Planning options in the Upper 6 GHz band

Public submission

16 July 2024

Executive Summary

We welcome the opportunity to provide our views to the ACMA's consultation on planning options for the use of the Upper 6 GHz band (6425-7125 MHz). The Upper 6 GHz band will be critical to meeting increasing demand for capacity on IMT networks. It will be used to deliver 5G Advanced services and is expected to be an important launching pad for the introduction of 6G networks to Australia.

IMT is the optimal use of the Upper 6 GHz band

The Upper 6 GHz band stands out as the largest remaining single block of mid-band spectrum that can be allocated to licensed IMT use in Australia in the foreseeable future. While bands in the range from 7 – 15 GHz are under consideration in the current WRC-27 cycle for future IMT-2030 technologies (6G), those bands offer poorer coverage and are already overcrowded in Australia. Reallocation of these bands would present significant spectrum re-planning issues for ACMA, making the Upper 6 GHz band the best option for meeting future IMT demand.

The Upper 6 GHz will initially be used to provide capacity and performance for 5G (including 5G Advanced) on a city-wide basis. This mid-band spectrum provides a unique combination of capacity and coverage for wide-area services, including indoor coverage. The mobile industry has invested billions deploying technologies such as active beamforming antennas that enable mid-band spectrum to provide high performance, high-capacity public mobile services across outdoor and indoor areas. Leveraging these existing investments, the Upper 6 GHz band can further enhance and add capacity to 5G networks. By the end of this decade, it is poised to deliver Australia's first 6G services, ensuring the country remains at the forefront of global technological progress.

RLAN does not need additional spectrum

The ACMA's earlier allocation of the lower 6 GHz band to RLAN provides sufficient capacity for the majority of households and strikes an appropriate balance between RLAN and IMT use of the band. Wi-Fi traffic demand is not currently constrained by spectrum in most residential settings.

In Australia, more than 50% of all households are on the 50 Mbps speed tier and only a little over 20% of all households are on a speed tier of ≥ 100 Mbps. RLAN advocacy for increased spectrum availability is based on the edge case of households on extremely high speed tiers in very densely populated apartment style accommodation. Less than 16% of Australian households are apartments.

Industrial users are more effectively and securely supported with a network solution that is provided by a network operator using 5Gtechnology, or in the future 6G technology. Such access technology provides a robust end-to-end solution which supports QoS classes, network slicing and enhanced end-to-end security. In this context, Wi-Fi is not generally a suitable alternative for offering the ultra-reliable, high capacity, ultra-low latency services required for industrial applications due to its inherent non-scheduled access mechanism for licence-exempt applications.

The Upper 6GHz band should be reallocated as spectrum licences in major population centres

The Upper 6 GHz band would be most efficiently used by IMT in highly populated areas. It should be reallocated for spectrum licensing in such areas. Spectrum licensing would require the incumbents (i.e. point-to-point (PTP) links and fixed satellite service (FSS) earth stations) to be cleared by the end of the reallocation period in those geographies which are spectrum licensed. Outside of these spectrum licensed areas, existing services could retain first-in-time status. However, provision should be made for IMT to operate under an Apparatus Licence or Area Wide Licence on a co-primary basis.

Contents

1 Introduction

The Upper 6 GHz band, 6425-7125 MHz, plays a critical role in meeting growing demand for capacity on International Mobile Telecommunications (IMT) networks and will spearhead the introduction of 6G networks to Australia. The future allocation of this spectrum is an important decision, and we are pleased to contribute our views on this matter.

We support the Australian Communications and Media Authority's (ACMA's) Option 3, for the entire 700 MHz of the Upper 6 GHz band to be allocated to IMT. We also consider this allocation should be performed using spectrum licences in defined geographic regions around metropolitan areas and larger regional towns and cities, and AWLs for the remainder of Australia. Spectrum licensing would require point-to-point (PTP) links and fixed satellite service (FSS) earth stations to be cleared in those spectrum licensed geographies. In AWL licensed geographies, PTP and FSS services can remain, as they will have first-in-time status in those geographies.

Our submission is structured as follows:

- **Section 2** responds to the ACMA's request for submitters to include detailed information on the services that will be provided, how those services will benefit end users, and evidence of demand for those services.
- **Section 3**contains our views on the planning options, and how our preferred option (Option 3) could be implemented to maximise utility of the band, including preserving backhaul point-to-point links.
- **Appendix 1** contains specific answers to each of the ACMA's four consultation questions.
- **Appendix 2** outlines the findings of a Coleago Consulting study on the quantum of additional mid-band spectrum needed for IMT by 2030.

2 IMT is the optimal use of the Upper 6 GHz band

The Upper 6 GHz band represents the largest remaining single block of mid-band spectrum that can be allocated to licensed IMT in the foreseeable future. While bands in the range from 7 – 15 GHz are under consideration in the current (WRC-27) cycle for future IMT-2030 technologies (6G), those bands have poorer coverage characteristics and are already over-crowded in Australia. Reallocation of those bands would present significant spectrum re-planning issues for ACMA, making the Upper 6 GHz band the best option to meet IMT's need.

We also note that the launch of 6G will require a substantial block of cleared mid-band spectrum that can be used as launching pad for this next generation of technology, similar to the way that the 3.4-3.7 GHz spectrum band was used to rapidly launch 5G in Australia. We consider that the upper 6 GHz band is the only viable option for this purpose in the foreseeable future. So, we see access to this band being critical for supporting the timely launch of 6G and maximising the future benefit of this technology in Australia.

A planning decision that carefully considers the maximisation of both social and economic benefit to Australians is required to ensure the band is allocated to its optimal use. Our strong view is that this is licensed IMT use.

This section of our submission responds to the ACMA's request for information to inform its consideration of the future use of the band. We understand the ACMA will consider proposed use cases through the lens of its desirable planning outcomes. We have structured our response around the three pieces of evidence the ACMA is seeking, namely: the services that will be delivered (section 2.1); how those services will benefit users (section 2.2); and evidence of demand (section 2.3).

We also provide evidence of a strong developing ecosystem of devices (section 2.4) to demonstrate that despite the Upper 6 GHz band not yet being allocated in many jurisdictions, chipset manufacturers have already developed the capability to use it. IMT network equipment and device manufacturers are already leveraging this capability for the next generation of equipment and devices.

Finally, in section 2.5 we demonstrate why Wi-Fi already has sufficient spectrum below 7 GHz, and that future demand for indoor Wi-Fi can be satisfied with mmWave spectrum in either the 24 GHz or the 60 GHz band. In this section, we also address some of the claims made by the Wi-Fi community.

2.1 IMT Services that will be delivered using the Upper 6 GHz band

Like any band used for IMT, the services delivered by the band will change over time. The 900 MHz band, for example, has played a role in the delivery of 2G, 3G, 4G and now 5G services. The same can be anticipated for use of the Upper 6 GHz band. Initially, we expect the Upper 6 GHz band will be used for 5G Advanced[1] services through to the end of this decade.

Figure 1 below, reproduced from Figure 3 of the GSMA's report, "*The socio-economic benefits of the 6 GHz band*",[2] shows the services that are supported by 5G today. These services, especially those

[1] 5G Advanced is the next milestone in the 5G Era. 5G-Advanced brings in new capabilities including improving speed, maximising coverage, enhancing mobility and power efficiency. See https://www.gsma.com/get-involved/gsma-foundry/advancing-the-5g-era-benefits-and-opportunities-of-5g-advanced/

[2] Source: GSMA, **The socio-economic benefits of the 6 GHz band**, Figure 3, p.11. Available at: https://data.gsmaintelligence.com/research/research/research-2022/the-socioeconomic-benefits-of-the-6-ghz-band-considering-licensed-and-unlicensed-options

requiring higher data speeds, will be enhanced by allocation of the Upper 6 GHz band to IMT. The additional spectrum will allow more users to receive the best possible experience.

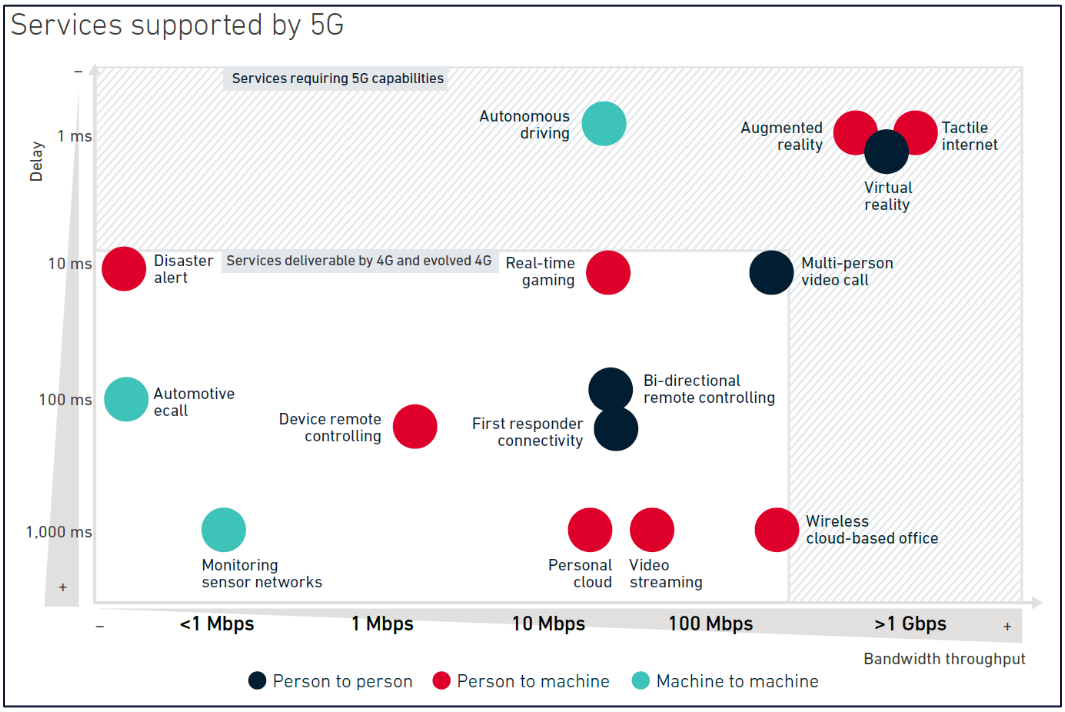

Figure 1: Services supported by 5G

The primary initial use of the Upper 6 GHz spectrum for mobile networks will be to provide capacity and performance for 5G advanced services on a city-wide basis, using existing base station sites that already use spectrum in the 3.4-3.8 GHz band. Mid-band spectrum provides a unique combination of capacity and coverage for wide-area services, including indoor coverage, and the mobile industry has invested billions developing technologies such as active beamforming antennas that allow mid-band spectrum to provide high performance, high-capacity public mobile services across outdoor and indoor areas. This is already being demonstrated today for 5G networks using the 3.4-3.8 GHz bands.

While it may be too early to tell with precision the types of new services that will arrive with 6G, it is reasonable to expect they will be more bandwidth intensive and will require lower latency. In addition, 6G is expected to bring several other advantages such as the convergence of currently disparate networks (terrestrial based and satellite based), improvements in edge computing (which will help reduce latency), and the introduction of AI-powered capabilities and network management, to again, improve performance.[3] By the end of this decade, we expect to be using the Upper 6 GHz band for 6G services.

2.1.1 6G and IMT 2030

In November 2023, ITU-R adopted its "*Framework and overall objectives of the future development of IMT for 2030 and beyond*" which outlines overall objectives for the development of IMT-2030 (or 6G). With the evolution of information and communications technologies, IMT 2030 is expected to support

[3] TechTarget Blog article, **What is 6G? Overview of 6G networks & technology**, dated Nov 2023. Available at: https://www.techtarget.com/searchnetworking/definition/6G

enriched and potential immersive experience, enhanced ubiquitous coverage, and enable new forms of collaboration. IMT 2030 is intended to support expanded and new usage scenarios compared to those of IMT 2020 (5G), while providing enhanced and new capabilities. These include ubiquitous intelligence, ubiquitous computing, immersive multimedia, digital twins, virtual worlds, and cognitive systems.[4]

The ITU-R IMT-2030 framework lays out usage scenarios of IMT-2030 it envisages will expand on those for IMT-2020 (i.e. enhanced Mobile Broadband, ultra-reliable, low-latency communication (URLLC) and massive machine-type communication (mMTC) defined for 5G). Enhanced mobile broadband (eMBB) will be expanded to Immersive Communication to cover use cases of rich and interactive video experience. Typical use cases include communication for immersive extended reality, remote multi-sensory telepresence, and holographic communication.

Ericsson's February 2022 whitepaper titled "*6G – Connecting a cyber-physical world*" outlines several new ways we will be using mobile networks in the new decade. The convergence of the cyber (digital) and physical worlds will better enable us to manage energy use, manage public transport, waste handling, or water and heating management systems, achieving higher levels of resource efficiency, better control, and increased resilience. The whitepaper describes 4D real-time maps, that not only contain spatial information, but also temporal information to enable better management of traffic with connected and autonomous vehicles to reduce energy consumption. Real-time information that is available at scale anytime, anywhere, will enable improved management of cities for energy, water and waste.

To support these new services in IMT-2030, the ITU makes the point that multiple frequency ranges will be needed to meet the capacity and coverage requirements of IMT systems and to serve the emerging services and applications.[5] New generations of IMT will require new spectrum for increasing data rates, capacity, new applications and to provide for new capabilities.

Supporting mixed traffic of video, audio, and other environment data in a time-synchronised manner is an integral part of immersive communications and will add to capacity demand in spectrum allocated for IMT use. Capabilities that aim for enhanced spectrum efficiency and consistent service experiences along with leveraging the balance between higher data rates and increased mobility in various environments will be seen as essential.

In May 2024, 3GPP held its IMT-2030 use case workshop giving industry and regional research organisations the opportunity to present their views on drivers they see for 6G. Many of these use cases were also seen as being able to be provided by 5G Advanced pointing to an expected increase in demand for spectrum used for IMT.

The 5G Alliance for Connected Industry and Automation (5G-ACIA) cited capacity intensive industrial use cases such as wide area connectivity for fleet maintenance, inbound logistics for manufacturing and augmented reality. The 5G Automotive Association (5GAA) highlighted future requirements for

4 Ericsson: **6G – Connecting a cyber-physical world**, Feb 2022, p.18. Ericsson describe future autonomous systems, and how they will benefit from "learning" from their environment. "*A cognitive system requires native capabilities to adjust to its environment, constantly observing and learning from previous actions. Lessons from operations and service performance are fed back in short cycles or in near real time to improve configurations, processes, and software.*" This is saying that the autonomous systems need high-speed data for that feedback loop. So, while the autonomous device is not *reliant* on the mobile network, it is *greatly improved* by enhanced connectivity and capacity. We expect the Upper 6 GHz band to assist in this capability. Available at: https://www.ericsson.com/en/reports-and-papers/white-papers/a-research-outlook-towards-6g.]

5 The ITU-R Framework for IMT-2030 – July 2023

enhanced communications multimedia and infotainment applications/services in vehicles along with secure, reliable and resilient communication for safety, advanced driving and remote vehicle services. In a submission to 3GPP[6] the Wireless Broadband Alliance showed the emerging use case for IMT for campus and venues supporting ultra-high definition video feeds, immersive AR-VR applications, and massive cloud access resulting from file download/broadcast to multiple students/patients.

These use cases from industry bodies were reflected in use cases presented by regional 6G Research alliances such as Europe's 6G Smart Networks and Services International and European Cooperation Ecosystem, Japan's Beyond 5G Promotion Consortium and China's IMT-2030 Promotion Group.

Services that are expected to be delivered on spectrum allocated for IMT use as we transition from 5G Advanced to 6G will have demanding performance requirements.[7] These requirements will need to be met from both existing and new IMT spectrum allocations. All frequency bands currently identified for IMT in the Radio Regulations are expected to be relevant for IMT-2030.

Given the current visibility of IMT-2030 timeframes in both ITU and 3GPP, we can expect the rollout of 6G networks to begin around the time of availability of the Upper 6 GHz band in Australia. This positions the upper 6 GHz band in Australia as a band that can be used when introducing 6G technology.

2.1.2 Indoor usage for Enterprise

The launch of ARM based processors into traditional x86 dominated environments (i.e. Windows on ARM in the Microsoft Surface Pro 9 5G) also highlights the growing trend of non-traditional mobility device types being provisioned with IMT modems out of the box. This will drive a dependency for more IMT capacity, capability and presence within an in-building environment where a majority of usage of these devices will be. This reinforces the requirement for the Upper 6 GHz band to be allocated for IMT usage due to this growing trend.

In-building low power solutions for IMT can also be deployed early in the licence period, including during the reallocation period as this can occur in the presence of outdoor PTP links due to the lower risk of interference from the inbuilding low power IMT solution, enabling efficient and effective use of this band for IMT early on into its adoption. The Installation of the in-building systems may be further accelerated where passive DAS systems are already in place for the lower 6 GHz for Wi-Fi simplifying the activation of IMT in the upper 6 GHz band.

While Wi-Fi and other indoor solutions are expected to continue playing a crucial role in partially offloading indoor traffic, mobile networks remain essential for enabling wide-area mobility and ensuring low latency beyond confined environments. Even in densely populated multi-dwelling apartments, the existing spectrum allocated to Wi-Fi provides sufficient spectrum to deliver 80 MHz, 160 MHz and 320 MHz channels to each apartment, allowing gigabit Wi-Fi connectivity to devices. Significantly

6 https://www.3gpp.org/ftp/workshop/2024-05-08_3GPP_Stage1_IMT2030_UC_WS/Docs/SWS-240010.zip

7 Ericsson: **6G spectrum - enabling the future mobile life beyond 2030**, March, 2023. This report also describes the near term (later this decade) use of digital twins as a driver for wide-area spectrum. Ericsson describe the need for up to 10 sensors/m², each at approximately 15 kbps, totalling 150 kbps/m². Access to digital twins is not only expected in very dense urban deployments, but also in less dense suburban areas where a lower spectral efficiency is expected. Noting the UL-heavy traffic connected to this use case, with an inter-site distance of 500m and an uplink spectral efficiency of 11 bps/Hz (approximately twice that of 5G), around 300 MHz of wide-area spectrum is required for communication purposes. This further emphasises the need for high-capacity, wide-area WBB networks. Available at: https://www.ericsson.com/en/reports-and-papers/white-papers/6g-spectrum-enabling-the-future-mobile-life-beyond-2030.

increased throughput and capacity can be achieved by Wi-Fi without the need for additional spectrum through the use of features in the Wi-Fi 6 standards such as higher order MIMO (up to 8x8 MIMO). IMT is also often deployed in indoor environments to offload user traffic from the wide area network using low-powered access points, particularly in enterprise networks, or in solutions that serve larger numbers of users in defined areas (such as stadiums).

Additionally, an alternative to 'mainstream' RLAN solutions using either 2.4 GHz or 5/6 GHz bands is to use the class licensed 24 GHz and 60 GHz bands as they can also provide high bandwidth and low latency for specific applications. Examples of this include WiGig (802.11 ay) which is touted as being useful for: wireless docking between devices like smartphones, laptops, projectors, and tablets; simultaneous streaming of multiple, ultra-high-definition videos and movies; and more immersive gaming, augmented reality and virtual reality experiences.

2.1.3 Security and Trust

Security is crucial in today's interconnected world and while Wi-Fi networks can be secured, IMT networks offer a more reliable shield against security risks.

Advancements have been made for both Wi-Fi and IMT implementations; however, many of vulnerabilities remain in deployed Wi-Fi systems due to the broad deployment of unmanaged systems. Some common issues include:

- **Lost or Stolen Devices**: When using the simple pre-shared key (PSK) mode of WPA2 security, a single global password is shared across the entire Wi-Fi network. If a device is lost or stolen, changing the password for all devices connected to an access point becomes essential.
- **User-to-User Snooping**: Even with encryption, the PSK mode of WPA2 can't prevent snooping by authorized users.
- **Session Hijacking**: Malicious actors can hijack sessions via poorly secured Wi-Fi.
- **Evil Twin Attacks**: Hackers set up fake, unsecured Wi-Fi networks that mimic legitimate ones. Users unknowingly connect to these rogue access points, compromising their security.

In contrast IMT networks employ strong and network wide access and encryption protocols securing each access individually making it more challenging for attackers to exploit.

2.2 Benefits these services will provide to our customers

In the previous sections, we outlined the vision we have for how the Upper 6 GHz band will be used, both before and after 2030. In this section, we answer the second of the ACMA's questions regarding the benefits these services will provide to all Australians.

- **Access to higher data speeds and real-time information**. This will allow workers to access information while on the move, or while working remotely. It will also allow people to access augmented reality, entertainment and gaming, and stay connected with family and friends in new, immersive ways. It will also flow into new health capabilities, with better telemedicine capabilities and access to patient data in an emergency, and improved education experiences.
- **The convergence of the cyber (digital) and physical worlds**. This convergence will better enable us to manage energy use, manage public transport, waste handling and more, to achieve higher

levels of resource efficiency, better control, and increased resilience of infrastructure. In addition to the (built) urban environment, it will also improve capabilities in agriculture and farming, with better ability to sense changes in the environment and make smart decisions based on real-time data.

- **Cognitive systems allow for autonomous learning**. The continual optimisation of "smart" systems will make those systems more dynamic than today's systems, and better able to cope with new situations.
- **Convergence of networks**. 6G capabilities will likely be initially deployed in the Upper 6 GHz band and will see convergence of different networks such as mobile and satellite-based networks.

2.3 The increasing demand for IMT

In this section, we consider the demand for IMT in the Upper 6 GHz band from three perspectives. Firstly, as measured by historic growth in mobile data traffic (both globally and on Telstra's network). Secondly from the perspective of the Asia-Pacific region, where we see the majority of countries moving to allocate the upper 6 GHz band for IMT to meet demand. Thirdly, we explore the growing demand for 5G Fixed Wireless Access (FWA) services globally and in Australia.

Studies done by Coleago for the GSMA and the Australian Mobile Telecommunications Association in 2021 forecast that 2 GHz of mid-band spectrum needs to be available in the 2025-2030 time frame to guarantee the IMT-2020 requirements for 5G.[8] See **appendix 2** for more details.

2.3.1 Using the Upper 6 GHz band for IMT in Australia

We have outlined how IMT will use the Upper 6 GHz band, and the benefits this will bring. It is important to also recognise that traffic and the demand on IMT networks continues to grow. Today, this arises from users simply doing more each year using the current technology. More people are storing and accessing video, gaming and other content, and enterprises and governments are moving more services and facilities online, requiring mobile networks for real-time access, anytime, anywhere. Additionally, there is an inherent preference for mobile connectivity, rather than fixed. This has been brought about due to rapid advancements in mobile technology (i.e. 3G to 4G to 5G) leading to the pricing for mobile services reducing significantly, with the result that there has been sustained growth in the volume of IMT traffic.

Figure 2 below, reproduced from Ericsson's June 2024 Mobility Report,[9] shows the growth in data traffic on mobile networks globally. While growth has slowed from the giddy heights of almost doubling annually around 2019 (when 5G was first being introduced), growth is still above 20% year-on-year today, and Telstra currently experiences 20% year-on-year growth in mobile data traffic on its network.

That is, in four years' time mobile networks will be carrying twice the traffic they are today.[10] While we expect some of this growth to be offset by technology improvements (e.g., mobile users shifting their

8 https://www.gsma.com/connectivity-for-good/spectrum/new-spectrum-for-5g-adding-up-the-mid-band-maths.

9 Ericsson, **Mobility Report**, June 2024, Figure 5, Global mobile network data traffic and year-on-year growth (EB per month), p.10. Available at: https://www.ericsson.com/en/reports-and-papers/mobility-report/reports/june-2024.

10 $1.2^4 = 2.07$, meaning the quantity has doubled.

traffic from 4G networks to 5G networks as a result of upgrading their devices) and cell densification, these cannot entirely offset the growth, and more spectrum is required.

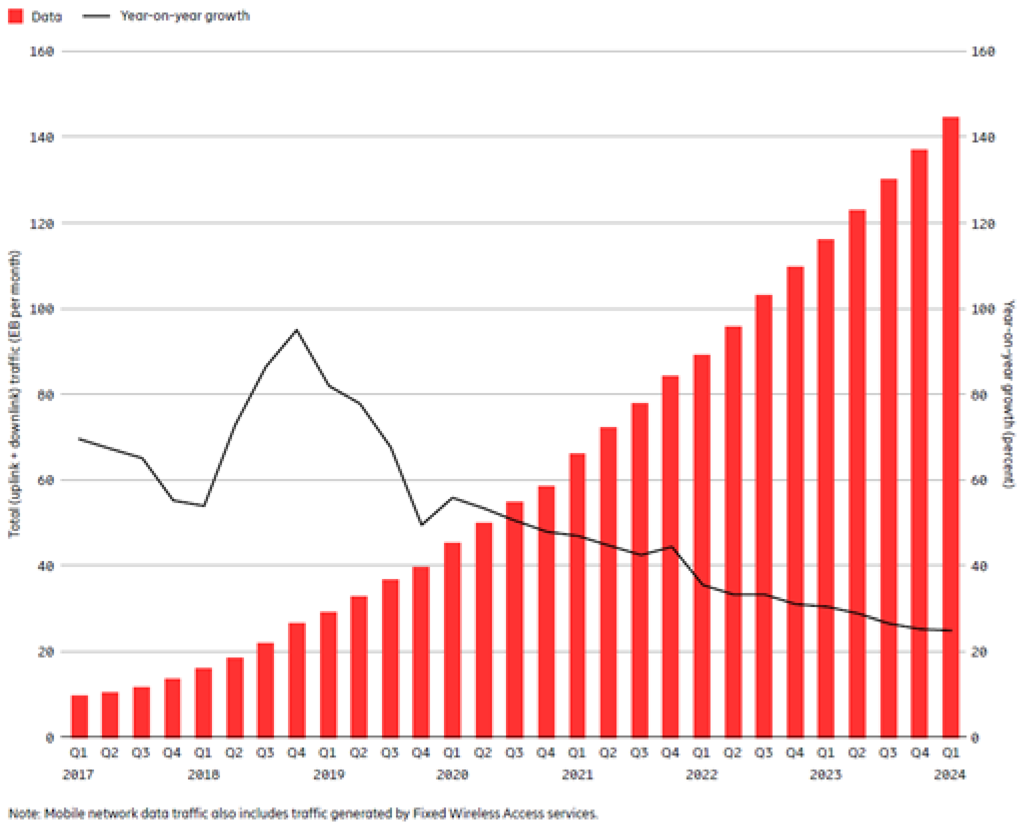

Figure 2: Global IMT Traffic (Exabytes/month) and YoY Growth (%)

2.3.2 The Upper 6 GHz band is being allocated to IMT across the Asia-Pacific region

Telstra firmly believes that the Asia-Pacific region (ITU Region 3) will overwhelmingly support the use of IMT across the entire Upper 6 GHz band, specifically from 6425 MHz to 7125 MHz (3GPP band n104).[11] This extends beyond the previously determined range of 7025 MHz to 7125 MHz for our region at WRC-23. It is anticipated that this will occur in 2025 and beyond, following the clearance of existing users in the 6 GHz band.

In addition to the three smaller countries—Cambodia, Lao PDR, and the Maldives—we expect that larger nations such as Bangladesh, China, Indonesia, Malaysia, Myanmar, the Philippines, Singapore, Sri Lanka, Thailand, and Vietnam will also support the identification of the 6425-7025 MHz frequency band for the terrestrial component of IMT.[12] Some industry experts suggest that India and Pakistan may also join this consensus, while Japan is currently reviewing its position.

Considerable new mid-band spectrum is needed in Asian cities given their rapidly growing populations, high urban densities, adoption of public transport and increasing mobile broadband demand. Beyond

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[11] 3GPP TS 38.101-1 User Equipment (UE) radio transmission and reception; Part 1: Range 1 Standalone. Section 5.2 Operating bands

[12] Refer to Scott Minehane, Presentation, *Deep Dive on Spectrum Management* to the Philippines Future Connectivity Conference, Manila 15 March 2024

legacy IMT bands, new allocations are essential. Notably, the C-Band (3.3-4.2 GHz or n77) faces constraints in Asia due to heavy usage for satellite communications in island archipelagos and regions with heavy rainfall.

For Australia, this means that countries in our region with a combined population of at least 2.2 billion people but possibly as high as 3.9 billion people or more will utilise Upper 6 GHz band for mobile broadband communications. This demand will drive economies of scale and enhance the device selection and usage experience for Australian consumers.

Supporting regional efforts on harmonisation aligns with Australia's active participation and support of the Asia-Pacific Telecommunity (APT) and its various working groups including AWG.

2.3.3 The growing demand for 5G Fixed Wireless Access (FWA) services globally and in Australia

There is a global surging adoption of fixed wireless access (**FWA**). Globally, FWA is forecasted by the GSA to exceed 180 million connections by the end of 2026, accounting for more than 20 percent of total mobile network data traffic globally. Of the 312 operators that had announced 5G launches worldwide as of May 2024, the GSA has catalogued 164 operators that that are marketing residential or business 5G FWA broadband services, up more than 300 percent from 41 in November 2021.

Such estimations are consistent with other industry reports. In the latest June 2024 *Ericsson Mobility Report,* Ericsson states that:

> *"From 130 million at the end of 2023, FWA connections worldwide are projected to increase to 330 million by the end of 2029.* ***This represents 18 percent of all fixed broadband connections.*** *Of the 330 million projected connections, close to 85 percent are expected to be over 5G. FWA data traffic represented 22 percent of global mobile data traffic at the end of 2023 and is projected to grow by a factor of more than 5 to reach 154 EB [Exabytes (10^{18} bytes)] in 2029 – representing* ***over 30 percent of total mobile network data traffic.***"[13] (our emphasis)

The surging adoption of 5G FWA in the USA highlights how FWA, which leverages mobile network infrastructure to deliver broadband internet, is rapidly becoming a significant player in the residential internet landscape in the USA. As detailed in a June 2024 Opensignal report,[14] as of Q1, 2024, there were over 8.8 million 5G FWA users in the USA, and that number is growing at about 1 million users per quarter. FWA is an interesting 5G use case because it consumes about 450 GB to 500 GB a month of data per FWA user, compared with 18 GB to 20 GB consumed by each mobile user - the equivalent of about 15 to 25 mobile users for every one fixed wireless user on the network.[15] In the USA, CTIA has highlighted that the latest C-band and 2.6 GHz spectrum allocations are providing new fuel to support such growth, and it has cautioned that meeting growing demand and enabling 5G FWA to reach its full competitive potential will require additional licensed IMT spectrum.[16]

In Australia, accordingly to tefficient (see Figure 3 below) the fixed 'wireline' network share of total data traffic is 87 percent, this is materially below a number of European markets but significantly above a number of Asian and Nordic markets.

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13 Ericsson Mobility Report, June 2024, page 19

14 Refer to https://www.opensignal.com/2024/06/06/5g-fixed-wireless-access-fwa-success-in-the-us-a-roadmap-for-broadband-success-elsewhere

15 See https://wia.org/5g-use-cases-to-drive-network-densification/

16 See https://www.ctia.org/news/5g-home-broadband-continues-to-bring-real-competition-to-cable

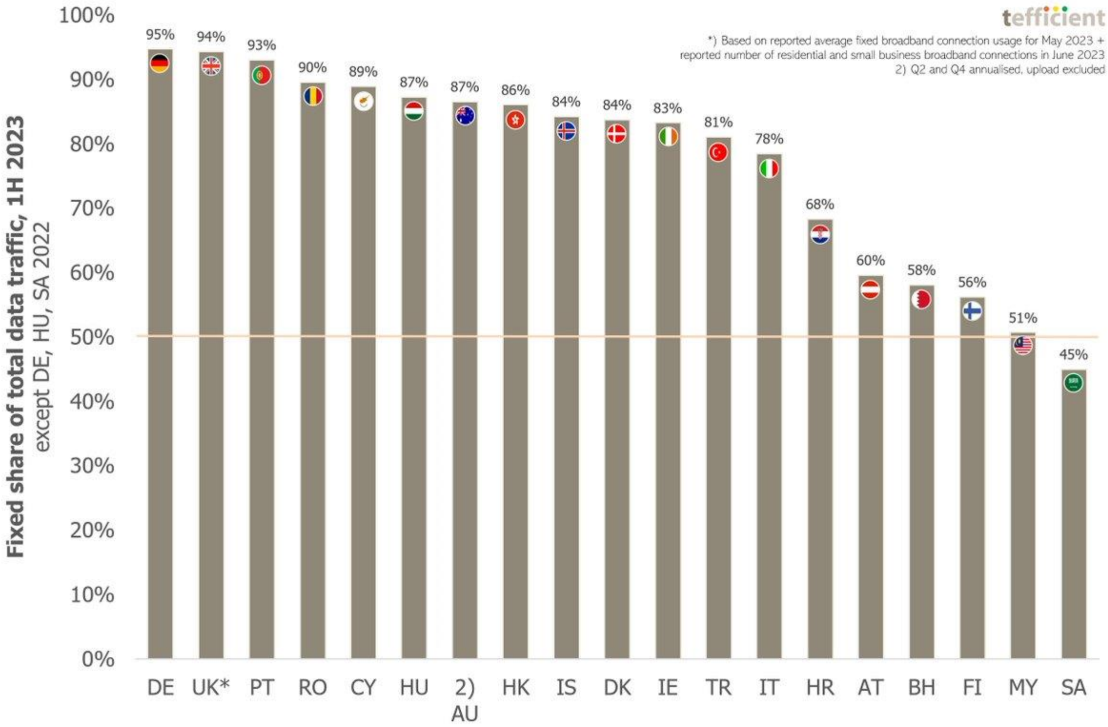

Figure 3: Selected countries share of total traffic – fixed versus mobile share

It should also be highlighted that tefficient's data,[17] as shown below, records Australia has having the highest data usage per data-only SIM per month out of all the countries it tracks.

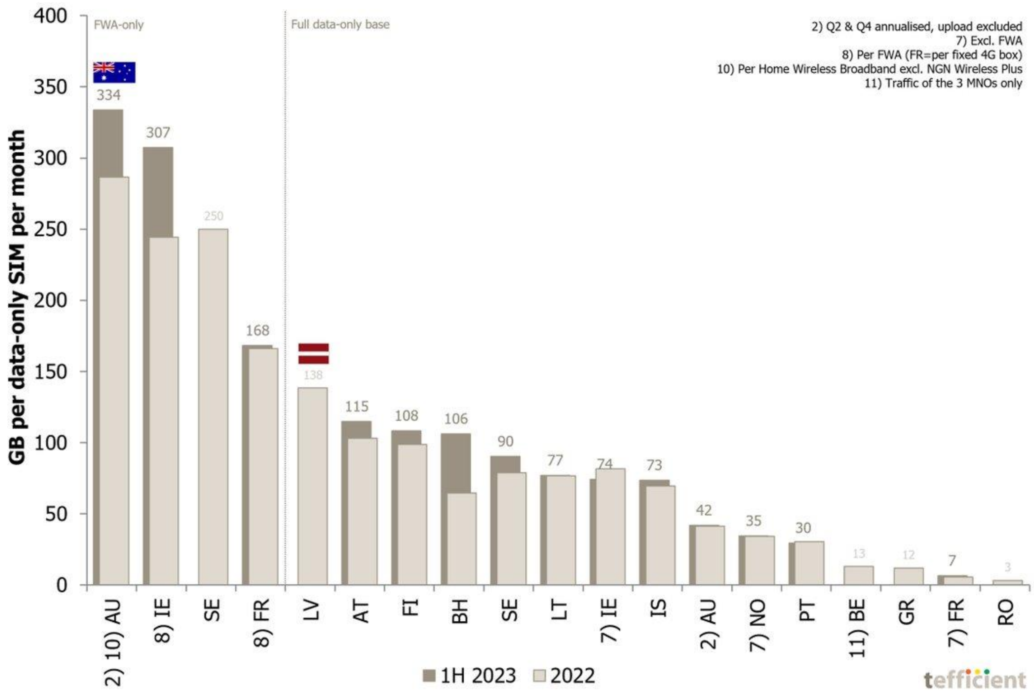

Figure 4: Selected countries GB per data only SIM per month

17 tefficient, *Industry analysis #4 2023*, page 12

Thus in Australia, we not only have rapid growth of 5G FWA services; when adopted those services are used much more than in other countries putting pressure on our wireless broadband networks and the underlying IMT spectrum used by those networks. This is arguably occurring due to a number of factors including but not limited to the pricing of NBN Co services, the desire of younger Australians to have control over their own broadband services when in a shared house/apartment living arrangements and cost of living pressures (i.e. looking for more economical service offerings).

Given the challenges in securing mid-band spectrum in Australia in order to meet the GSMA's recommendation of 2 GHz of mid-band spectrum by 2030, the strong growth of FWA in subscriber and usage terms which is consistent with international experience (such as in the USA) emphasises the need for a significant proportion of the 6 GHz band to be allocated to IMT purposes to support the growth in this market segment.[18]

2.4 A strong device ecosystem is being developed

The development of support in 3GPP for IMT use of the 6 GHz band started at the end of 2020 with the approval of the work item detailing the specification updates required. This work item was supported by Telstra as well as a diverse range of companies from across Asia and Europe including network equipment vendors (Ericsson, Nokia, Huawei, ZTE), Operators (Telia, Telefonica, DT, Vodafone, Orange, CMCC, China Unicom, China Telecom), device chipset vendors (MediaTek, HiSilicon, Spreadtrum) and device vendors (Oppo, Lenovo, ZTE, Vivo, Xiaomi).[19]

The work item led to the specification of band n104, approved by 3GPP in June 2022 enabling the development of the use of the band for 5G to start. The introduction of a new band into the device ecosystem takes multiple years and commercial devices are yet to start shipping, however chipsets with support are now available, which will enable the device vendors to start introducing the band (likely using 5G Advanced) in coming device generations. Beyond the introduction of 5G on the 6 GHz band, we anticipate support for 6G will shortly follow, once the 6G specifications have been completed in 3GPP, expected by the end of 2028.

While this may seem a long way off, chipset manufacturers and equipment manufacturers will not invest in the development of a new band without sufficient evidence that the band has been or will be allocated to IMT. To presume this will occur the other way around (i.e. wait for the chipsets and equipment to arrive before allocating the band) is incorrect; it can only occur with the band being allocated first.

2.5 The Upper 6 GHz band is required for IMT in Australia

The ACMA's consultation paper primarily considers whether the Upper 6 GHz band should be allocated to IMT or to RLAN. In this section of our submission, we reflect on why the Upper 6 GHz band should not be allocated to RLAN, drawing both on international reports and on our own internal traffic consumption.

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[18] Windsor Place Consulting, *Updated Report: Optimising IMT and Wi-Fi mid-band spectrum allocation. The compelling case for 6 GHz band partitioning in Asia-Pacific,* November 2022

[19] 3GPP RP-220686

The GSMA's July 2021 report, "*Vision 2030: Insights for mid-band Spectrum Needs*"[20] recommends that governments and regulators plan to make 2 GHz of mid-band spectrum available by 2030. In the view of GSMA, this is the spectrum needed to guarantee the IMT-2020 requirements for 5G.

In Australia, less than 1000 MHz of low and mid-band spectrum is currently allocated for IMT use as can be seen from the graph in Figure 5 below. This estimate accounts for regional variations and serves as a general reference for discussions. The most recent IMT allocation occurred in 2023 within the 3.4 to 3.7 GHz range, adding approximately 100 MHz for IMT use across the country—a 10% increase. In March 2022, an additional 500 MHz of spectrum in the 6 GHz band was allocated for unlicensed Wi-Fi use, bringing the total allocated to 1.1 GHz. This represented a substantial 76% increase.

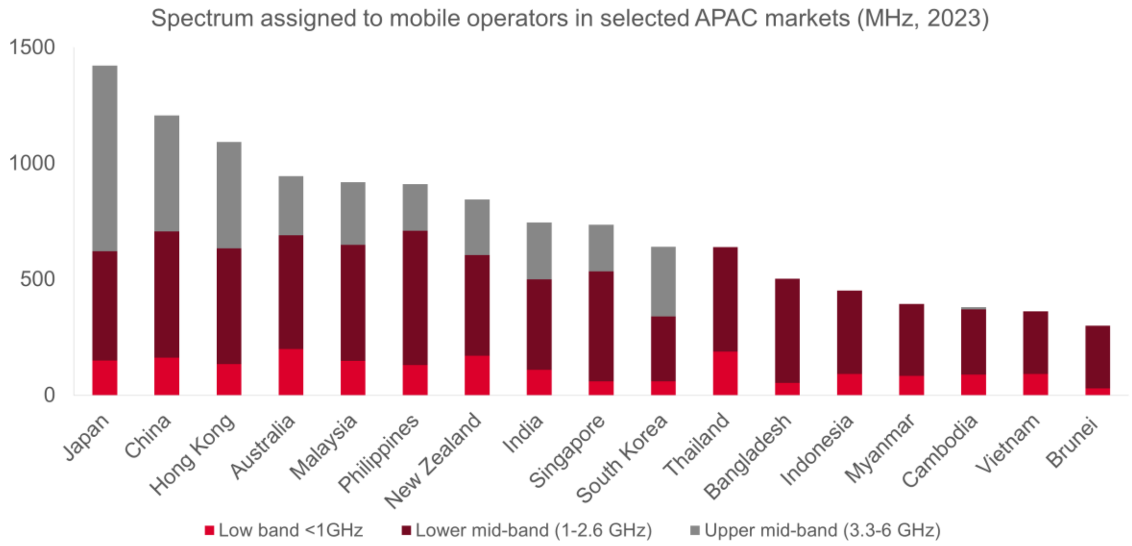

Figure 5: GSMA Intelligence, Spectrum assigned to mobile operators in selected APAC markets in MHz, December 2023.

2.5.1 Demand for residential Wi-Fi is satisfied by the Lower 6 GHz band

The GSMA's June 2022 report, "*The socio-economic benefits of the 6 GHz band*", concludes that Wi-Fi traffic demand is not currently constrained by spectrum in a "house dwelling" residential setting.[21] The GSMA observe that if fixed broadband into a house or apartment does not offer speeds greater than 1 Gbps, then there is no capacity constraint from existing Wi-Fi spectrum allocations. This is important because in Australia, more than 50% of all households are on the 50 Mbps speed tier (one-twentieth of the lowest supply scenario in the GSMA report), and only a little over 20% of all households are on a speed tier of ≥ 100 Mbps.[22] Even under scenarios where average Australian broadband speeds were to

[20] GSMA, **5G Mid-Band Spectrum Needs – Vision 2030**, p.24. Available at: https://www.gsma.com/connectivity-for-good/spectrum/gsma_resources/5g-mid-band-spectrum-needs-vision-2030/

[21] GSMA, **The socio-economic benefits of the 6 GHz band**, p.24. Available at: https://data.gsmaintelligence.com/research/research/research-2022/the-socioeconomic-benefits-of-the-6-ghz-band-considering-licensed-and-unlicensed-options

[22] ACCC, **Internet Activity Record Keeping Rule for June 2023** (published, Dec 2023). See Figure 6, p.8. Available at: https://www.accc.gov.au/by-industry/telecommunications-and-internet/telecommunications-industry-record-keeping-and-reporting-rules/internet-activity-record-keeping-rule/june-2023-report. Note, the December 2023 Internet Activity RKR should be published shortly, as reports generally lag each half-year end by around 6 months.

materially increase, Wi-Fi traffic demand would not be constrained by spectrum. Currently, the fastest NBN speed tier available for residential services is 1 Gbps, which is the lowest of the three supply scenarios compared in the GSMA report.

Figure 12A from the GSMA's report (repeated below in Figure 6) shows Wi-Fi demand for three different households with three distinct Wi-Fi supply scenarios, projected out to 2035. The households vary on the number of connected devices:

- Household 1 assumes 11 devices.
- Household 2 assumes 6 devices.
- Household 3 assumes 3 devices.

In all cases, the devices are assumed to require 100 Mbps each.

On the supply side, the scenarios assume distinct allocations from the 6 GHz band to Wi-Fi:

- Scenario 1 has no Wi-Fi allocation from the 6 GHz band.
- Scenario 2 has the entire 1200 MHz of the 6 GHz band.
- Scenario 3 has the lower 500 MHz of the 6 GHz band allocated to Wi-Fi, which is the case in Australia.

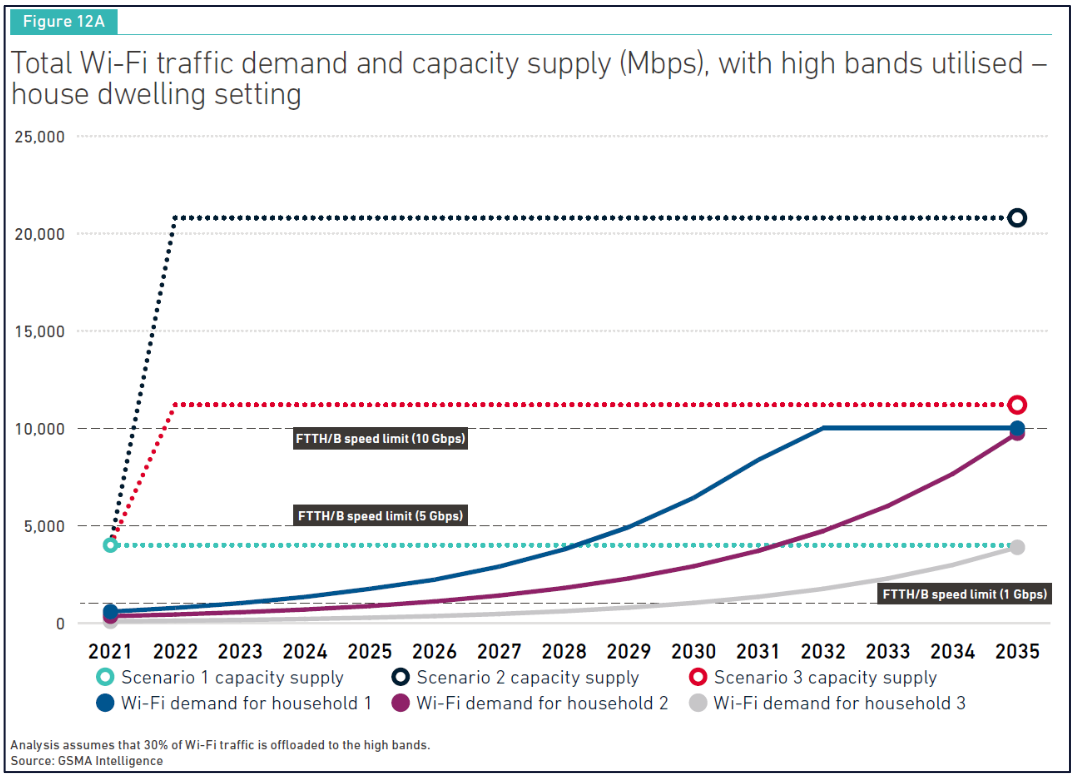

Figure 6: Wi-Fi traffic demand for three **household** scenarios with / without Wi-Fi allocated in the 6 GHz band.

The GSMA report shows that even where fixed broadband speeds provide access to 5 Gbps (well in excess of what is capable using residential broadband today), there is generally still sufficient capacity with existing Wi-Fi spectrum (noting that scenario 3 is the one that currently applies to Australia). Even with 10 Gbps supply to the house, spectrum supply to Wi-Fi is not the limiting factor for Scenario 3, which is where the lower 6 GHz band is allocated to Wi-Fi, as is the case in Australia.

2.5.2 RLAN advocacy centres on dense urban living and would result in inefficient spectrum use

The GSMA's June 2022 report, "*The socio-economic benefits of the 6 GHz band*", goes on to conclude that Wi-Fi traffic demand is not currently constrained by spectrum in a dense apartment dwelling setting either. The GSMA observe that if fixed broadband into a house or apartment does not offer speeds greater than 1 Gbps, then there is no capacity constraint from existing Wi-Fi spectrum allocations. This is important because in Australia, more than 50% of all households are on the 50 Mbps speed tier (one-twentieth of the lowest supply scenario in the GSMA report), and only a little over 20% of all households are on a speed tier of ≥ 100 Mbps.[23] Currently, the fastest NBN speed tier available for residential services is 1 Gbps, which is the lowest of the three supply scenarios compared in the GSMA report.

Figure 14A from the GSMA's report (repeated below in Figure 7) shows Wi-Fi demand for three different apartments with three different Wi-Fi supply scenarios, projected out to 2035. The same assumptions apply in this case as they did for Figure 12A from the GSMA report. That is:

- Apartment 1 assumes 11 devices
- Apartment 2 assumes 6 devices
- Apartment 3 assumes 3 devices.

In all cases, the devices are assumed to require 100 Mbps each.

On the supply side, the scenarios assume three distinct allocations from the 6 GHz band to Wi-Fi:

- Scenario 1 has no Wi-Fi allocation from the 6 GHz band
- Scenario 2 has the entire 1200 MHz of the 6 GHz band
- Scenario 3 has the lower 500 MHz of the 6 GHz band allocated to Wi-Fi, which is the case in Australia.

For the first half of the period (2021-2027), the GSMA assumes 2 antennas per station[24] and 4 antennas per access point (AP), and for the second half of the period (2028–2035), the GSMA assumes 4 antennas per station and 4 antennas per AP.[25] The GSMA introduces this, because Wi-Fi capacity is constrained compared to a house dwelling due to the higher probability of interference from neighbouring Wi-Fi users. The increase in the number of antennas in the station after 2028 goes some way to mitigating the interference effects, and clearly, consumers would need to upgrade their devices. An important fact to consider is that in Australia, apartments account for just 16% of the housing market.[26] This diminishes the extent of demand for additional RLAN spectrum in these higher-density residential settings.

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[23] ACCC, **Internet Activity Record Keeping Rule for June 2023** (published, Dec 2023). See Figure 6, p.8. Available at: https://www.accc.gov.au/by-industry/telecommunications-and-internet/telecommunications-industry-record-keeping-and-reporting-rules/internet-activity-record-keeping-rule/june-2023-report. Note, the December 2023 Internet Activity RKR should be published shortly, as reports generally lag each half-year end by around 6 months.

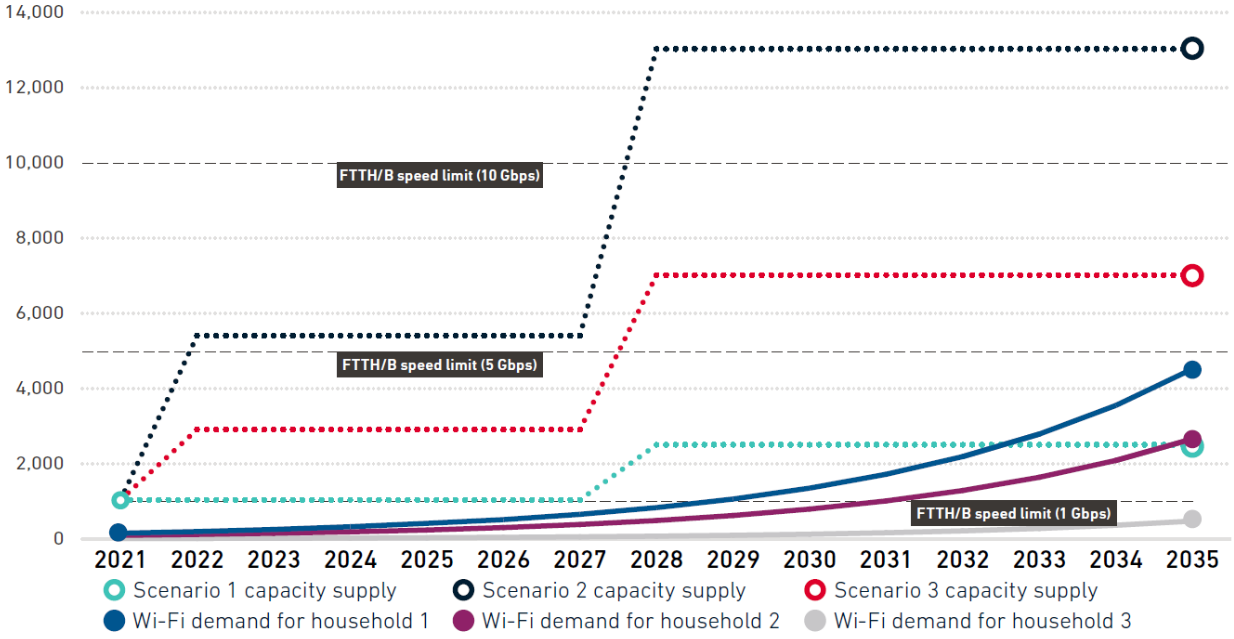
[24] Station, abbreviated as "STA". See: https://en.wikipedia.org/wiki/Station_(networking)

[25] GSMA, **The socio-economic benefits of the 6 GHz band**. See Appendix A, Methodology, Table A2, second row. p.42.

[26] Australian Bureau of Statistics – 2021 Census: Information on housing type and housing costs

Figure 14A

Total Wi-Fi traffic demand and capacity supply (Mbps), with high bands utilised – apartment setting



Source: GSMA Intelligence

Figure 7: Wi-Fi traffic demand for three **apartment** scenarios with / without Wi-Fi allocated in the 6 GHz band.

2.5.3 Upper 6 GHz is also not required for RLAN in manufacturing or the logistics industry

While proponents of RLAN technology advocate that the Upper 6 GHz band is needed for the provision of coverage to sprawling industrial buildings, Telstra maintains that there are significant benefits to be realised by using IMT networks as an alternative to those solutions.

For these kinds of use cases, users are more effectively and securely supported with a network solution that is provided by a network operator using a 5G, or in the future, a 6G solution. Such access technology provides an end-to-end solution which supports QoS classes, network slicing and enhanced end-to-end security. In this context, Wi-Fi is not a suitable alternative for offering the ultra-reliable, high capacity, ultra-low latency services required for industrial applications due to its inherent non-scheduled access mechanism for licence-exempt applications.

In situations where RLAN is still preferred over an IMT solution in such environments, there is scope to consider a dedicated mmWave network using class licensed spectrum at either 24 GHz or 60 GHz.

2.6 RLAN does not need additional spectrum

Below, we rebut arguments put forth by proponents of allocating all of the remaining 6 GHz band spectrum (i.e. 700 MHz) to Wi-Fi.

2.6.1 Although fixed networks carry more traffic than mobile networks, this does not justify more spectrum for Wi-Fi

This argument points to the significantly greater volume of Internet traffic carried by fixed broadband networks compared to mobile broadband networks and argues that greater allocations of spectrum to Wi-Fi are required to make use of that data at the end user point.

However, this claim does not bear scrutiny:

- A significant proportion of the data carried on fixed broadband networks will not be accessed via Wi-Fi at the network periphery because a significant proportion will be accessed using fixed ethernet connections. This will include machine-to-machine communications (particularly between Internet servers of various types) but also will include human users connected to ethernet networks where high-speed, low contention and high reliability are priorities.
- The fact that the volume of traffic on fixed broadband networks exceeds that on mobile broadband networks is not decisive. The critical factor determining the socially optimal allocation is *value* not volume. It is well-established that users value the mobility that comes with IMT applications which deliver greater mobility than Wi-Fi applications.
- The value of mobility is also demonstrated by the phenomenon of 'cord cutting'. As mobile and fixed prices converge and uncapped plans become more common, consumers, especially young and cost-conscious consumers are increasingly cancelling their fixed plans accessing broadband via 4G and 5G FWA.
- Spectrum allocations need to be based on the trajectory of future spectrum demand in addition to current usage. The demand for data traffic delivered over mobile spectrum is growing significantly more quickly than this corresponding demand over fixed networks. This suggests that the lifetime social benefit of spectrum allocations to IMT is greater than allocations to Wi-Fi.
- The argument that a primary benefit of spectrum allocated to Wi-Fi is the avoidance of internal cabling in business premises and homes neglects the fact that, if spectrum is allocated to Wi-Fi, it is unavailable for the delivery of wireless broadband access which clearly necessitates additional fixed broadband capacity if demand is to be met.[27] Additional broadband capacity entails all of the civil works and cabling associated with landline broadband networks. A more balanced analysis would include and compare both sets of costs.

2.6.2 Allocating more spectrum to Wi-Fi will not lead to the avoidance of CO2 emissions

The paper titled *Sustainability Benefits of 6 GHz Spectrum Policy: Study for Wi-Fi Alliance*, 31 July 2023 by Wik Consult argues that allocating the upper 700 MHz of 6 GHz band to IMT will release 3.2 megatons more CO2 by 2030 in Europe than if it had been allocated to Wi-Fi and suggests that similar results would pertain in Australia. This argument is based on the metric that IMT requires more energy to transmit a unit of data than Wi-Fi.

[27] It also neglects the fact that in the Australian context, there are range of NBNCo and other rules/guidelines which facilitate developments (especially new developments) having cabling in place. Refer to: https://www.nbnco.com.au/develop-or-plan-with-the-nbn/industry-collaboration-and-community-planning/cabling

Again, there are significant problems with this argument:

- The amount of energy required to transmit a unit of data is an inappropriate metric for determining optimal spectrum allocation. Again, this is confusing volume and value. A more appropriate metric for this type of analysis would be the compare *benefits* (the amount of consumer and producer surplus) created per unit of energy used to transmit data. Overall, when considering minimization of CO_2 emissions, the objective should be to maximise welfare per unit of CO_2 emission. To the extent that consumers value mobility and data transmitted over mobile networks over data transmitted by Wi-Fi networks, then more spectrum should be allocated to those IMT services.[28]
- Another problem with the analysis is that it is highly partial. The amount of energy required to transmit a unit of data is relevant but so is the amount CO_2 emission avoided using either Wi-Fi or IMT. Because IMT spectrum applications have superior mobility characteristics to Wi-Fi, it is overwhelmingly likely that IMT-based communications are a better substitute for physical mobility than Wi-Fi-based communications. IMT networks enable individuals anywhere to communicate and access data without having to move to a particular location at an office, at home or other Wi-Fi access point. Distributed transport and logistics tasks will overwhelmingly be dependent on IMT networks rather than Wi-Fi networks. IoT applications for devices that are highly geographically mobile are dependent on IMT systems. IMT is better than Wi-Fi at enabling the movement of bits as a substitute for the moving of atoms and moving atoms is much more CO_2 intensive than moving bits. Given this, it is more likely overall to reduce CO_2 emissions by allocating spectrum to IMT rather than Wi-Fi.
- In addition, it is important to highlight the Wik Consult Report published in July 2023 is already out of date. This is because the paper is only concerned with Wi-Fi 5, Wi-Fi 6 and Wi-FI 6E[29] and does not explore the new Wi-Fi 7 standard which was released 8 January 2024. While there are a couple of mentions of Wi-Fi 7 (mainly on pages 20 and 21), the paper explicitly states that it *"... models the impact of 100% of all FTTH 100% of FTTH subscribers will have a Wi-Fi 6E modem/router in 2030.*[30] *Thus, the energy consumed for each FTTH connection will include the energy associated with the Wi-Fi 6E modem/router*." It goes on to say that is does this even though by 2030 "*a significant portion of Wi-Fi deployments will be Wi-Fi 7.*" This is important as Wi-Fi 7 is significantly different to Wi-Fi 6E as noted on page 21 in that Wi-Fi 7 supports Multi-link Operation (MLO).[31] MLO in Wi-Fi 7 allows for multi-link aggregation between a single Wi-Fi station (STA) and a single Access Point (AP) that has multiple radio chips, including 2.4 GHz, 5 GHz, and 6 GHz chips. It is a MAC layer technology that can aggregate multiple links across different frequency bands into a virtual link. Therefore, MLO by enabling the establishment of multiple links between an AP and a STA across different frequency bands, greatly enhances the transmission rate of the AP and reduces latency. This process is called bonding or aggregation. According to the tests a Wi-Fi 7 AP equipped with MLO technology is able to establish two links in the 5 GHz and 6 GHz frequency bands, reducing average latency.[32] This ability to bond links

[28] This limitation is acknowledged in footnote 17 of the WIK Consult report then it poses the question "Furthermore, the report did not consider the economic feasibility of this 15% shift (are end users willing to pay more for their mobile subscriptions?)".

[29] Refer to inter alia Figure 3 of the WIK Consult Report (page 3), page 20 and the Annexes.

[30] We would also query this assumption.

[31] There are two modes are available in MLO: STR mode and NSTR mode. Simultaneous Transmit and Receive (STR) mode is referred to as asynchronous mode and Non-simultaneous Transmit and Receive (NSTR) mode is known as synchronous mode. In NSTR mode, data can only be transmitted or received over multiple links at a single time. Simultaneous receiving and transmitting operations are not allowed, effectively avoiding interference between the links.

[32] Refer to https://www.ruijienetworks.com/support/tech-gallery/wifi7vswifi6-part2

across the 5 and lower 6 GHz, is a profound change developed by the industry allowing Wi-Fi users to better utilise the 5 GHz band and materially undercuts any arguments that the upper 6 GHz band is needed for Wi-Fi use. This is because bonding is likely to materially reduce the WIK Consult's estimate of the data traffic that would shift from FTTH/Wi-Fi networks as a result of insufficient spectrum availability.[33] Thus the estimated 15 percent shift would be much lower; perhaps even zero. It is the shift figure which drives the estimate of the additional CO_2.

2.6.3 The economic value of Wi-Fi to Australia is less than the economic value of IMT

The Wi-Fi Alliance's claim, in accordance with Wi-Fi Alliance report titled The Economic Value of Wi-Fi: a global view (2021-25) developed for that organisation by Telecom Advisory Services in September 2021 that the economic value of Wi-Fi to Australia in 2025 will be $42 billion is not, of itself, relevant for spectrum allocation decisions. The value of IMT applications, assessed on the same basis, to provide a comparison, would also be required to make such estimates of any use in helping decide spectrum allocations.

Furthermore, this estimate for Wi-Fi application benefits, as detailed on page 63 of the report, is for the benefits of *all* Wi-Fi applications using *all* of the spectrum allocated to Wi-Fi, and not the incremental assessment of the value of allocating the 6 GHz band for Wi-Fi services. That is, it is an estimate of *total* benefit, where what is required is an estimate of *incremental* benefit.[34]

Ideally, the ACMA needs to know the *incremental* benefit to Australia from allocating *additional* spectrum to Wi-Fi and the same for allocations to IMT. To be useful at all, such estimates need to be calculated using transparent methodology that is consistently applied to both cases.

Furthermore, given the principle of decreasing marginal utility described above, it is arguable that the significant majority of any social benefits associated with increasing spectrum allocated to Wi-Fi in the 6 GHz range will have already been secured through use of the 500 MHz of spectrum already allocated to Wi-Fi in 2022 as part of the LIPD class licence.

Generally speaking, economic benefit estimates like those utilised by the Wi-Fi Alliance are useful for making standalone statements about economic contributions. But they are less useful for making comparative statements across different technologies, sectors, and timeframes. This is because there are many potential differences in methodology, data sources analysis timeframes and assumptions. It is much more useful to undertake comparisons between, for example, competing technologies within a single analysis where consistent methods can be scrupulously applied.

Nonetheless, to provide some context to the figure provided by the Wi-Fi Alliance, in a 2022 report titled, *Realising the potential of the next generation of mobile technology*, commissioned by the Australian Mobile Telecommunications Association (AMTA), Deloitte Access Economics estimated that "5G will increase Australia's GDP by $67 billion by 2030 based on the current trajectory for adoption, however an additional $27 billion can be realised by maintaining Australia's global leadership position through accelerated adoption – a 40% uplift in economic benefit over nine years."

In a 2014 report for ACMA produced by The Centre for International Economics and Analysys Mason, the economy wide impacts of mobile broadband were estimated to be $33.8 billion in 2013 (that is,

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33 Refer to page 3 of the WIK Consult Report.

34 The incremental element assigned to Wi-Fi 6/ 6 GHz Scenario is $5.4 billion in 2025.

GDP was estimated to be higher by that amount due to mobile telephony). In inflation-adjusted terms this figure is $45.6 billion in 2024 dollars.

However, this inflation-adjusted figure should be regarded as a significant underestimate of the value of mobile telephony in 2024. Prices have plummeted, users consume vastly more data over mobile devices and the number of applications and their value to consumers has expanded enormously since 2013.

These empirical results strongly indicate that the value of mobility is high and that simple data volume consumed or time spent using comparisons miss the essential point that the value of networks and their services is the value that consumers put on them.

2.6.4 New and emerging applications such as AR/VR and high-resolution video will also require greater IMT capacity

While the argument that new and emerging applications such as AR/VR and high-resolution video might require greater Wi-Fi capacity in the home and business is valid. This is also true of similar applications supplied using IMT. Both fixed and wireless, will need to have the capacity to deal with the aggregated traffic demands generated by these applications.

It is arguable that bandwidth bottlenecks are more likely to occur in the local access networks than within homes and businesses in Wi-Fi networks. This will of course most obviously be at periods of peak demand, in particular early evenings. Given that local access networks will be subject to both the use of high bandwidth applications and the additional impacts of aggregation in peak periods, they are likely to need additional capacity to a greater extent than Wi-Fi networks. These problems are likely to manifest first in 'brown fields' locations, typically older suburban areas, where fixed infrastructure still contains bandwidth-limiting legacy elements and where mobile networks must provide the balance of local access capacity.

3 Planning arrangements for the Upper 6 GHz band

3.1 We support Option 3—IMT is the optimal use case for the Upper 6 GHz band

We believe assignment of the Upper 6 GHz band best meets the ACMA's desired planning outcomes[35] by making optimal use of this spectrum in places where the current and future demands for high-speed, low-latency connectivity are present. The by-line of 'take your world wherever you go' is appropriate in this case. IMT network operators have built business cases around providing the optimal user experience for their customers, and their stewardship of the spectrum held for this purpose is well established. The IMT use case is compelling and is consistent with optimising the use of the upper 6 GHz band.

The GSMA Intelligence (GSMAi)[36] report previously cited, concludes that in almost every type of residential setting (which is by far the most common use case for RLAN) the most efficient and highest value comes from assigning the lower 6 GHz band to RLAN and the Upper 6 GHz band to licensed IMT services. This balanced approach is favoured by Telstra. We expand on this point further in section 3.1.1 below.

Mobile data volumes on IMT networks continue to grow, so there is an ongoing need for more spectrum. While carrier aggregation allows spectrum blocks from disparate bands to be utilised, it is far more efficient to deliver IMT in single wider bandwidth blocks. As the demand for higher data speeds increases, so does the demand for wider contiguous blocks of spectrum to deliver those services.

The entire 700 MHz bandwidth between 6425 MHz and 7125 MHz (The Upper 6 GHz band) should be allocated to IMT on a primary basis, as IMT is undeniably the most efficient and highest value use of this spectrum.

3.1.1 Highest value use of the upper 6 GHz band is IMT

Spectrum is a finite resource and there are multiple competing uses for it at any given time; in the case of the 6 GHz band, the primary contenders are IMT and Wi-Fi. To determine the highest value use of this spectrum, we need to examine the economic benefits derived from its utilisation. One way to do this is to apply the fundamental economic principle of decreasing marginal benefits. Specifically, in the context of spectrum allocation, this principle suggests that as we allocate additional spectrum to a particular use, the positive impact on economic benefits per unit diminishes. In simpler terms, each successive unit of allocated spectrum provides a smaller social welfare benefit compared to the preceding one.

This proposition allows us to explore the interplay between increasing and decreasing allocations of spectrum to IMT and Wi-Fi. In Figure 8 below, the horizontal axis simultaneously represents the increasing proportion of the 6 GHz spectrum band allocated to one use, implying a corresponding decrease in allocation to the alternative use. An allocation at the leftmost axis corresponds to 100% allocation to Wi-Fi and zero to IMT, while the rightmost axis represents the opposite scenario.

[35] Australian Communications and Media Authority, **Future use of the upper 6 GHz band: Options paper**, June 2024, p 1.

[36] GSMA, **The socio-economic benefits of the 6 GHz band**.

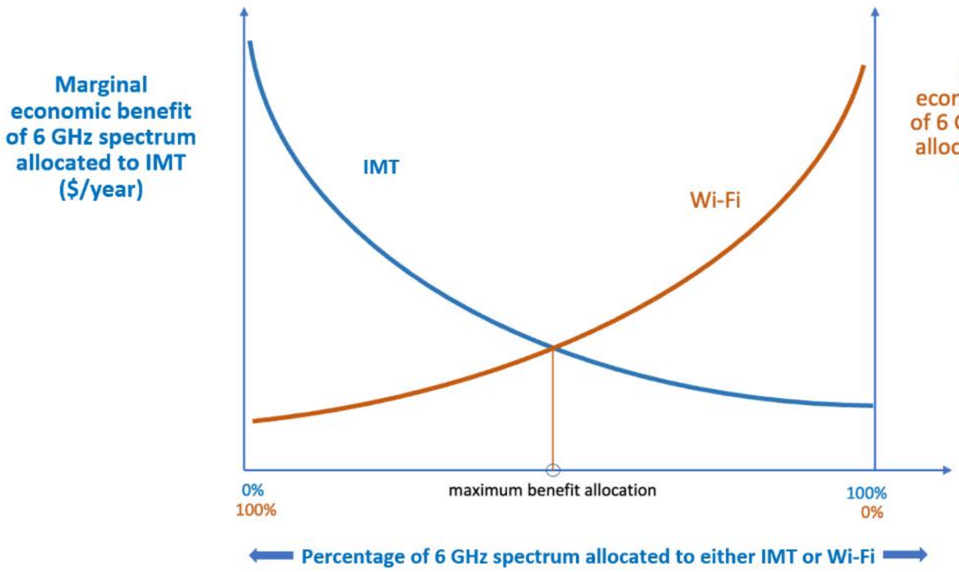

Figure 8: Declining marginal benefit for IMT and Wi-Fi

The concept of decreasing marginal benefit is represented by declining marginal benefit as the allocation of spectrum to IMT increases (the blue curve). The same is true of increasing allocation to Wi-Fi shown by the declining value of the orange curve.

This diminishing marginal benefit of allocations to either IMT or Wi-Fi reflects the fact that individuals and businesses will employ spectrum for the most valuable uses first. As additional spectrum becomes available, subsequent uses yield diminishing returns.

Considering that both IMT and Wi-Fi contribute to social benefits, it is highly likely that the greatest overall benefit occurs at an intermediate spectrum allocation.[37] This “maximum benefit allocation” occurs when the marginal benefit from additional IMT allocations equals the marginal benefit from additional Wi-Fi allocations. At this point, the economic benefits to society from allocating spectrum to both of these uses is maximised.

While this analysis remains hypothetical and lacks empirical data, it strongly suggests that the optimal allocation of spectrum in the 6 GHz band will not favour either all IMT or all Wi-Fi. Allocating the entire 6 GHz spectrum to Wi-Fi, for instance, would necessitate sacrificing the highest-value use cases for IMT (and vice versa).[38] Given that in 2022, 500 MHz of spectrum in the 6 GHz range was added to the pre-existing 660 MHz of spectrum available for unlicensed/Wi-Fi use (an increase of 76%) our strong view is that the highest value use of the remaining Upper 6 GHz band is IMT.

[37] This was the view of Windsor Place Consulting, Updated Report: *Optimising IMT and Wi-Fi mid-band spectrum allocation: The compelling case for 6 GHz band partitioning in Asia- Pacific*, November 2022 which supported the sharing of the 6 GHz band by allocating 500 MHz to Wi-Fi and 700 MHz to IMT/5G services

[38] We acknowledge that existing spectrum allocations to both Wi-Fi and IMT introduce some bias into this analysis. Nevertheless, dismissing this approach would imply that the most valuable IMT use is less valuable than the least valuable Wi-Fi use - this seems highly implausible.

3.1.2 Option 1 (No Change Option) will delay economic benefits

The ACMA's Option 1 contemplates maintaining existing arrangements, with potential reconsideration at a later date. This 'so-called' conservative approach reflects the uncertainty surrounding technology trends and acknowledges the highly contested nature of this band, where diverse views on its future use exist.

We acknowledge that it may be reasonable for the ACMA to delay spectrum allocation decisions in some circumstances, for example, if a particularly significant technology standard is about to be finalised in the near future in order to avoid the lock-in of the spectrum to a legacy technology or avoid other decisions which can only be meaningfully evaluated once additional critical information is available.

However, the delay in spectrum allocation decisions can have tangible consequences, particularly in the wake of our increased reliance on connectivity and mobility spurred by the pandemic. The opportunity cost of unused spectrum, especially in the valuable mid-band range, the upper 6 GHz, can be substantial in terms of economic and social benefits foregone. Therefore, while caution is prudent, the ACMA must also weigh the potential costs of inaction against the benefits of waiting for additional information before making critical spectrum allocation decisions.

Additionally, in the context of spectrum allocation, maintaining flexibility for future decision-making is crucial, especially for the critical 6 GHz band. In this regard is important to note that any allocations of the 6 GHz band to class licensed (Wi-Fi) usage are inherently more difficult to change or undo than allocations for licensed IMT spectrum. Removing a particular band from class licensed use is challenging as any future ability to clear the multiplicity of public class licensed users from the spectrum will be very difficult, expensive and slow. Spectrum allocations for spectrum licensed use are inherently easier to change at the end of the licence term as there will be a small number of clearly identifiable licensees. This consideration, of itself, supports allocating the upper 6 GHz band to IMT because it preserves further flexibility in relation to the spectrum band.

3.2 The Upper 6 GHz band should be allocated through a combination of spectrum and apparatus licensing

The Upper 6 GHz band should be reallocated for spectrum licensing in metropolitan and larger regional centres. Areas outside these defined spectrum licensed areas (i.e. less densely populated areas in regional and remote Australia) should made available for IMT using AWLs, with co-primary status for PTP and IMT. Thus, whomever is first-in-time has protection from harmful interference from new proposed services, and existing PTP and FSS links in regional and remote Australia are grandfathered.

The propagation characteristics of this band are well suited to providing coverage in densely populated areas such as metropolitan and regional centres where the demand for high-capacity mobile coverage is likely to be greatest. Overseas trials[39][40][41] have conclusively shown that coverage from 6 GHz base stations will nearly match the coverage footprints of those base stations using the next lowest frequency IMT band (3GPP n78).

39 Nokia and Telia complete successful outdoor trial in 6 GHz range with Massive MIMO radio.

40 Deutsche Telekom 6 GHz trial – Alzey (Germany) Sept 2023.

41 Telefonica 6 GHz trial – Stuttgart (Germany).

Telstra therefore supports spectrum planning options where the 6 GHz band is made available for IMT deployment – along with other high-capacity bands such as 3.4 GHz where the coverage footprint is likely to be complementary to that provided by the 6 GHz band.

The demand for 6 GHz IMT in less densely populated areas of Australia is likely to be centred on those communities and other activities such as mining where the demand for high-capacity WBB will be greatest. Given that these locations are sparsely distributed, it seems logical to offer access to the 6 GHz band under a flexible licensing arrangement such as AWL. This also accommodates the need to maintain essential PTP services in areas where 6 GHz IMT is unlikely to be deployed but does offer the flexibility to accommodate 6 GHz IMT if the need arises.

3.3 TOB (ENG) in 7100-7125 MHz should be cleared.

In the section on coexistence in the consultation paper,[42] the ACMA describes the likelihood of interference from IMT into Television Outside Broadcast (TOB, which is sometimes referred to as Electronic News Gathering – ENG) services operating in the 7.2 GHz band.[43] We agree with the ACMA that IMT services are likely to cause interference to TOB, and vice versa.

Telstra therefore proposes that ACMA review the TOB band-plan with a view to providing incumbent TOB licensees the flexibility to use this spectrum as efficiently as is possible. The band-plan should take into account the emission characteristics of future IMT services that will use the adjacent band (i.e. immediately below 7125 MHz). It is important that the utility of the upper part of the proposed IMT spectrum is not compromised by the proximity to adjacent band services. The TOB band-plan currently accommodates itinerant operation of TOB services over a large range of 325 MHz, between 7100 and 7425 MHz. Given the high demand for and scarcity of spectrum in some areas, it is imperative that ACMA review the efficiency of this use of this resource.

3.4 Coexistence with PTP links

As is noted by ACMA, there are 12,118 frequency assignments for PTP fixed links in the 6.7 GHz band. Each of these fixed links has the potential to deny access to valuable 6 GHz spectrum due to co-channel or adjacent channel interference. The interference issue is further complicated due to the standard 340 MHz duplex spacing which is used by these link systems. This means that for a given channel width (40 or 80 MHz) the minimum amount of spectrum denial is either 80 or 160 MHz. Since the coordination rules include the 1st and 2nd adjacent channels, the actual level of denial is even greater (albeit over a smaller area).

The migration of PTP links out of this band is a complex project in itself. Should the ACMA decide that existing PTP links need to be cleared to make way for future IMT services, then we believe there is a need to plan a workable migration path for each link. PTP licensees must have certainty around having equivalent system performance with any alternative solution.

In ACMA's discussion paper, it is stated that '*coexistence between RLAN systems and fixed point-to-point stations is feasible if RLAN systems are deployed with adequate power limitations and/or deployment constraints, such as indoor use only (such as the VLP/LPI model adopted in Australia)*'.

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42 ACMA Consultation paper, p.13.

43 The Television Outside Broadcast (TOB) 7.2 GHz band is 7100-7425 MHz. See: https://www.acma.gov.au/television-outside-broadcast-72-ghz-band. Appendix 1 of RALI FX-03 has the channel plan for the band, and the 7.2 GHz TOB band can be found here: https://www.acma.gov.au/sites/default/files/2022-10/7-2%20GHz%20band%20plan%20-%20Oct%2022.pdf.

There is some evidence that shows that this is not necessarily the case, and that there may be potential for co-channel interference to PTP links from RLAN Access Points. We understand that CEPT is continuing to seek input on this work item. [44] [45] [46] [47]

Telstra proposes the ACMA adopt a staged approach to this link clearance project. The highest priority is likely to be metropolitan areas, followed by the larger regional centres. There is a relatively small number of PTP links that deny access to 6 GHz spectrum for IMT in these areas.

A far greater challenge exists in regional and remote Australia where the majority of PTP links are located. We submit that in these areas, IMT could be licensed on a site-by-site basis under either Apparatus Licensing or an Area Wide Licence. This would then obviate the need to unnecessarily clear a large number of PTP in regional or remote areas where IMT is less likely to be deployed.

Nevertheless, some frequency planning ‘challenges’ exist because, if the 6.7 GHz band is no longer available for use, the alternative options include the 7.5, 8, 11 GHz or even higher frequency bands. These bands already have high occupancy, and higher frequency bands may not support the longer path lengths that are traversed by some 6.7 GHz PTP links.

3.5 Coexistence with C Band FSS

It is important to recognise that as spectrum in the 3400-4200 MHz range is being progressively assigned for IMT on a global scale, there is a corresponding decrease in the use of C band frequencies to support FSS services. It is therefore logical that FSS use of frequencies in the 6 GHz range (used for its paired C band FSS uplinks) will also decrease over time.

To date, the IMT/FSS co-existence studies have been based on the current scale of satellite deployment. However, constraints on future IMT deployment in this band need to recognise the decline in the use of C band for FSS links, so it seems likely that any constraints would be become less restrictive over time. Therefore, the corollary of ACMA’s success in refarming the C-Band for IMT services in Australia is that the 6 GHz band also becomes available for IMT services for the benefit of the country.

3.5.1 Protection of FSS satellite receivers (Earth to Space)

During the 4-year cycle leading up to WRC-23, sharing studies were conducted aimed at understanding the interference from terrestrial mobile networks using the Upper 6 GHz band into satellites in geostationary orbits. To mitigate such interference, various elevation masks were proposed to limit the emissions toward the satellite receivers.

At WRC-23 it was agreed to apply an elevation mask to terrestrial base stations to ensure coexistence/protection of GSO satellites receivers from the **aggregated emissions** from IMT base stations in the 6 GHz band. The mask is defined in resolves 2 of Resolution 220, as is a description of

[44] Report to CEPT CE45 Meeting #20 from PTS (Swedish Regulator)

[45] ECC Report 235 - Assessment of the feasibility of the possible joint use, on a long term basis, of the adjacent bands 5925-6425 MHz and 6425-7125 MHz for P-P links

[46] ECC Report 302 - Sharing and compatibility studies related to Wireless Access Systems including Radio Local Area Networks (WAS/RLAN) in the frequency band 5925-6425 MHz

[47] ECC Report 316 - Sharing studies assessing short-term interference from Wireless Access Systems including Radio Local Area Networks (WAS/RLAN) into Fixed Service in the frequency band 5925-6425 MHz

the methodology used to characterise the IMT base station emissions above the horizon. These details can be found in the Conference Preparatory Meeting's Report (CPM Report)[48] to WRC-23.

We support the ACMA's proposal to include this elevation mask as a licence condition on IMT licences (Spectrum or AWL) for the Upper 6 GHz band. This is sufficient to protect geostationary satellites from any interference effects from terrestrial IMT base station transmitters in Australia when using the Upper 6 GHz band[49].

3.5.2 Coexistence between 6 GHz IMT and FSS Earth Station uplink transmitters

Currently parts of the Upper 6 GHz band are used for FSS uplinks. We have identified that three of these earth stations are located in or near capital cities (Sydney, Perth and Ningi (near Brisbane)), with another two being located in regional Australia (Uralla), and remote Australia (Mingenew).

As these earth station transmitters may cause harmful interference to nearby IMT base stations and user terminals, Telstra proposes that these be subject to the same reallocation period as would apply to PTP links in the same geographic area. Certainly, the three earth stations in Sydney, Perth and Ningi should be required to surrender their licences at the end of the relevant reallocation period. We note that the Earth stations at Uralla and Mingenew are already located in Earth Station Protection Zones (ESPZ).[50] As RALI MS44 does not identify any active transmitters in the Uralla ESPZ, it might need to be reviewed pending the outcome of this consultation.

By relocating the services using the Upper 6 GHz to locations to within a remotely located ESPZ, it would allow the licensees to continue to operate their earth station transmitters and receivers with the protection afforded by RALI MS44.

This situation is an excellent example of the ACMA's concept of providing long-term security for the satellite industry by identifying suitable ESPZ locations away from the more densely populated areas of Australia. This would ensure that such satellite ground stations don't deny access to spectrum that has been reallocated to terrestrial services in the more densely populated areas, thus enabling the spectrum to reach its highest value use.

3.6 Reallocation period

The length of reallocation period should reflect both the needs of the incoming service, as well as any constraints on the re-deployment of incumbent services. As mentioned earlier in this submission, we expect the 6 GHz band will first be used to deliver 5G Advanced services and then will likely spearhead the introduction of 6G networks to Australia. The IMT ecosystem is expected to reach a stage of maturity where deployment of 6G networks would begin from 2030 onwards. We therefore propose that the reallocation period for metropolitan areas conclude by the end of 2029. Given the challenges brought about by the need to replace many fixed PTP links servicing regional centres that may also be

48 ITU, 2023, Report of the CPM on technical, operational and regulatory/procedural matters to be considered by World Radiocommunication Conference 2023.

49 Some informal sharing studies indicate that since the Australian deployment of 6 GHz IMT stations is likely to be relatively low density and would be geographically diverse compared to examples used in the ITU sharing studies, the aggregate interference seen by satellites in geostationary orbits from Australian IMT base stations in this band is likely to be insignificant.

50 RALI MS44 - Frequency coordination procedures for the earth station protection zones

identified for spectrum licensing, we propose that the reallocation period for those areas conclude three years later at the end of 2032.

Appendix 1: Answers to the ACMA's consultation questions

This appendix contains answers to the ACMA's consultation questions.

1. What are your views on the 4 broad planning options identified for the Upper 6 GHz band?

We support Option 3, as this option allows us to meet demand for mobile traffic growth towards the end of this decade and is a primary band for consideration with the introduction of 6G. This option also enables the entire 6 GHz spectrum range (both lower and upper bands) to achieve its optimal use.

2. If we decide to divide the band into different RLAN and WA WBB segments, should the WA WBB segment:

a) be a multiple of 100 MHz? This would align with the largest 3GPP channel size (noting that the ability for WA WBB operators to deploy one or more 100 MHz channels will depend on the outcome of the assignment process)

b) align with the 160/320 MHz wi-fi channel raster? This would maximise the number of the larger wi-fi channels available (by avoiding options that would split these channels).

We do not support the band being divided for RLAN and IMT, however, if the ACMA decides to proceed in this manner, we support 100 MHz multiples.

3. Of the segmentation options based on wi-fi channels (options 1–3 in this paper), what is the preferred option and why?

Telstra supports Option 3.

4. Is it appropriate to limit our consideration of hybrid options for accommodating multiple services to frequency segmentation only? For example, should geographic segmentation or less traditional sharing models be considered when determining models for enabling access to the Upper 6 GHz band by both WA WBB and RLAN services?

We do not support the band being divided between RLAN and IMT. Whether by frequency segmentation or by geographic segmentation or through the use of dynamic sharing schemes such as using different locations (e.g. sports stadiums) at different pre-arranged times (as contemplated in the UK) or forms of dynamic sharing that involve sensing another service operating before using a channel ('listen before talk' models). All forms of sharing introduce interference issues that require guard bands (in the case of spectrum sharing) or buffer zones (geographic sharing) or result in degraded performance. Dynamic sharing schemes also introduce the risk that a device will not "hear" another service (e.g., where a RLAN is indoors does not "hear" a weak IMT signal outdoors because it is a reasonable distance from the base station).

We note that with these so-called hybrid options there is a substantial risk of mutual harmful interference between Wi-Fi and IMT uplink and downlink, and significant degradation in the performance of both Wi-Fi and IMT if they are to operate co-channel in the same geographic area and at the same time. For example, studies on downlink directions (both indoors and outdoors) show:[51]

- Interference from Wi-Fi to IMT downlinks. Wi-Fi will keep transmitting as it is unable to detect the presence of IMT downlink signals. Thus the Wi-Fi transmissions thereby cause potential harmful interference to IMT. The IMT downlink throughput would be substantially degraded as a result of emissions from the Wi-Fi.
- Interference from IMT downlink to Wi-Fi. If Wi-Fi can detect received IMT downlink signals, Wi-Fi will cease transmissions resulting in zero Wi-Fi throughput. If Wi-Fi cannot detect received IMT downlink signals and the Wi-Fi does transmit signals, the IMT downlink signals would reduce the Wi-Fi throughput.

We do not believe that there are any mitigation techniques to enable co- channel sharing between IMT and Wi-Fi in 6 GHz band. Possible options like geographic separation is not practical in this case: demand for IMT and Wi-Fi is typically at the same locations (e.g. dense urban/suburban areas); and the location of Wi-Fi may not always be known with sufficient accuracy. Using a database is not always practical and there are examples in other global markets, for example in relation to TV White Space (TVWS) where it has not been successful.

Further, the ability of Wi-Fi to detect IMT would improve if the Wi-Fi detection threshold is decreased. But this has a number of implications including: (a) the reduction of the Wi-Fi detection threshold will make Wi-Fi more sensitive to other Wi-Fi radio services (a Wi-Fi radio would need to compete with many other Wi-Fi radios for access to the channel) as well as other co-channel services, which would result in less stable use of Wi-Fi; and (b) it may require a change of the protocols at Wi-Fi side, which may imply additional work on the applicable standards, implementation costs, and additional equipment hardware costs.

[51] Scott Minehane, Presentation, *Important approaches to sharing in the 6 GHz band,* 10th Asia-Pacific Spectrum Management Conference, Jakarta, 24 April 2024

Appendix 2: Details of Coleago Consulting study on the quantum of additional mid-band spectrum needed by 2030

In 2021, the Australian Mobile Telecommunications Association (AMTA) commissioned Coleago to complete a study to compute the amount of IMT spectrum which the industry and mobile operators need going forward. The analysis, focusing on Sydney, Melbourne and Brisbane, found that up to an additional 827 MHz in mid-band spectrum was needed in the 2025-2030 timeframe.

Estimating the Mid-Band Spectrum Needs in the 2025-2030 Timeframe' report by Coleago Consulting Ltd for the GSMA (July 2021)

Coleago Consulting's initial global study (which did not include Australia) examined mid-band spectrum requirements for the 5G spectrum rollout. Mid-band spectrum offers a good mixture of coverage and capacity and hence access to an increasing amount of mid-band spectrum is key to the 5G era.

Coleago and the GSMA found that particularly in high-density areas, more IMT spectrum is needed to deliver a user experience of 100 Mbps in downlink and 50 Mbps in the uplink. Their modelling found that substantial amounts of mid-band spectrum are required to deliver this quality of 5G service in cities with a population density of more than 8,000 people per km^2. Densely populated cities need, on average, a total of 2 GHz of mid-band spectrum. Precise spectrum demands vary depending on population density, fibre availability and other factors.

Total mid-band spectrum needs in the 2025-2030 timeframe

	Minimum Estimate	Maximum Estimate
High income cities	**1,260 MHz**	**3,690 MHz**
Upper middle income cities	**1,020 MHz**	**2,870 MHZ**
Lower middle income cities	**1,320 MHz**	**3,260 MHz**

Source: GSMA, July 2021

The study notes that small cell densification is not an economically feasible substitute for additional mid-band spectrum. Significantly increasing outdoor small cells would increase power consumption, be very costly, and have a negative impact on the city environment from an aesthetics point of view. Additional base stations would generate a carbon footprint 1.8-2.9x higher without sufficient spectrum.

The study also explored whether mmWave could be a substitute to additional mid band spectrum. Coleago Consulting found that mmWave densification approach would not represent a viable option, being very costly and undesirable from an environmental perspective due to the large number of sites.

In areas with a population density below 8,000 per km^2, additional spectrum would also deliver benefits including lower site density and higher speeds, and the ability to deliver fibre-like 5G FWA to small towns.

In conclusion, the GSMA recommends that governments and regulators:

- plan to make 2 GHz of mid-band spectrum available in the 2025-2030 time frame. This is the average value needed to guarantee the IMT-2020 requirements for 5G;

- carefully consider 5G spectrum demands when 5G usage will be reaching its peak, and advanced use cases will carry additional needs;
- base spectrum decisions on real-world factors including population density and extent of fibre rollout; and
- support harmonised mid-band 5G spectrum (e.g. within the 3.5 GHz, 48 GHz and 6 GHz ranges) and facilitate technology upgrades in existing bands.

As the GSMA/Coleago Study July 2021 did not include Australia, AMTA engaged Coleago Consulting to re-run its projections on the mid-band spectrum need in Australia's largest and most population dense cities. Coleago carried out a population density analysis of Sydney, Melbourne and Brisbane[52] all of which have a sizeable densely populated area. Compared to the cities analysed in the Global report, population densities in those three cities are at the lower end of the scale, but still sufficiently high to require significant amounts of mid-band spectrum beyond that which is currently available.

The Coleago analysis shows that in Sydney there is a need for 1,230 to 1,440 MHz of mid-band spectrum compared to 703 MHz currently assigned to operators. Therefore, to deliver the city-wide 5G user experience in an economically and technically feasible manner in the 2025-2030 timeframe, an additional 527 to 757 MHz of mid-band spectrum is required. For Melbourne an additional 587 to 827 MHz is needed and for Brisbane it is an additional 379 to 569 MHz. This is summarised in the figure 9 below.

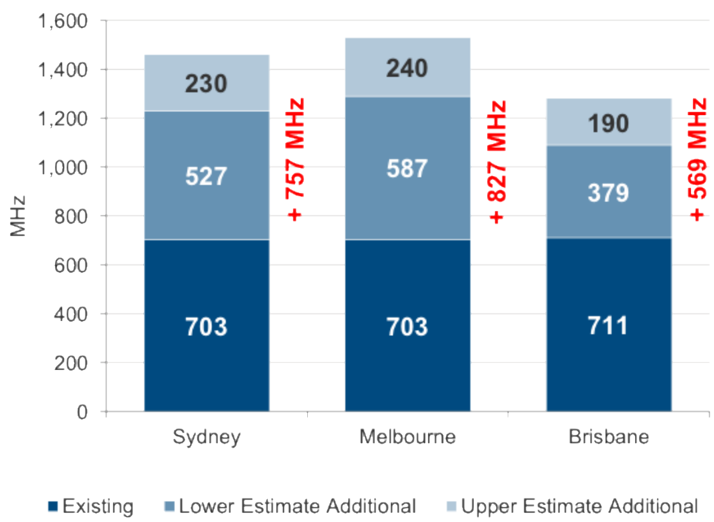

Figure 9: Mid-band spectrum needs in Australian cities

Source: Coleago, Estimating the mid-band spectrum needs in the 2025-30 time frame in Australia, November 2021

Importantly since that time, especially in Sydney and Melbourne, urban densification as a way to build reduce urban sprawl, rapidly build new housing etc has markedly increased driving even higher estimates of IMT spectrum demand then those only done in 2021.[53]

52 IMT Spectrum demand. Estimating the mid-bands spectrum needs in the 2025-2030 time frame in Australia, Coleago Consulting Ltd, 15 November 2021

53 https://www.abc.net.au/news/2024-04-28/housing-density-surging-in-sydney-and-melbourne-but-prices-rise/103773604