be used for service operation. Data on optical fibre networks is transported using light. Equipment is connected to a strand of optic fibre sending light-emitting signals up and down the cable. Additional strands of optic fibre networks are built to allow for additional capacity for future use. These fibres do not generally have equipment connected and therefore have no light travelling along them, hence being termed 'dark fibre'.

Dark fibre is not considered a transmission service as the equipment is not yet installed to provide services.⁵² It is considered a wholesale service as network providers sell and/or rent dark fibre generally for private networks use or to on-sell high-speed networks to retailers (at which point the equipment is installed).

The market for dark fibre providers is diverse, comprising established telcos and growing businesses. Australia's main dark fibre providers include Superloop, Telstra, TPG, Vocus and 5GN.

⁵⁰ NBN Co, [White label wholesale providers](#), accessed on 22 August 2022.

⁵¹ Aussie Broadband, [4Q FY22 Trading Update](#), 1 August 2022.

⁵² ACCC, [ACCC Final Report on the review of the declaration for the Domestic Transmission Capacity Service](#), March 2014, p. 29.

Mobile networks

Australia has 3 national mobile network operators (MNOs) – Telstra, Optus, and TPG. All sell access at a wholesale level to mobile virtual network operators (MVNOs) as well as at the retail level. FSG and Pivotal are mobile carriers that focus on regional, rural and remote communities. FSG has also positioned itself as a neutral host operator (see [Neutral hosts](#)).

Mobile infrastructure

Towers and sites

Towers and sites are the foundation infrastructure for wireless networks and are used to install base stations such as those operated by MNOs. Other wireless networks include specialised fixed wireless networks (for example, NBN Co's fixed wireless network) and microwave links. Sites are built by telcos or neutral operators to expand network coverage areas and to increase capacity for higher data rates and speed. Wireless networks consist of a tower, radiocommunications equipment, power connection, and antennas. The number of antennas depends on the technology, antenna performance, coverage, and capacity required.

The most common base station types deployed at mobile sites include⁵³:



Macrocell

These are larger mobile tower structures that provide a coverage radius between 1.5 to 20 km.



Microcell

Also referred to as small cells, these are low-powered base stations that are generally fitted on streetlight poles. Microcells provide a coverage radius between 0.5 to 2 km, primarily in urban areas with high traffic.



Picocell

These are smaller base stations, generally installed inside buildings, which provide a coverage radius of up to 0.5 km, primarily in dense urban areas with high traffic.

Neutral hosts

The 2 types of network-sharing arrangements include active and passive⁵³:

- > **Passive network sharing** occurs where operators share physical cell sites and passive network elements (for example, masts and power supplies).
- > **Active network sharing** involves operators sharing transport infrastructure (such as antennas and base stations), and baseband processing resources, in addition to passive equipment. It also includes sharing of critical spectrum resources, which is commonly known as multi-operator core network (MOCN) sharing.

The neutral host model refers to an active network-sharing arrangement, where independent infrastructure providers own infrastructure and allow multiple carriers to use it on a shared basis. Its infrastructure services participate in the Australian wholesale market. See below for examples.

⁵³ ACMA, [A guide to small cells](#), accessed on 27 April 2022.

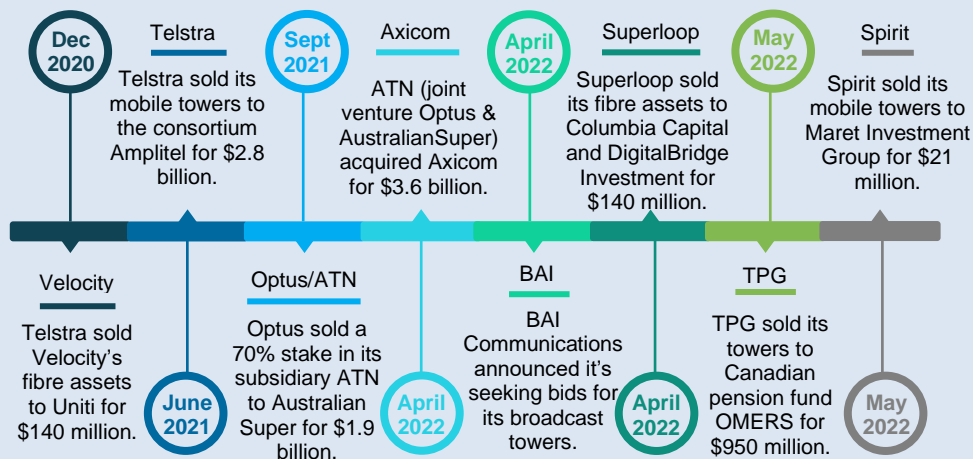
Unlike MNOs or private network operators each building their own sites or towers, the neutral host builds and maintains sites and equipment for use by multiple operators. As such, it has the potential to improve coverage as well as give consumers increased choice if more than one operator uses the site.⁵⁴

 **Market trend: Tower divestment**

Throughout 2022, Australian telcos have been divesting their passive network assets as a capital-raising activity. Selling part or all of a company’s mobile tower assets is referred to as the ‘Towerco’ model.⁵⁵

This model is well-established overseas. Operators divest their towers and passive infrastructure then lease space for transmission equipment from the tower owner under long-term agreements. The tower-owners then become neutral parties motivated to lease space to as many operators as possible.

Figure 11: Australian telco divestment timeline (A\$)



Source: ACMA analysis.

Co-location refers to the sharing of passive infrastructure that aims to reduce the cost of site deployment. Reducing this cost enhances the ability for MNOs to expand mobile infrastructure to improve their coverage, thereby promoting delivery of competitive services.⁵⁶ While co-location between MNOs in 2022 is largely steady in regional and remote areas, metro areas are seeing new initiatives with alternate infrastructure providers. For example, Telstra and Optus have signed partnerships with Jemena Electricity Network to co-locate 5G small cells on Jemena’s existing power poles to improve 5G coverage.⁵⁷

⁵⁴ ACCC, [Regional Mobile Infrastructure Inquiry: Consultation Paper](#), 1 July 2022.

⁵⁵ KPMG, [Capitalisation of internally generated intangible assets](#), 3 May 2021.

⁵⁶ ACCC, [Mobile Infrastructure Report 2022](#), 9 September 2022, p. 15.

⁵⁷ Jemena Electricity Network, [Jemena new partnership with major telcos brings 5G to Melbourne's north-west](#), 21 November 2022.



Neutral hosts deploying macro and small cells

The ACMA has recently allocated spectrum to neutral hosts providers, enabling them to build infrastructure to support wireless broadband services:

- > Dense Air is a neutral host provider that won 3.6 GHz and 26 GHz spectrum in the 2016 and 2021 auctions (subsequently trading its 3.6 GHz spectrum for TPG's 2.5 GHz spectrum and selling its 26 GHz holdings to TPG). Dense Air specialises in deploying small cells in cities, to enhance MNOs existing services while avoiding interference with its macro networks. Dense Air's virtualised small cells can separate domains for MNOs, private networks and public networks, so each operate their own 'slice'.⁵⁸ They have deployed neutral host services in New Zealand but are yet to deploy in the Australian market.
- > Field Solutions Group has been selected to lead the Neutral Host Pilot trial for the NSW Government. They will build infrastructure and a single radio network for participants to share and allow for domestic roaming, Open RAN and equipment sharing.⁵⁹ They were allocated 26 GHz spectrum via AWLs in 2022.

With the recent growth in network-sharing arrangements, the ACMA will continue to monitor spectrum demand and its impacts on licensing, interference management, device supply arrangements, customer equipment and cabling compliance.

Mobile wholesale market

MNOs sell access at a wholesale level to retailers known as mobile virtual network operators (MVNOs). Under the MVNO business model, resellers compete against MNOs on product differentiation such as customer service, niche marketing, pricing, or bundling with other products. The 3 types of virtual services on mobile networks are mobile virtual network enablers (MVNEs), mobile virtual network aggregators (MVNAs) and MVNOs), see Figure 12.

For example, TPG (MNO) has extended its reach in the mobile wholesale market after launching its MVNE platform. TPG's MVNE solution targets organisations (such as retail, banking and food) looking to enter the telco sector by providing pre-integrated IT functions such as business and operating systems. This is in addition to offering 5G network access to its MVNOs partners, which then on sell mobile services directly to end users.⁶⁰

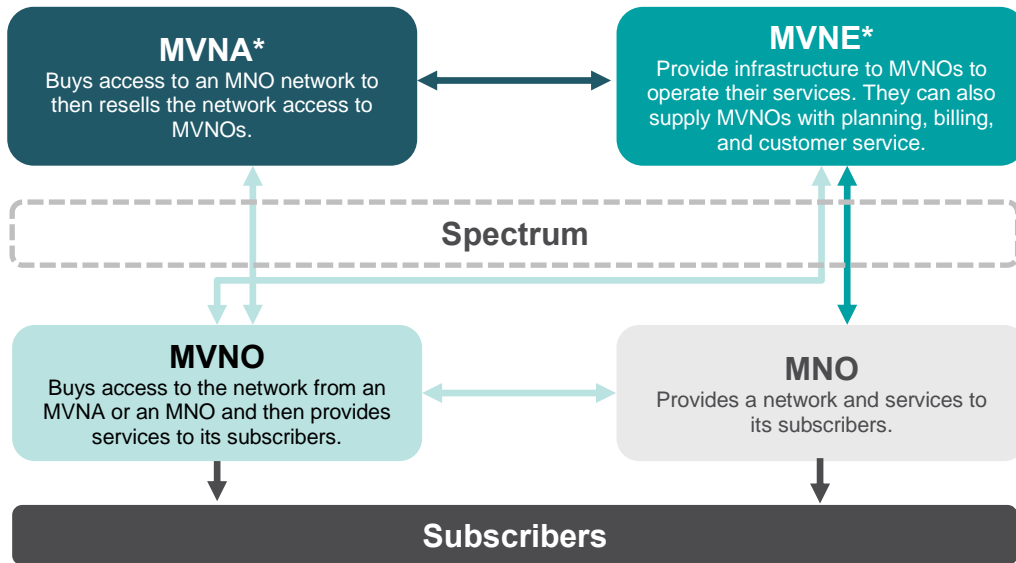
MVNOs generally do not control the network they operate, and instead make a wholesale purchase arrangement to use the network of one of the MNOs. This provides network access, allowing them to resell mobile telco services to retail consumers. MVNOs represent a white label wholesale service in the mobile market (for example, ALDIMobile uses the Telstra network to offer mobile services to customers, which is resold under its brand).

⁵⁸ Dense Air, [We build and own secure and shared wireless network](#), accessed on 20 December 2022.

⁵⁹ Fields Solutions Group, [NSW Government appoints FSG to lead neutral host trial \(MOCN\)](#), 29 April 2022.

⁶⁰ TPG Telecom, [TPG Telecom 2022 Investor Day: Third-party Transcript](#), 23 June 2022.

Figure 12: How the mobile virtual environment operates



Source: ACMA analysis.

*MVNAs and MVNEs do not provide mobile services direct to customers, only MVNOs and MNOs do this.



Market trend: MVNO market contraction

The MVNO market share dropped from 15% to 9% during the pandemic (June 2020 to June 2022).⁶¹ Opposing forces at play have ultimately resulted in a market contraction:

- > The MVNO sector generally benefits from households becoming more price-conscious during periods of economic uncertainty, such as the COVID-19 pandemic and recent inflationary pressures.
- > However, this benefit was outweighed by MNOs retaking market share through acquisitions, for example Amaysim’s customers now belong to Optus after the purchase in February 2021.

⁶¹ ACCC, [Communications market report 2020-21](#), 10 December 2021, p. 28 and ACCC, [Communications market report 2021-22](#), 9 December 2022, p. 12.

Fixed wireless networks

There are various providers of fixed wireless services in Australia. These include MNOs that leverage their mobile network to provide wireless communications to fixed locations. The NBN uses its fixed wireless network where it is not commercially viable to build fibre links. Several smaller operators known as wireless internet service providers (WISPs) also operate in this market, such as Pentanet and Swoop.

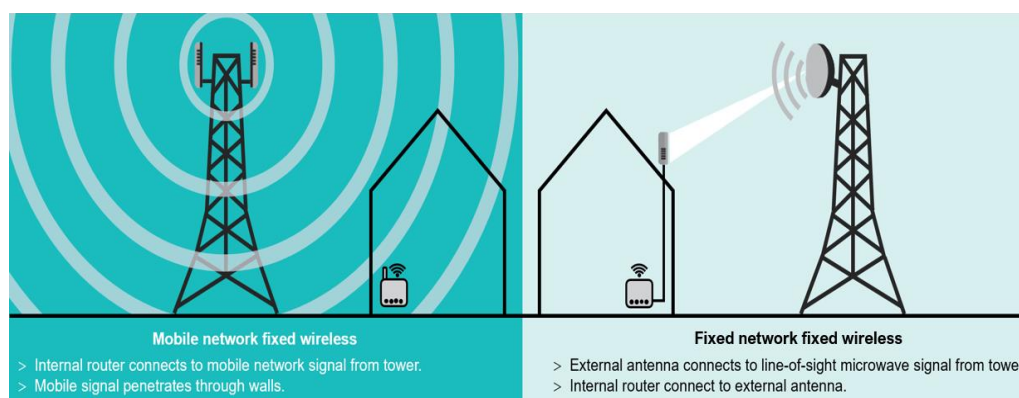
Fixed wireless infrastructure

Fixed wireless links

Fixed wireless links use towers to transmit data (via radio signals) direct to a fixed location. There are 2 types of fixed wireless links; those supplied by mobile networks and those by fixed networks.

Fixed wireless services supplied by mobile networks (connected by routers), typically connect from a mobile tower to a modem or dongle located at a fixed address. Fixed wireless services supplied using fixed networks instead generally connect to an external antenna at fixed location.

Figure 13: Fixed wireless visualised



Source: ACMA analysis.

Microwave transmission links

Microwave links can also be used as a type of transmission fixed wireless communication network which transmits signals between 2 fixed locations. In Australia, it is predominantly used to provide backhaul services rather than providing access directly to consumers.

These links are extensively used to provide telco services in metro areas, and the primarily type of link in rural or remote areas of Australia where other infrastructure such as fibre, is not commercially viable. Microwave link sites can be placed anywhere as long as the distance between them is within the operating range of the equipment and there is a line of sight (that is, no solid obstacles) between the towers. These links operate within several frequency bands in Australia, primarily the 8 GHz, 11 GHz, and 18 GHz bands for telco services.

The major users of microwave links in the above-mentioned bands represent those that hold the greatest number of spectrum holdings. These suppliers include Telstra, Optus, TPG, NBN Co, Digital Distribution Australia, GoldNet and BigAir (Superloop subsidiary). This excludes emergency services licences.



Market trend: Greater reliance on microwave links

Microwave links have experienced a changing market landscape in the recent decade. They have become largely substituted by fibre networks in Australian metro and urban locations. These links have also seen shifts in spectrum availability as frequency bands are continually repurposed for mobile services (for example, the 1800 MHz band, previously used for microwave links, was cleared for mobile services).

Despite fibre being the preferred option for MNOs for 4G/5G transmission (backhaul), microwave links are still the most used technology in regional Australia due to their capability and relative ease of deployment at low-cost.⁶² This technology is now experiencing growth in industries deploying private networks in outer-urban or regional areas that have no fibre connections or poor connectivity.

Fixed wireless wholesale market

The main suppliers of fixed wireless wholesale services include Telstra, Optus, TPG and NBN Co.

Optus was the first MNO to sell its 5G services to its wholesale customers.⁶³ Telstra recently announced selling 5G fixed wireless to wholesale customers in mid-2022.⁶⁴ While TPG recently received functional separation approval from the competition regulator, its wholesale strategy is focused on fixed-line assets, particularly to high-density dwellings.⁶⁵ At the time of this report, TPG has yet to commence selling its 5G fixed wireless at a wholesale level.

NBN Co is the largest fixed wireless wholesaler in Australia. It currently sells to retailers that collectively have 393,945 active customers as at December 2022.⁶⁶ NBN Co has commenced upgrades to its fixed wireless cells in rural areas to 5G technology, increasing speeds previously allocated to satellite services.⁶⁷

Similar to fixed-line access networks, NBN Co provides fixed wireless wholesale access to white label providers; Aussie Broadband, BTB Australia, Superloop and Uniti.⁶⁸ Alternatives to the nbn include white labeller, iiNet, which instead receives wholesale access to TPG's fixed wireless network.⁶⁹

⁶² GSMA, [Mobile Backhaul: An Overview](#), 19 June 2019.

⁶³ Optus, [Optus Launches market-first 5G mobile for wholesale partners](#), 12 October 2020.

⁶⁴ Telstra Wholesale, [Telstra Wholesale launches new 5G service and IoT product range](#), 10 May 2022.

⁶⁵ TPG Telecom, [TPG Telecom 2020-21 Annual Report](#), 4 February 2022, p. 9.

⁶⁶ NBN Co, [Weekly Progress Report](#), 15 December 2022.

⁶⁷ NBN Co, [\\$750 million investment to 5G-enable nbn Fixed Wireless to deliver faster speeds to regional Australia](#), 22 March 2022.

⁶⁸ NBN Co, [Compare white label providers](#), accessed on 15 December 2022.

⁶⁹ iiNet, [iiNet Home Wireless Broadband - Great Value NBN Alternative](#), accessed on 15 December 2022.

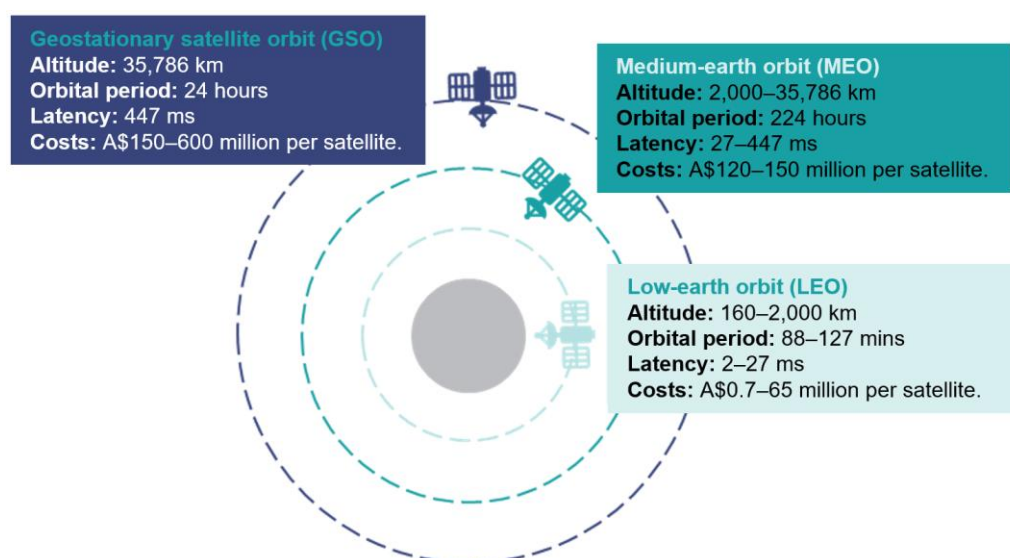
Satellite networks

Australia's communications sector includes satellite services receiving and sending data into and out of the country. Satellites are broadly split into 3 categories – geostationary satellite orbit (GSO), medium earth orbit (MEO) and low earth orbit (LEO). GSO satellites have traditionally been used by communications services to provide high-capacity broadband data links across Australia. LEO and MEO satellites have grown in popularity due to cheaper construction costs and fewer deployment limitations at lower altitudes.

Generally, LEOs have an operating lifespan of less than 5 years, MEO satellites between 5–10 years, and GSO satellites over 15 years.

Satellite wireless communication, similar to fibre and microwave links, can be used in transmission networks, particularly in rural and remote areas of Australia. Satellites transmit signals to a point or multiple points in the network, which then distribute the data across the entire network.

Figure 14: Satellite orbit characteristics

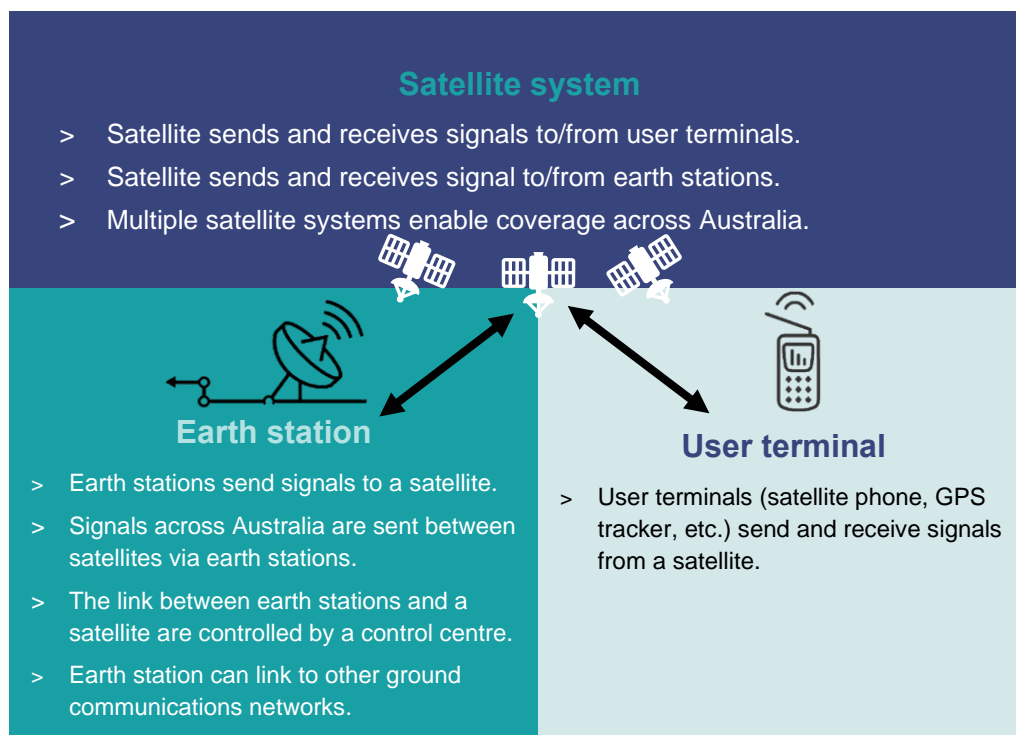


Source: ACMA, [Trends and developments in telecommunications 2020–21](#), December 2021.

Satellite infrastructure

Satellite communication services require 3 main elements: a satellite, an earth station and a user terminal. Earth stations can provide a link (connected by fibre optic cables) between satellites and other communications networks, particularly fibre networks. Earth stations play a vital role in supporting satellite services, monitoring satellite health and performance, and providing feedback to ensure that a satellite is operating optimally. Major companies that build and manage teleports and gateways in Australia include Inmarsat, Intelsat, iPSat Australia, Kordia, Optus, Quasar Satellite Technologies, SES, Telstra and Vocus.

Figure 15: Satellite and earth station signal transmission



Source: ACMA analysis.

Satellite wholesale market

Satellite wholesalers operate across each satellite category – GSO, MEO and LEO. The typical customers of satellite wholesale services include local telcos, which seek to offer connectivity to customers in rural and remote areas of Australia where it is not commercially viable for to build out their network.

Government-owned NBN Co participates in this wholesale market, among private satellite operators. It owns and operates 2 satellites to provide broadband data services to 103,600 premises⁷⁰ through 11 retail service providers, 10 business service providers and 9 white labellers.⁷¹ Unlike the fixed-line, fixed wireless and mobile markets, Australia’s major telcos (with the exception of Optus) do not participate heavily in the satellite market.

The main satellite operators across Australia’s wholesale markets include Inmarsat, Intelsat, Thaicom, SES, Starlink, Optus and NBN Co and Viasat.⁷² New entrants in the Australian satellite wholesale market include Amazon’s Kuiper, OneWeb and Starlink (owned by SpaceX).

⁷⁰ NBN Co, [Weekly Progress Report](#), 15 December 2022.

⁷¹ NBN Co, [White-label wholesale providers](#), accessed on 23 December 2022.

⁷² Viasat owns and operates earth stations in Australia and has [announced](#) its launch of Viasat-3 satellite services from 2023.

The companies operating in specific bands are:⁷³

- > sub-1 GHz
- > L band: 1–2 GHz
- > C band: 4–8 GHz
- > Ku band: 12–18 GHz
- > Ka Band: 18–30 GHz.



Market trend: The role of technology, competition and partnerships

Once dominated by large satellites operating predominantly in GSO, advances in technology means there are a greater variety of satellites operating at different orbits, with a broader range of uses. For example, LEO satellite operators, using smallsats,⁷⁴ are now competing against wireless broadband providers and incumbent satellite operators.

LEO satellites have lower latencies, lower deployment costs and/or faster speeds in some parts of Australia. This enables LEO satellite operators to provide higher bandwidth per user than other technologies (such as GSO satellites and, in some cases, copper, cable (HFC) and pre-5G fixed wireless at a competitive price.⁷⁵

As such Australia is experiencing growing partnerships between local telcos and LEO satellite operators to provide connectivity to customers in regional and remote areas:

- > Telstra signed a non-exclusive agreement with OneWeb to deliver innovative connectivity – March 2022.⁷⁶
- > TPG partnered with NBN SkyMuster to offer rural businesses enterprise-grade solutions – April 2022.⁷⁷
- > Vocus announced a new deal with Starlink to deliver business connectivity – November 2022.⁷⁸
- > Optus and Lynk trialled direct-to-mobile technology for rural emergency services – November 2022.⁷⁹



ACMA activity

The ACMA's key priorities for 2022–23 for the satellite market involve monitoring relevant regulatory developments, as well as spectrum demand from the space sector. Recent and upcoming activities:

- > Implemented planning outcomes from the reviews of 2 GHz and 28 GHz bands, by varying the Radiocommunications (Communication with Space Object) Class Licence Act 2015 (completed: Q2 2022)

⁷³ International Telecommunication Union, [Recommendation ITU-R V.431-8](#), 25 January 2022, p. 3.

⁷⁴ [NASA](#) defines smallsats as spacecrafts with a mass less than 180 kgs.

⁷⁵ McKinsey & Co, [Large LEO satellite constellations: Will it be different this time?](#), 4 May 2020.

⁷⁶ Telstra, [Telstra & OneWeb sign MOU to explore new connectivity solutions in Australia](#), 2 March 2022.

⁷⁷ TPG, [TPG Telecom brings business-grade satellite connectivity to the bush](#), 13 April 2022.

⁷⁸ Vocus, [Vocus signs with SpaceX to provide Starlink Business to customers](#), 30 November 2022.

⁷⁹ Optus, [Optus and Lynk complete successful LEO satellite-to-mobile test](#), 21 November 2022.

- > Investigating permanent arrangements for the assignment and coordination of FSS earth stations in the 5.9 GHz band (ongoing)
- > Preparing apparatus licensing for mobile satellite services in the 1980–2005/2170–2195 MHz bands band (upcoming: Q1 2023).

The ACMA amended the Radiocommunications Foreign Space Objects Determination in May 2022 to include an additional 2 companies:⁸⁰

- > OQ Technology Sarl (incorporated in Luxembourg)
- > Satelio IoT Services, SL (incorporated in Spain).

These operators are now able to apply for space apparatus licences as well as use frequencies in the Communication with Space Object (CSO) Class Licence for user terminals. The ACMA will continue to help facilitate new entrants into the satellite market for service provision across Australia.



Supply chain impact: Communications networks

Impact of emerging market trends on the supply chain:

Demand side	Supply side
<p>Increasing demand for higher bandwidth applications (video streaming, gaming, social media), and the growing number of internet-enabled devices in Australia has driven up the amount of data traffic.</p> <p>Data volumes over the NBN are experiencing consistent annual growth, recording a 22% p.a. increase from the June 2021 period.⁸¹ More end users are demanding higher speeds, with NBN plans of 50 Mbps or higher up from 55% (Nov 2018) to 77% (Nov 2022).⁸²</p> <p>Fibre connections are increasingly preferred to support rising bandwidth requirements (where commercially viable).</p>	<p>Significant network upgrades and government funding are enabling building out fixed-line assets to support the growing data volumes:</p> <ul style="list-style-type: none"> > Funding of A\$4.5 billion (March 2022) and A\$2.4 billion (Oct 2022) for NBN's fibre upgrade program, allowing a further 3.1 million premises to upgrade from FTTN to FTTP.⁸³ > HyperOne, Telstra and Vocus have invested significant funds to build national fibre networks. > 9 submarine cables connecting to Australia were built in past 4 years. <p>The number of smaller retail fibre networks has risen over the past 5 to 10 years. Fibre providers are increasing economies of scale through mergers and acquisitions, resulting in more NBN alternatives providing competitive offerings (high-speed plans at least equivalent to NBN).</p>

⁸⁰ ACMA, [Update to Foreign Space Objects Determination - consultation 03/2022](#), 12 May 2022.

⁸¹ ACCC, [Internet Activity Report for the period ending 30 June 2022](#), 5 December 2022.

⁸² NBN Co, [Monthly Progress Report November 2022](#), 20 December 2022.

⁸³ NBN Co, [NBN welcomes \\$2.4b Government investment to enable 1.5m more premises to upgrade to full fibre](#), 20 October 2022.

Innovation requiring newer technologies is rising across enterprise and government retail segments. These include AI, IoT, extended reality (xR), smart cities, autonomous machines and wireless power.

Australian MNOs have been monetising their passive infrastructure to gain a return on their investment and fund future investments into new technologies. Greater site and asset sharing reduces costs associated with deploying networks.

There has been increased deployment of private networks and IoT platforms across regional and rural Australia. This has increased demand for, and reliance on, microwave links for backhaul services, particularly in sectors such as agriculture, mining and manufacturing, which commonly operate outside urban areas.

Microwave infrastructure has remained steady for areas providing retail communications to regional/remote locations where fibre is not commercially viable. It has seen growth in industrial areas to support backhaul connectivity for IoT, private networks and edge computing use-cases for large Australian sectors found outside fibre build-out zones.

Advances in satellite technology has led to greater deployments of LEOs and smallsats. Their lower latencies and/or faster speeds in some parts of Australia provide higher bandwidth per user than other technologies (such as GSO satellites and in some cases - copper, cable (HFC), and pre-5G fixed wireless) at a competitive price.

Satellite operators have shifted towards launching more LEOs to better compete with other fixed technologies. This is in addition to partnering with telcos to provide connectivity solutions in regional and rural areas to grow their customer base.

Equipment manufacturers have been working closely with Australian communications and satellite providers to ensure deployments and expansion projects are on schedule.

Cloud

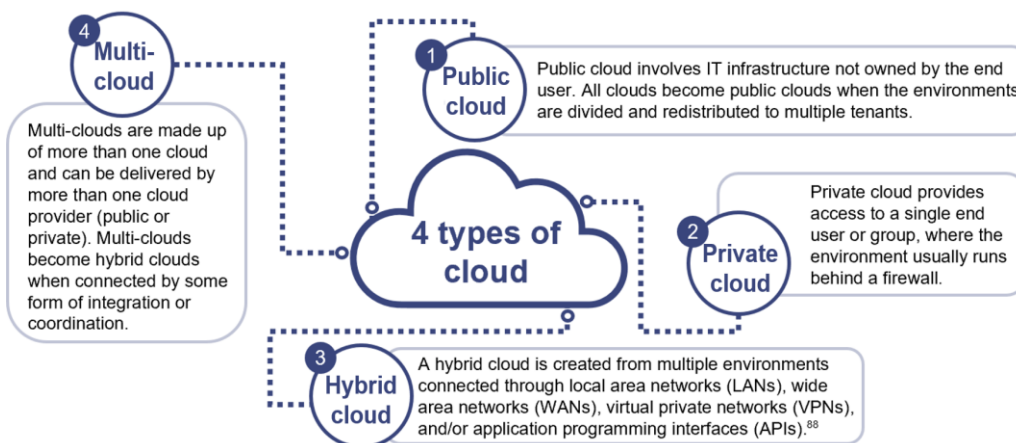
Cloud services are used across multiple sections of Australia’s communications supply chain. It can act as an input to access networks, by replacing functions previously performed by hardware and/or infrastructure with software and servers (network virtualisation). It is also used as an input to move network functions to decentralised locations instead of performing them at the network’s core (edge computing).

Alternatively, cloud providers can also offer services in the wholesale market as a managed service, administered by Australian telcos. These telcos can then retail their own cloud offerings (cybersecurity, data storage and digital transformation) direct to customers – predominately to enterprise and government segments.

A key benefit of cloud services is their flexibility and ability to scale up or down rapidly according to diverse needs. Meeting increased demand or new applications no longer means a telco needs to acquire more hardware or build more infrastructure to meet spikes in demand for communications services.

Cloud computing and services

There are 4 main types of cloud computing models; hybrid, multi, private and public.⁸⁴



Source: ACMA analysis.

A subset of cloud computing is cloud services. There are 3 broad types of cloud services which can be supplied across all 4 cloud computing models:

- > platform as a service (PaaS)
- > infrastructure as a service (IaaS)
- > software as a service (SaaS).

Cloud infrastructure

Data centres

The provision of cloud services relies on infrastructure such as data centres. These are physical facilities that organisations use to house their critical applications and data. They include physical hardware built to support a network of computing and storage resources that enable cloud services delivery. Key components of a data centre include routers, switches, firewalls, storage systems, servers, and app controllers.

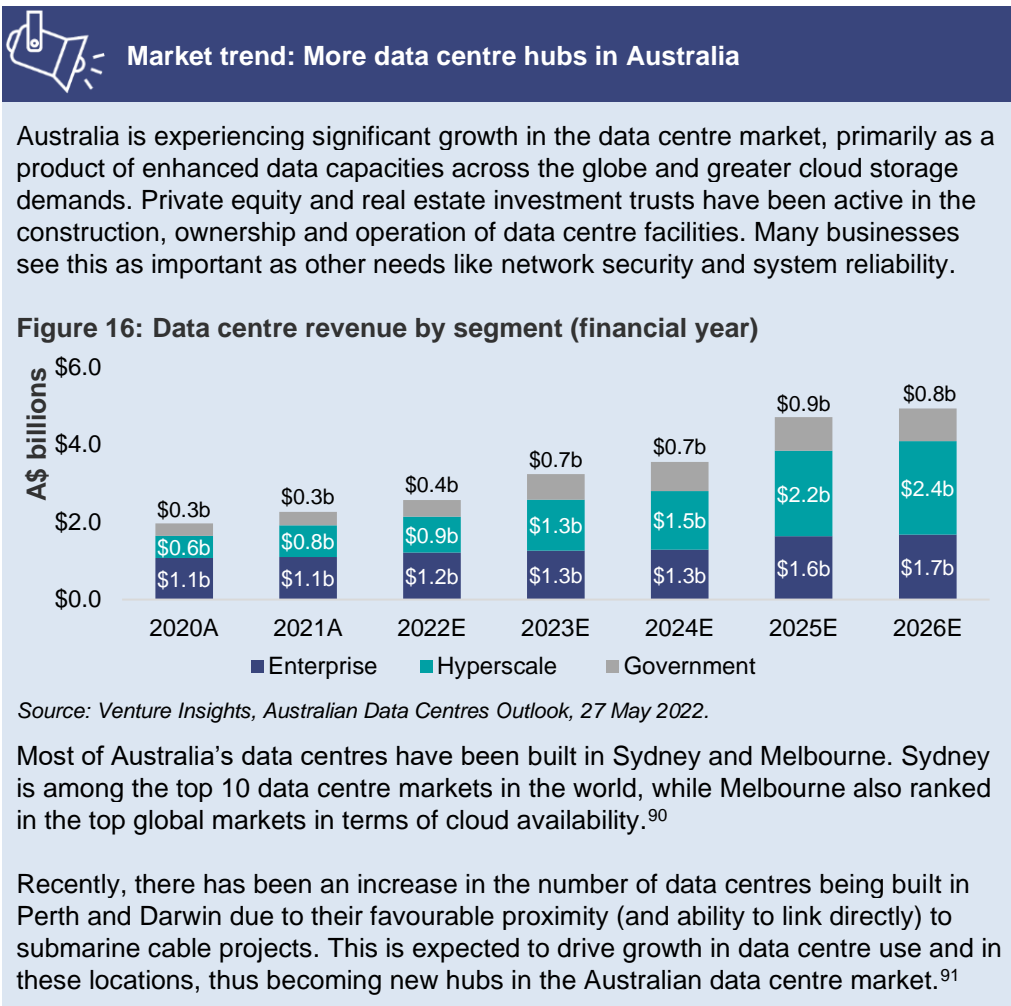
⁸⁴ Red Hat, [Types of cloud computing](#), 15 March 2018.

Data centres are used directly by customers (such as retail service providers) or are managed by system integrators such as IT specialists, hyperscalers and telcos. Data centres are accessed through an internet connection (via a local network), instead of using on-premises facilities.⁸⁵

There are currently 292 data centres operating in Australia.⁸⁶

The main data centre providers in Australia include 5GN, DCI, Digital Realty, Equinix, Leading Edge, Global Switch, NEXTDC and Microsoft. These data centre providers partner with cloud providers or directly with Australian telcos to supply cloud services at the wholesale and retail level.⁸⁷

However, there are few Australian telcos that own and operate their own data centre facilities. Telstra InfraCo owns 9 data centres, Vocus owns 13 and Macquarie Telecom owns 5 across Australia.⁸⁸ All act as data centre wholesale suppliers to smaller IT companies (for example, Ever Nimble and GenNet), which bundle data centre services such as cloud storage with other business telco services like internet and phone.⁸⁹



⁸⁵ Cisco, [What Is a Data Centre](#), accessed 29 June 2022.

⁸⁶ Cloudscene, [Data Centres in Australia](#), accessed on 18 November 2022.

⁸⁷ Pentanet, [NEXTDC x Pentanet](#), 22 September 2020.

⁸⁸ See the following websites: [Macquarie Telecom](#), [Telstra InfraCo](#), [Vocus](#), for data centres figures as at 31 December 2022.

⁸⁹ GenNet, [Vocus' Cloud Connect is a straightforward path to the cloud](#), accessed on 17 December 2022.

⁹⁰ Cushman & Wakefield, [2022 Global Data Centre Market Comparison](#), 13 January 2022.

⁹¹ Venture Insights, [Australian Data Centres Outlook](#), 27 May 2022.

Cloud services: Supply chain input

Cloud services are used as a substitute for physical infrastructure. The main applications are edge computing and network virtualisation.

Edge computing

Edge computing refers to a network that uses devices or cloud-compute nodes to process and store data closer to where it's being generated. Instead of the data being transmitted and processed at a centralised location (the network's core or the cloud), it is processed at decentralised locations (edge of the network) at greater speeds and volumes.⁹²

With the emergence of 5G and its associated lower latencies, edge computing technology has been enhanced by hosting functions at lower response times and with improved network performance. 5G edge computing allows for greater applications such as machine learning, augmented and virtual reality tools and near real-time M2M communication.⁹³



Market trend: Multi-access edge compute

There is also activity in the market between the hyperscalers (dominate global cloud providers such as Google, Amazon and Microsoft) and MNOs around the use of operator network infrastructure and real-estate as cloud compute nodes. While most data centres operated by the hyperscalers provide resources from a remote centralised location, some enterprise applications cannot be moved due to performance or security requirements. This is driving demand for 'edge' services. The type of cloud service delivery model, with infrastructure sitting at nodes at the edge of telco networks, is termed 'multi-access edge compute' (MEC).

Hyperscalers are beginning to seek partnerships with telcos to provide their cloud services closer to clients through MEC solutions.⁹⁴

Network virtualisation

The process of reducing a telco's hardware by moving core network infrastructure into the cloud is known as 'network virtualisation'. Software is used to create a network overlay that can run separate virtual network layers on top of the same physical network fabric.

In the case of network virtualisation, the network owner will still operate its core software in the cloud rather than by a third-party provider.



Market trend: Network virtualisation

Australian MNOs have succeeded in reducing their infrastructure by virtualising their core networks:

- > Ericsson and Cisco virtualised TPG's (formerly Vodafone Hutchison Australia) core network to increase its agility and programmability from network slicing

⁹² Accenture, [What is edge computing?](#), accessed on 15 December 2022.

⁹³ Verizon, [What 5G networking brings to edge computing](#), accessed on 15 December 2022.

⁹⁴ GlobalData, [The GlobalData 2023 Key Technology Market Drivers and Predictions](#), 15 December 2022.

(where a separate part/domain of the network can be privately accessed by authorised users only).⁹⁵

- > Ericsson's evolve packet core was used to virtualise Telstra's network, aimed to initially enhance its media cloud capabilities.⁹⁶

Cloud services: Supply chain wholesale service

Similar to access networks, telcos resell services offered by cloud providers. In Australia, the effects of the pandemic accelerated cloud services adoption, particularly in cybersecurity, data storage and digital transformation (cloud migration).⁹⁷ Local telcos have demonstrated their intention to compete in this market against other cloud providers and hyperscalers. However, there is also significant co-operation with hyperscalers to provide holistic cloud services to government and enterprise customers, particularly for digital transformation.⁹⁸

The major suppliers of wholesale cloud services in Australia include:

- > domestic telcos: Telstra, NCS Australia, TPG, Macquarie Telecom (MacTel) and Aussie Broadband
- > global providers: Amazon Web Services, Google Cloud Platform, Microsoft Azure, Apple, Oracle.

Australian telcos are also partnering with independent data centre providers to offer managed services (cloud solutions) directly to customers. For example, TPG launched its private cloud in Queensland and Western Australia, which is hosted in 3 datacentres operated by Data Centre Alliance Networks.⁹⁸ Similarly, Pentanet has partnered with NEXTDC to use Perth's first data centre to support its cloud gaming service.⁹⁹

Cloud-dependent services

Despite cloud services mainly providing virtual storage, application and software external management, there are a range of markets in the communication sector that rely on cloud as a foundation to their supply chain. Cloud-dependant services include:

- > AR/VR
- > artificial Intelligence (AI)
- > blockchain
- > cloud gaming
- > drones
- > IoT
- > robotics.

These services and applications will be further explored in the upcoming *Communications supply chain market study: Services, applications and retail*.

⁹⁵ Vodafone, [Ericsson and Cisco to virtualise Vodafone Australia's core and IP network](#), 16 January 2017.

⁹⁶ Telstra, [Telstra and Ericsson lay foundation for 'network of the future'](#), 27 February 2017.

⁹⁷ GlobalData, [ASEAN Telecom Enterprise ICT 2022 Predictions](#), 26 January 2022.

⁹⁸ TPG Telecom, [TPG launches its first WA Private Cloud Region](#), 22 June 2022.

⁹⁹ Pentanet, [NEXTDC x Pentanet](#), 22 September 2020.



Supply chain impact: Cloud

Impact of emerging market trends on the supply chain:

Demand side	Supply side
<p>The COVID-19 pandemic has triggered an increased uptake in cloud services such as digital transformation (cloud migration), cybersecurity and cloud storage.</p> <p>Enterprise and government segments are requiring higher levels of data security.</p> <p>More workplace communications are being hosted in the cloud and delivered across the network virtually to any remote location or endpoint in real time. This has changed consumption patterns, giving rise to communications platform-as-a-service (CPaaS) solutions.</p>	<p>Networks continue to evolve to support greater network traffic occurring outside the traditional office by embedding communications into applications and online services.</p> <ul style="list-style-type: none">> Telcos were pivotal in the recent digital transformation of the workplace. Telstra brought forward its A\$500 million investment in network capacity, while TPG switched on its first section of 5G and announced network integration to be a key priority following its merger.> Companies are addressing the demand for greater cloud-based CPaaS solutions. For example, Australian-owned Symbio launched its first unified cloud-based CPaaS product in Singapore in June 2022, marking a new milestone in its international expansion.
<p>Increasing data requirements from digital platforms is increasingly globally, including in Australia.</p>	<p>Hyperscalers that own digital platform services have become very active in the construction, ownership and operation of data centre facilities. There has been a major focus on sustainability and energy efficiency in the current times.</p> <ul style="list-style-type: none">> Microsoft announced data centres builds in Melbourne in March 2022 following builds in Sydney in late 2021.> Amazon and Google have partnered with NEXTDC to build datacentres across Australian capital cities.
<p>Increases in global content generation and consumption, specifically for websites, news, social media, video, music, and written content to end users in Australia.</p>	<p>As there are no Australian-owned content delivery networks (CDNs), there is a reliance on international CDNs (mostly Asia-Pacific, given its proximity) to transfer global content domestically.</p> <p>Local telcos host CDN servers within their network, which are physically located in their data centres. This speeds up the internet by caching or saving content closer to end users from the CDNs nearest server rather than the creator's website, which could be overseas.</p>

Glossary

Term	Definition
A\$	Australian dollars
AARNET	Australian Academic and Research Network
ACCC	Australian Competition and Consumer Commission
ACMA	Australian Communications and Media Authority
AI	artificial intelligence
Apps	applications
AR	augmented reality
AWLs	Area-wide licences – a type of apparatus licence introduced in 2020
backhaul	high-capacity wholesale services that carry large volumes of voice, data and video. Also referred to as transmission services
COVID-19	coronavirus (COVID-19) pandemic
FTTB	fibre to the building (FTTB) – where fibre extends to the basement of larger buildings or apartment blocks
FTTC	fibre to the curb (FTTC) – where fibre extends to a point beyond the node on to the street, requiring a copper connection from the curb to the end user
FTTN	fibre to the node (FTTN) – where fibre extends to the node (for example, a cabinet on the street) with copper being used from the node to the premises
FOTP	fibre to the premises (FOTP) – where the fibre connection extends all the way to the end user
FYSO	five-year spectrum outlook
FSS	fixed satellite services
FWA	fixed wireless access
GSO	geosynchronous orbit – operates at an altitude of approximately 36,000 km
HFC	hybrid fibre coaxial – refers to the existing television cables used to provide connectivity from a node to a residential household where cable networks were deployed by Telstra and Optus
IoT	Internet of Things
LEO	low earth orbit – operates between 160 km and 2,000 km
LTE	long-term evolution – a type of wireless communication for mobile devices, primarily used for transferring data
M2M	machine-to-machine

Term	Definition
macrocell	larger mobile tower structures that provide a coverage radius between 1.5 and 20 km.
Mbps	megabits per second
MEC	multi-access edge compute – cloud service delivery model with the infrastructure sitting at nodes at the edge of telco networks
MEO	medium earth orbit – altitudes between around 2,000 km to below the geosynchronous orbit (approximately 36,000 km).
microcell	low-powered base stations that are generally fitted on light poles. Microcells provide a coverage radius between 0.5 to 2 km, primarily in urban areas with high traffic. Also referred to as small cells
MIMO	multiple-input and multiple-output – technology that uses multiple antennas to transmit and receive multiple channels over the same spectrum, aimed to increase capacity of a radio frequency
MNO	mobile network operator – commonly associated with Australia's 3 largest operators: Telstra, Optus and TPG Telecom
MVNA	mobile virtual network aggregator
MVNE	mobile virtual network enabler
MVNO	mobile virtual network operator
NBN Co	Australia's government-owned national wholesale broadband provider that operates the National Broadband Network
payload	part of a vehicle's load from which revenue is derived, for example, a satellite on a rocket
picocell	smaller base stations generally installed inside buildings, which provide a coverage radius of up to 0.5 km, primarily in dense urban areas with high traffic
POI	point of interconnect – the physical location and connection point that allows retail service providers and wholesale service providers to connect to an access network
PSTN	Public Switched Telephone Network (commonly known as the Telstra copper network)
SA	standalone network – 5G standalone refers to networks that independently connect the 5G radio directly to the cloud-native 5G core, whereas 5G non-standalone networks connect the 5G radio to a 4G core (therefore, the 5G service relies on existing 4G networks)
SD-WAN	software defined wide-area network
SIPs	statutory infrastructure providers – carriers that must provide basic wholesale broadband services in the areas they service. This

Term	Definition
	includes voice services if they operate fixed-line or fixed-wireless networks
smallsat	satellite that weighs less than 500 kgs, also known as a small satellite
SMS	short messaging service
RAN	radio access network
RSP	retail service provider
TB	terabyte (there is 1000 GB in 1 TB)
telco	telecommunications service provider
Towerco	tower companies – wholesale wireless infrastructure providers that manage and own the passive tower infrastructure of telcos
US\$	United States dollars
VSAT	very small aperture terminal – a two-way satellite ground station that provides high speed, broadband satellite communications for internet or private network communications
VR	virtual reality
wi-fi	wireless fidelity – a type of radio communication that sends signals using radio waves from a router to nearby devices
WISPs	wireless internet service provider – small and medium enterprises that provide wireless communications services to consumers
xR	extended reality