Optimising IMT and Wi-Fi mid-band spectrum allocation:

The compelling case for 6 GHz band partitioning in Asia-Pacific

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Optimising IMT and Wi-Fi mid-band spectrum allocations: The compelling case for 6 GHz band partitioning in Asia-Pacific

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REPORT BY
WINDSOR PLACE CONSULTING PTY LTD

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Report Author:

Scott Minehane is the Managing Director of WPC and an international regulatory and strategy consultant in the telecommunications sector who has been involved in advising international organisations including the ITU, World Bank, ASEAN, APT, and the GSMA, investors, operators, Governments and regulators in Australia, Asia, the Pacific and Africa for over 30 years. His expertise extends to policy, legislative drafting, regulation, spectrum management, national broadband network and new generation fixed and mobile technologies including 5G.

WPC's staff and associates namely Simon Molloy, Chris Zull, Michelle Benington and Olga Kerry were also involved in the preparation of the report.

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1 EXECUTIVE SUMMARY

The Asia-Pacific includes some of the world's most populous countries, such as China, India, Indonesia, Pakistan and Bangladesh, and some of the smallest countries on the planet, especially the small island states of the Pacific. ICT adoption therefore also differs considerably among economies in the region, and Internet usage rates range from more than 90 per cent in the advanced economies to less than 15 per cent in the region's least developed economies. According to the United Nations, seven of the top ten largest cities in the world are located in Asia, and Asia has the most mega cities of any continent. India and China are projected to have 416 and 255 million urban dwellers respectively by 2050.

In this context, it is critical that the Asia-Pacific critically examine its approaches to mid-band spectrum for 5G and its evolutions, especially for the 6 GHz band. It is important that such approaches are bespoke; customized for the region today and its future. As this spectrum band represents the largest remaining single block of spectrum which could be allocated for mobile services in the mid-band, it is critical to get right. While we ought to be informed by the approaches in North America and Europe to the 6 GHz band, the unique characteristics of the region including the legacy allocations of spectrum in ITU Region 3, necessitate the early partitioning of the 6 GHz band between IMT and Wi-Fi uses.

The assessment contained in this report finds there is a compelling case for policy makers, regulators and mobile network operators (MNOs) in Asia-Pacific to allocate only the lower part of the 6 GHz band (5925-6425 MHz) for unlicensed use with the upper part of the band (6425-7125 MHz) to be allocated for IMT services as soon as practicable.

Crucially such an approach preserves future flexibility as any assignment of the 6 GHz band to unlicensed use is not a decision that can be reversed, this is quite different to the assignment of the 6 GHz band to licensed uses. Importantly, a decision to allocate the upper part of the band (6425-7125 MHz) to IMT services can be made now before 2023 at the WRC-23.

The major reasons for this recommended approach are *inter alia*:

(i) An acute need for additional mid-band spectrum in Asia-Pacific given lack of C-Band and low-band spectrum which could be partially addressed by the partitioning of the 6 GHz band. Early field studies show that the 6 GHz band is a very good substitute for the 3.5 GHz band in terms of performance; and

(ii) A large allocation to Wi-Fi does not of itself address the digital divide: The allocation of the entire 6 GHz band for unlicensed use does not provide additional coverage and help bridge the region's urban digital divide which COVID-19 pandemic has highlighted is a key public policy issue;

(iii) The allocation of 1,200 MHz of prime spectrum to Wi-Fi is not supported by any demand analysis. Further, such a decision would be premature as experience and studies are showing that faster broadband services (especially 5G)/larger data allowances/ recharges mean reduced Wi-Fi offload;

(iv) Strong regional FWA growth supports an IMT allocation in the 6 GHz band: Growth in 4G and 5G FWA in Asia-Pacific region (which has underdeveloped fixed network infrastructure especially fibre deployments) would be supported by reservation of additional mid-band spectrum in the 6 GHz band to support additional users and higher download usage patterns;

(v) The likely economic benefits are maximised with shared allocation of the 6 GHz band spectrum as the short and long term economic benefits of improved IMT and Wi-Fi services can both be secured;

(vi) Partitioning the 6 GHz band assists in future proofing for upcoming 6G services;

(vii) Making more IMT spectrum in the 6 GHz band supports strong mobile/ wireless competition by making available 700 MHz of additional mid-band spectrum. This will ensure at least 3 to 4 MNOs in a market have sufficiently large IMT spectrum portfolios to provide high speed, high quality wireless broadband and to be viable/sustainable in commercial terms; and

(viii) Possible additional proceeds to Government arise from the allocation of IMT spectrum in the 6 GHz band.

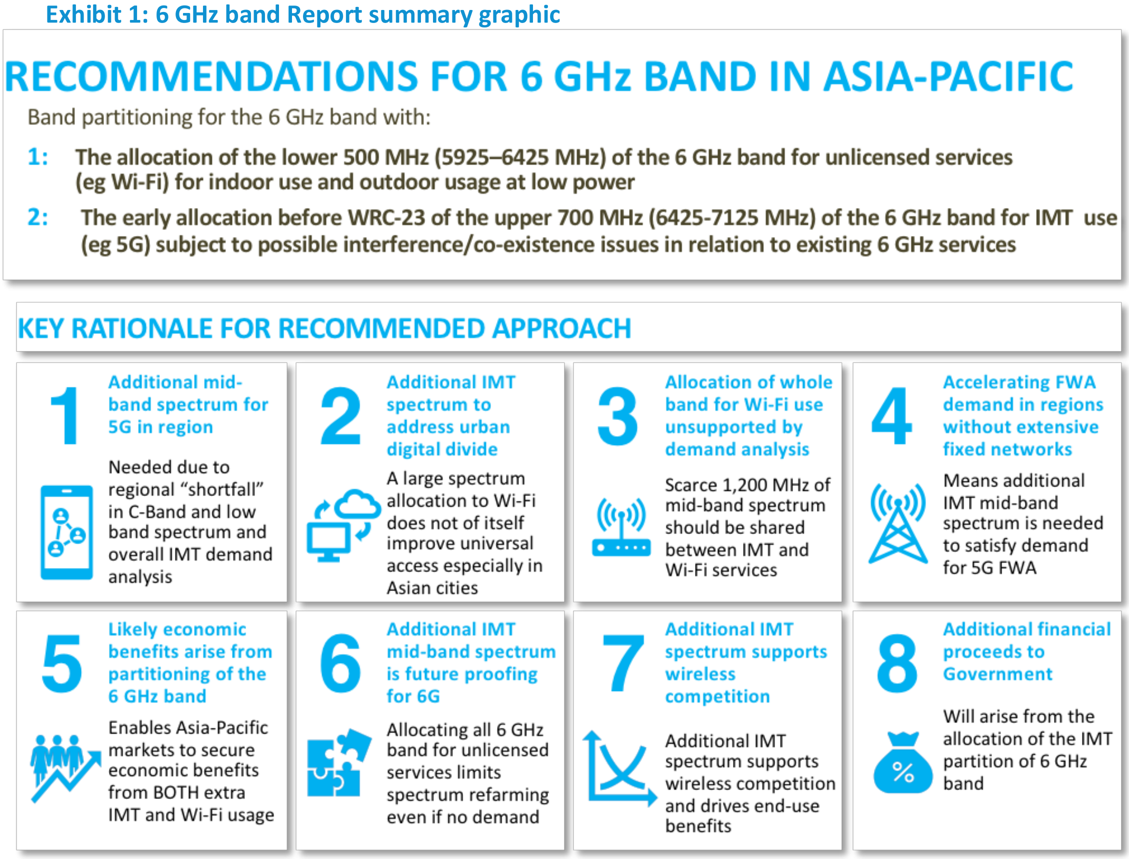
In terms of technical issues, it is further recommended that:

- ***Lower part of the band:*** The allocation of the lower part of the 6 GHz band (5925-6425 MHz) for unlicensed use should generally be restricted to indoor use with a maximum mean EIRP 23 dBm), or very low power 25 mW (14 dBm) outdoor; and
- ***Upper part of the band:*** The allocation of the upper part of the 6 GHz band (6425-7125 MHz) for IMT use, will be subject to addressing the possible interference/co-existence issues in relation to existing 6 GHz services, namely FSS and FS services.

Importantly, there's wide industry support for IMT services in the 6 GHz band – it is a high priority band for many MNOs and vendors. The 3GPP has already started its standardisation work and with at least China and Russia supporting the band (both announced trial plans in 2021), there will be an affordable network and device ecosystem for the band.

The recommended approach contained in the report is best summarized in Exhibit 1 below.

Exhibit 1: 6 GHz band Report summary graphic



2 INTRODUCTION

2.1 Importance of spectrum in relation to the digital economy

The 6 GHz spectrum band is, like all other low and mid-band spectrum, a valuable resource that needs to be utilised and managed in a manner that will maximize national economic benefits. In addition to this general imperative, there are several contemporary factors which make it even more critical to allocate spectrum in this relatively lightly used band carefully and rationally especially in the Asia-Pacific region.

COVID-19 has considerably raised the stakes in the allocation and manage of spectrum. As the first pandemic of the Internet age, COVID-19 has dramatically demonstrated critical role in our digital systems play in the modern economy enabling a huge array of adaptions to problems thrown up by the pandemic. COVID-19 has rapidly driven broader and deeper adoption of digital systems and practices across the globe. Digital transformation, often spoken about in future terms, is happening now, due to the catalyst of the corona virus and its impact on humanity, global and domestic travel and trade and social interaction. Greater reliance on digital communications means that the issue of the digital divide is now drawn in sharper relief than previously. Refarmed, well allocated spectrum following exemplar spectrum management practices enables harmonised solutions and further integration in our digital economies.

The emergence of 5G is another factor following on the growth in 4G services underlining the importance of current IMT spectrum allocation decisions. The technical characteristics of 5G, primarily its capacity and low latency, will deliver great economic benefits across a range of uses, often described under the rubric, 'Industrial Revolution 4.0' (IR4.0: AI, machine learning, big data, IoT, automation etc). Given that 6 GHz band is a large, mostly lightly utilised mid-band in the spectrum landscape, and that 5G NR works best in large contiguous spectrum blocks, the importance of making forward-looking decisions by policy makers and spectrum regulators is obvious.

Our region, the Asia-Pacific region includes some of the world's most populous countries, such as China, India, Indonesia, Pakistan and Bangladesh, and some of the smallest countries on the planet, especially the small island states of the Pacific. ICT adoption therefore also differs considerably among economies in the region, and Internet usage rates range from more than 90 per cent in the advanced economies to less than 15 per cent in the region's least developed economies. According to the United Nations, seven of the top ten largest cities in the world are located in Asia, [1] and Asia has the most mega cities of any continent. India and China are projected to have 416 and 255 million urban dwellers respectively by 2050. [2]

One of the biggest ongoing challenges for regulators in the Asia-Pacific region (and indeed elsewhere in the world) is to design a process for allowing access to in demand IMT spectrum that ensures an efficient assignment of the available bandwidth at a fair price to licensees like MNOs; and ultimately delivers a competitive market and encourages innovation in mobile and wireless broadband services to support the digital economy and secure the benefits arising from IR4.0.

This is critical as an argument can be made that globally countries and regions that have allocated more IMT spectrum have been arguably better prepared to minimize the adverse impacts of the pandemic and its associated social distancing rules, especially when such IMT spectrum has permitted better connectivity for all of society including uneconomic and rural and remote users.

[1] United Nations, *The World's Cities in 2018 Data Booklet*.
[2] United Nations Department of Economic and Social Affairs, *68% of the world population projected to live in urban areas by 2050, says UN,* 16 May 2018

The objective of this paper is deceptively simple. Informed by the approaches in North America and Europe to the 6 GHz band, what it is the optimal approach to the allocation of the 6 GHz band between IMT and Wi-Fi uses in the Asia-Pacific region? What approach best takes account of the unique characteristics of the region including the legacy allocations of spectrum in ITU Region 3? What approach is best able to preserve future spectrum flexibility in relation to this band?

It is important to highlight that IMT (including 5G and its evolutions) and Wi-Fi 6/6E (and future versions) are more complementary, than competitors. As noted by commentators,[3] cellular mobile services (IMT services in the ITU world) will continue to remain the dominant wide-area technology for wireless internet connectivity; Wi-Fi will remain the dominant indoor technology for such connectivity. 5G hotspots or smartphones can "share" their IMT wireless connectivity using Wi-Fi; conversely many techniques developed in the cellular world are finding their way into Wi-Fi standards.

The rivalry which exists between IMT and Wi-Fi is about securing a key input – namely prime spectrum. It is also a rivalry between licensed (exclusive) and unlicensed (non-exclusive) spectrum rights. In this contest, IMT spectrum licensees (along with broadcasters and satellite providers) by continuing refarming earlier allotments of licensed spectrum previously used for 1G, 2G, 3G and 4G services have done considerably better than Wi-Fi industry. Wi-Fi by continuing to support antiquated and legacy devices has not been the most efficient spectrum user in relation to its earlier allocations in the 2.4 and 5 GHz bands. Hopefully this changes in Wi-Fi 7 and beyond.

2.2 Structure of the report

Compared with its objectives, the structure of this Paper is straight-forward. It comprises six parts focussing on the need for customised approach in Asia-Pacific to the 6 GHz band. It supports the early partitioning of the 6 GHz band between IMT and Wi-Fi. Its structure is as follows:

- Exploring the Global Proposals for the 6 GHz band (see Section 3);
- Key drivers of Global IMT Spectrum demand (see Section 4);
- Why the approach in Asia-Pacific to the 6 GHz band should be customised for the region (see Section 5);
- Recommended Approach: Undertaking the early partitioning of the 6 GHz band between IMT and Wi-Fi use (see Section 6); and
- Alternative Recommended Approach (See Section 7).

As will be explored, the examination contained in this report finds there is a compelling case for policy makers, regulators and mobile network operators (MNOs) in Asia-Pacific to allocate only the lower part of the 6 GHz band (5925-6425 MHz) for unlicensed use with the upper part of the band (6425-7125 MHz) to be allocated for IMT services in Asia-Pacific as soon as practicable.

WPC considers there are signs that the 6 GHz band will be a key frequency band for future 5G and its evolutions. The 6 GHz band offers good propagation properties and large contiguous bandwidth of 700 MHz (in accordance with our recommendation for band partitioning). Importantly, the 6 GHz band offers to licensees a good technical trade-off between capacity and coverage. It will be able to meet the different scenarios likely to be encountered in the Asia-Pacific region. Critically, deploying 5G commercial networks and its evolutions in the 6 GHz band will be at a materially lower cost which is a major consideration especially for developing countries in Asia Pacific. Deploying and operating 5G services in the 6 GHz band involves lower capex and opex costs compared with doing similar utilising mmWave band spectrum.

[3] Refer to Edward J Oughton, William Lehr, Konstantinos Katsaros, Ioannis Selinis, Dean Bubley, Julius Kusuma, *Revisiting Wireless Internet Connectivity: 5G vs Wi-Fi 6,* September 2020

3 EXPLORING THE GLOBAL PROPOSALS FOR THE 6 GHz BAND

The 6 GHz range is a mid-band frequency and has good coverage and capacity, making it most suitable for both licensed and unlicensed use.[4] Both IMT and Wi-Fi benefit would from additional mid-band spectrum. Proponents of the allocation of the 6 GHz band to both IMT and Wi-Fi use note the band's potential ability to support for health care, transport systems, and the Internet of Things (IoT), among others.

It should be highlighted that while the use of the 6 GHz band is currently on the agenda for the next ITU World Radiocommunications Conference in 2023 (WRC-23), a number of countries are already making important decisions on the use of this valuable mid-band spectrum. The sections below detail the current approaches to the 6 GHz band adopted globally while <u>Exhibit 2</u> summaries the 6 GHz band proposals in a selection of global and Asia-Pacific markets.

Exhibit 2: 6 GHz band proposals in selected global and Asia-Pacific markets

Country/Region	5925–6425 MHz	6425–7125 MHz
ITU	Agenda item 1.2 for WRC-23 will consider additional frequencies for IMT in 2 sections of the 6 GHz band (i) 6425–7025 MHz in ITU Region 1 (Europe, Russia, Africa, Middle East) and (ii) 7025–7125 MHz in all regions	
European Union	Unlicensed use. Allocation promulgated in Germany. France has begun consultations[5]	Agenda item 1.2 for consideration at WRC-23
Russia	Radio permission/registration is required in 5650-6425 MHz	Support IMT identification. On-going trials for use of this upper part of the band for IMT purposes
United States	Unlicensed[6]	
Australia	Current ACMA consultation on use of the 5 and 6 GHz bands[7]	
China		Support IMT identification
Indonesia	To be determined	Support Agenda item 1.2 study of IMT identification. Being studied and monitored for IMT ahead of WRC-23[8]
Japan	To be determined	Support IMT identification under AI 1.2
Malaysia	Current public inquiry paper by the MCMC.[9]	
New Zealand	Radio Spectrum Management (RSM) is considering the use of band[10]	
		Support Agenda item 1.2 study of IMT identification

[4] GSMA, *Capacity to Power Innovation: 5G in the 6GHz Band,* May 2021
[5] Refer to www.bundesnetzagentur.de/SharedDocs/Downloads/DE/Allgemeines/Presse/Pressemitteilungen/2021/20 2107 14_WLAN6GHz.pdf and www.arcep.fr/actualites/les-consultations-publiques/p/gp/detail/projet-decision- designant-frequences-bande-5945-6425-mhz-systemes-acces-sans-fil-incluant-reseaux-locaux-radioelectriques- 300721.html
[6] Refer to www.fcc.gov/document/fcc-opens-6-ghz-band-wi-fi-and-other-unlicensed-uses
[7] ACMA, *Exploring RLAN use in the 5 GHz and 6 GHz bands*, April 2021
[8] Dr Denny Setiawan, SDPPI, *Indonesia 5G Updates, APT Web Dialogue*, 30 August 2021, page 4
[9] MCMC, *Public Consultation Paper: Wireless Local Area Network (WLAN) in the 6 GHz Frequency Band*, 12 August 2021. Responses due 11 October 2021. Current use of the frequency range of 5925 MHz to 7125 MHz includes fixed service (terrestrial microwave links) and fixed- satellite service.
[10] Refer to www.rsm.govt.nz/projects-and-auctions/current-projects/planning-for-wlan-use-in-the-6-ghz-band/

Country/Region	5925–6425 MHz	6425–7125 MHz
Singapore	To be determined	Support Agenda item 1.2 study of IMT identification
South Korea	Unlicensed	
Thailand	Public hearing with NBTC Focus group, both IMT and unlicensed use under consideration	
Vietnam	To be determined	Support Agenda item 1.2 study of IMT identification and studies on the sharing and compatibility between IMT and existing primary services in band.

Source: Industry sources including regulator websites, September 2021

3.1 Option 1: Proposals to WRC-23 for upper part of band of the 6 GHz band (6425 – 7125 GHz) to be reserved for IMT usage

China, Russia and the African Telecommunications Union (ATU) were the main proponents at WRC-19 for the inclusion of Agenda item 1.2 for WRC-23. WRC-23 will consider additional frequencies for IMT in 2 sections of the 6 GHz band (i) 6425–7025 MHz in ITU Region 1 (Europe, Russia, Africa, Middle East) and (ii) 7025–7125 MHz in all regions.

Similar to many parts of Asia, Russia was motivated to support the allocation of 6 GHz spectrum to IMT purposes because of extensive use of satellite in the C-Band which has made the release of 3.5 GHz band spectrum for 5G very challenging. RCC[11] is currently developing a Recommendation on the *"Harmonized conditions for 5G-NR / IMT-2020 systems in the RCC countries in the frequency band 6425-7125 MHz*". Likewise it is understood that African Telecommunications Union (ATU) has recently formed its position on Agenda item 1.2 for WRC-23, stating its *"preliminarily support identification of the frequency band 6 425-7 125 MHz for IMT, taking into account the result of the coexistence studies in ITU-R"*.

The corollary of proposals to allocate the upper portion of the 6 GHz band is that the lower part of the band can be allocated for unlicensed/Wi-Fi use. On 30 June 2021, the European Commission ('EC') formally released the 480 MHz of lower 6 GHz band spectrum to Wi-Fi and other WLAN technologies, which is binding for EU member states. As a result, EU Member States shall designate the 5 945-6 425MHz frequency band and make it available for the implementation of WAS/RLANs by 1 December 2021.[12] This followed earlier European studies (see Exhibit 3 below).

Exhibit 3: European studies on the lower part of the 6 GHz band for unlicensed use

Since 2017, the European Communications Committee (ECC) and European Telecommunications Standards Institute (ETSI) have both been looking into the possibility of introducing WAS/RLAN in parts of the 6 GHz band.[13] The study was limited to the 5925–6425 MHz frequency range, after the ECC opposed considering the additional 6425-6725 MHz frequency range.[14] CEPT was subsequently tasked with studying and identifying interference scenarios to identify possible coexistence conditions for RLANs operating within the 5925–6425 MHz band.[15]

CEPT Report 75 (November 2020) presented final recommendations on technical conditions for operating WAS/RLAN in the 6 GHz band:

[11] Regional Commonwealth in the Field of Communications (RCC). Refer to https://en.rcc.org.ru
[12] Official Journal of the European Union, *Commission Implementing Decision (EU) 2021/1067 on the Harmonised use of Radio Spectrum in the 5945 – 6425 MHz Frequency Band for the Implementation of Wireless Access Systems including Radio Local Area Networks (WAS/RLANs)* 30 June 2021
[13] See https://eccwp.cept.org/WI_Detail.aspx?wiid=627.
[14] The original ESTI study considered the need for additional licence-exempt spectrum in the 5925 MHz to 6725 MHz range: ETSI TR 103 524, *Wireless Access Systems Including Radio Local Area Networks (WAS/RLANs) In the Band 5925 MHz to 6725 MHz* (October 2018).
[15] CEPT ECC, *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,* approved 29 May 2019.

Continued:

- unlicensed use in the band, with 2 different power levels:
- low power (23 dBm, 10 dBm/MHz) for indoor use only
- very low power (14 dBm, 1 dBm/MHz).
- operation starting at 5945 MHz, giving a 20 MHz guard band to protect urban rail ITS.[16]

On 17 June 2021, EU decision 2021/1067 was implemented, which allocated 480 MHz of spectrum in the lower 6 GHz band for unlicensed use. The reasons stated for increasing spectrum resources for the provision of wireless broadband via WAS/RLAN were the rising connection speeds and data traffic volumes, and to improve wireless connectivity in the EU and allow the internal market to benefit.[17]

The EC chose to release the lower 6 GHz frequency band to improve wireless connectivity in the EU and to achieve their target of all main socio-economic drivers — including schools, transport hubs and main providers of public services as well as digital intensive enterprises — having access to internet connection with download or upload speeds of 1 gigabit of data per second by 2025. The EC is also aiming for all houses in the EU to have internet connection with a download speed of at least 100 Mbps which can be upgraded to 1 Gbit/s.[18]

The recommended framework identifies two use cases for the 480 MHz: (i) low power indoor ('LPI'), which restricts use to buildings, trains with metal coated windows and aircraft; and (ii) very low power ('VLP') which can be used indoor and outdoor.[19]

Germany's Federal Network Agency has already published its allocation for Wi-Fi use in the 6 GHz range in accordance with the EC's release.[20] This has made Germany the first country in Europe to permit lower 6 GHz operation for Wi-Fi. France was quick to follow with a public consultation released in July 2021 regarding the 6 GHz band as summarised in Exhibit 4 below. The United Kingdom while no longer a member of the European Union has also taken a similar approach.

Exhibit 4: Other European country approaches on the allocation of lower part of the 6 GHz band for unlicensed use

France:

Following on from decision (EU) 2021/1067 of 17 June 2021, ARCEP, the French regulator, published a consultation paper on 30 July 2021 regarding the designation of 480 MHz in the 6 GHz band.[21] This consultation will close on 30 September 2021. Currently in France, there is 538.5 MHz of spectrum for indoor use and 338.5 MHz of outdoor spectrum for WAS/RLAN. The additional radio frequencies for WAS/RLAN are anticipated to provide the wide channels for many applications such as video conferencing, media downloads, telemedicine, online learning and games, augmented reality and virtual reality which need extended bandwidth to achieve gigabit speeds. The 480 MHz will be designated on a non-exclusive, interference free and unprotected basis.

[16] ACMA, *Exploring RLAN Use in the 5 GHz and 6 GHz Bands: Discussion and Options Paper*, April 2021, page 24, citing CEPT Report 73, *Assessment and Study of Compatibility and Coexistence Scenarios for WAS/RLANs in the Band 5925–6425 MHz,* 6 March 2020.
[17] Official Journal of the European Union, *Commission Implementing Decision (EU) 2021/1067,* Volume 64, 30 June 2021.
[18] *Ibid* page 1.
[19] *Ibid* pages 2–3.
[20] Federal Network Agency, *Press Release: WLAN usage now also in 6 GHz range*, 14 July 2021.
[21] ARCEP, '*Public consultation: Draft decision designating frequencies in the band 5945-6425 MHz for wireless access systems including networks radio rooms*', 30 July 2021

United Kingdom:

In January 2020, Ofcom consulted on the potential introduction of RLAN devices into the 'lower 6 GHz' band (5925–6425 MHz). In July 2020, Ofcom released 500 MHz of spectrum in the 6 GHz band for unlicensed use.[22] The UK now allows devices to operate unlicensed in the lower 6 GHz band but restricted to indoor use with a maximum mean EIRP 250 mW (24 dBm), or very low power 25 mW (14 dBm) outdoor. The maximum allowed power density for indoor use is 12.6 mW/MHz (11 dBm/MHz), allowing 20 MHz channels to be used.

Ofcom acknowledged that allowing unlicensed access to the 6425–7125 MHz band would enable more wider channels. However, they decided not to open the full 6 GHz band for RLAN at the present time and will keep this decision under review.[23]

In the Asia-Pacific region, in Australia, the Australian Communications and Media Authority (ACMA) is still undertaking a review of the 6 GHz band but their initial view is that "we believe there is sufficient momentum internationally to propose that the lower 500 MHz (5925–6425 MHz) of the 6 GHz band be made available for [Wi-Fi] use'.[24] See the detailed summary of ACMA's review in Exhibit 5 below.

Exhibit 5: Australia: ACMA public review of the 6 GHz

As part of the latest five-year spectrum outlook process, ACMA is investigating whether to open up access to the 6 GHz band for radio local area network (RLAN) systems.[25] ACMA has progressed the 6 GHz band to 'initial investigation', stating that '[a]s a starting point for discussion on the future of the 6 GHz band, we believe there is sufficient momentum internationally to propose that the lower 500 MHz (5925–6425 MHz) of the 6 GHz band be made available for RLAN use'. It is not proposed that access be limited to RLANs – other devices that meet these technical conditions, such as 'unlicensed' variants of 4G and 5G technologies, would also be enabled under amendments to the current Low Interference Potential Devices (LIPD) class licence.[26]

Demand for unlicensed spectrum is expected to increase in Australia due to the rollout of 5G and increasing uptake of the national Broadband Network, as consumers expected WLAN performance not to be a limiting factor in overall performance of their home and business fixed and mobile broadband networks.[27] As access to faster broadband speeds becomes more commonplace in Australia, expectations will also increase for WLAN. This is in addition to the developments including augmented and virtual reality that will benefit from wider channels.

It was noted in ACMA's Discussion Paper that there does not appear to be any immediate demand for the upper portion of the 6 GHz band for IMT in Australia, and globally a clear case for allocation of the 6 GHz band to IMT is yet to develop. ACMA is currently seeking industry views on whether to include the upper 6 GHz band in the LIPD class licence, but proposes to consider this spectrum at a future time and adopt the arrangement recently implemented in the UK.

Other options that ACMA has indicated could be considered are:

- Continuing to limit RLAN use (at least initially) to the lower 500 MHz but with revised power limits and/or additional limitations.
- Making the entire band available for LPI and VLP, rather than restricting operation under the class licence to the lower 500 MHz.
- Permitting standard power devices (that is, higher power devices including outdoor operation) under a DSA-like arrangement such as the AFC system adopted in the US.[28] Under this approach, the ACMA would not develop and manage the DSA/AFC system and would instead look to industry to provide this service.

[22] Ofcom, *Improving spectrum access for Wi-FI: Spectrum use in the 5 GHz and 6 GHz bands*, 24 July 2020.
[23] *Ibid* page 72.
[24] ACMA, *Op cit*, page 1
[25] ACMA is also considering whether to update the existing arrangement for the adjacent 5 GHz band, to potentially reflect updates to international regulations made at WRC-19.ˇ
[26] ACMA, *Op cit* page 11.
[27] *Ibid* page 5
[28] Federal Register, Unlicensed Use of the 6 GHz Band, 26 May 2020, accessed 1 April 2021. www.federalregister.gov/documents/2020/05/26/2020-11236/unlicensed-use-of-the-6-ghz-band

3.2 Option 2: Allocation of entire 6 GHz band (5925 – 7125 MHz) for IMT/5G services

Going beyond their support for the inclusion of Agenda item 1.2 at WRC-23, China is considering test in 6GHz in 2021 for 5G and its evolution.[29] CAICT has listed the 6 GHz band as a frequency for 6G technology in accordance with the 6th Generation Whitepaper.[30]

The Chinese Ministry of Industry and Information Technology (MIIT) considers that the entire 6 GHz band should be allocated to IMT purposes to meet the increased demand for 5G: there are already 285 million 5G subscribers in China.[31] The 6 GHz band has been labelled the key frequency band for 5G and its evolutions because of its good propagation properties (it has a similar footprint to the 3.5 GHz band using MIMO antennas) and large contiguous bandwidth as well as the lower costs compared with the deployment of mmWave infrastructure. Further, it should be noted that Russia has commenced trials for the use of IMT services in the upper part of the 6 GHz band.

3.3 Option 3: Allocation of the entire 6 GHz band (5925-7125 MHz) for unlicensed usage

The final option is to make the entire 1200 MHz in the 6 GHz band available for unlicensed use. Following review, this option was been adopted in the United States in April 2020 by the Federal Communications Commission ('FCC') in order support Wi-Fi 6, increasing the amount of spectrum available for Wi-Fi by almost a factor of five.[32]

The whole band is available for low power indoor use, and most of the band also can be used by devices at higher power levels – both indoor and outdoor – by making use of an Automatic Frequency Co-ordination (AFC) system. The AFC is an online service that accesses the FCC's Universal Licensing System (ULS) data and can calculate the maximum allowable power for an unlicensed device based on (i) the device's geographic location; (ii) information in the ULS database about nearby licensed services and (iii) a predefined calculation method and set of parameters for protecting licensed services. This is depicted in Exhibit 6 below.

The AFC is designed to protect devices with fixed locations registered with the ULS – these are mainly fixed links. However setting up an AFC system is not a negligible task in both technical and regulatory aspects. Currently there are no studies that confirm that AFC system could guarantee adequate protection to fixed services and this now the subject of much debate and litigation in the United States on potential harmful interference. And the standards for AFC are yet to be developed. The fixed satellite service (uplink) is protected from receiving interference from aggregate signals from a large number of devices on the ground via antenna pointing restrictions – higher power devices must not radiate more than 21 dBm in a direction 30 degrees or more above horizontal. Radio astronomy sites are protected via geographic exclusion zones.[33]

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[29] www.ccsa.org.cn/detail/4267?title=IMT-2020%285G%29%E6%8E%A8%E8%BF%9B%E7%BB%84%E5%90%AF%E5%8A%A86GHz%E9%A2%91%E6%AE%B5IMT%E7%B3%BB%E7%BB%9F%E6%B5%8B%E8%AF%95

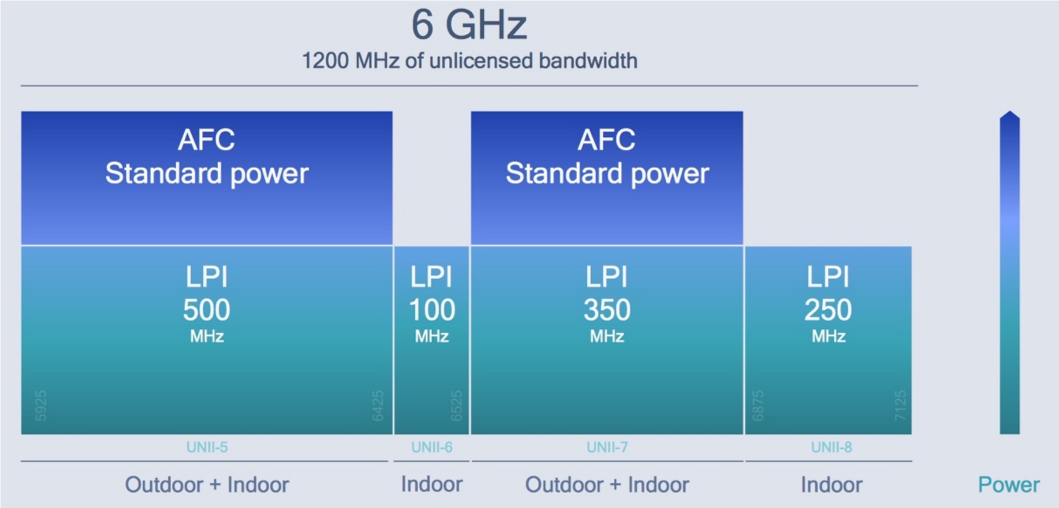
[30] www.caict.ac.cn/kxyj/qwfb/ztbg/202106/P020210604552573543918.pdf

[31] Zeng Fansheng, Bureau of Radio Regulation, MIIT, *Consideration of 5G Spectrum Planning & Future Development in China,* Asia Pacific Spectrum Management Conference, May 2021

[32] Cnet, *FCC Unlocks a Massive Amount of Bandwidth for Next-Gen Wi-Fi Devices,* 29 April 2020

[33] Extracted from ACMA, *Op cit*

Exhibit 6: Power levels for 6 GHz band in the USA



Source: Qualcomm, December 2020.[34] Note AFC= Automated frequency control, and LPI= Low power indoor

The argument is made that by allocating the entire band to Wi-Fi 6 will make Wi-Fi in the US two and a half times faster than the current standard.[35] The decision to open up the 6 GHz band for Wi-Fi was strongly supported by Google, Facebook and Apple, who stated that this decision would help increase wireless innovation and ensure better connections for Americans.

The approach of allocating the entire 6 GHz band to unlicensed use has now been adopted in a number of countries including Brazil, Canada, Chile and Saudi Arabia. In the Asia-Pacific region the approach has thus far only been adopted by South Korea.

[34] Qualcomm, *Global update on spectrum for 4G and 5G*, December 2020, page 9
[35] FCC News Release, *FCC Adopts New Rules for the 6 GHz Band, Unleashing 1,200 Megahertz of Spectrum for Unlicensed Use,* 23 April 2020.

4 KEY DRIVERS OF GLOBAL IMT SPECTRUM DEMAND

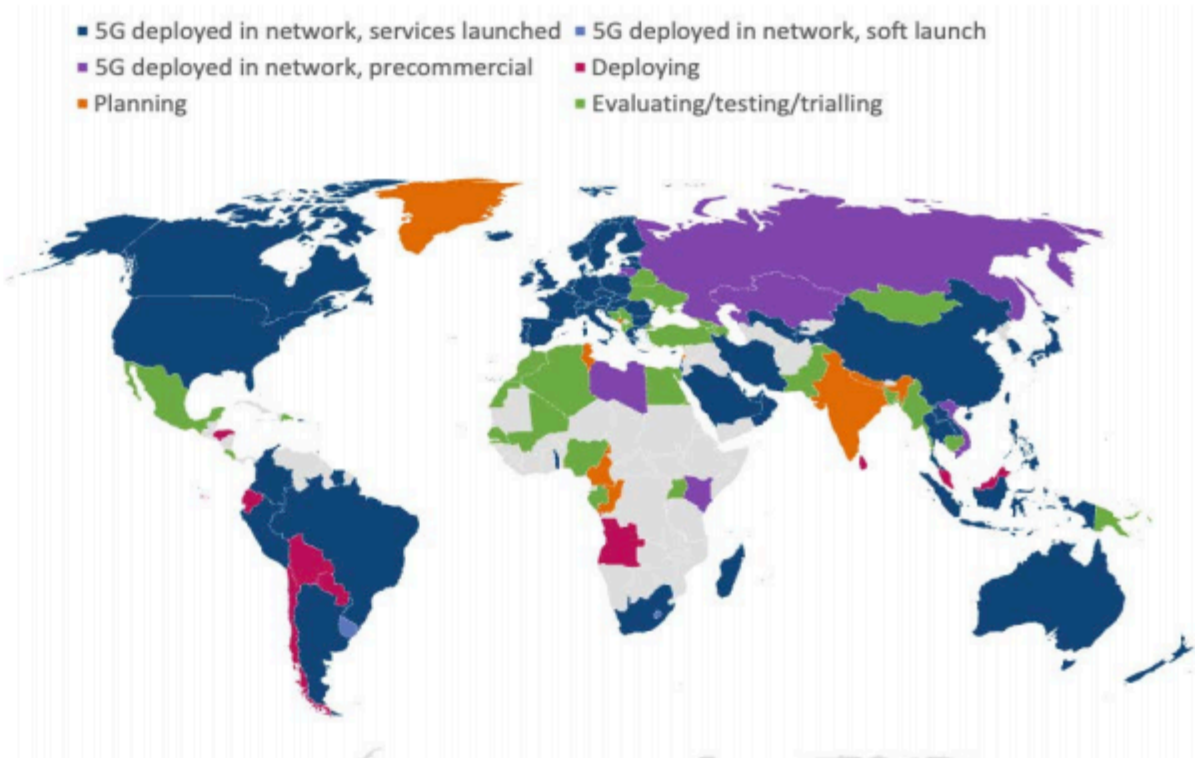
4.1 Rapid growth in 5G services with the transition from legacy 2G/3G services to 4G/5G services

There are a variety of global trends that are sparking a demand for more usable spectrum to be allocated to IMT services. These include *inter alia* 5G NR deployment which is optimised for larger contiguous blocks of spectrum, the switch-off of legacy 2G and 3G networks, the shift to remote working and learning due to COVID-19 lockdowns and other social distancing rules, and a consumer preference for faster and more secure wireless data rather than public Wi-Fi. These key trends are canvassed below.

4.1.1 Rapid 5G deployment is generating new IMT spectrum demands

There has been a rapid deployment of 5G and associated assignment of 5G spectrum globally since 2018. As of August 2021, according to the Global mobile Suppliers Association (GSA), 461 operators in 137 countries/territories are investing in 5G networks in the form of tests, trials, pilots, planned and actual deployments (see Exhibit 7**).**[36]   Further it is estimated that by 2026, globally there will be 3.6 billion 5G subscriptions (see Exhibit 8 over).

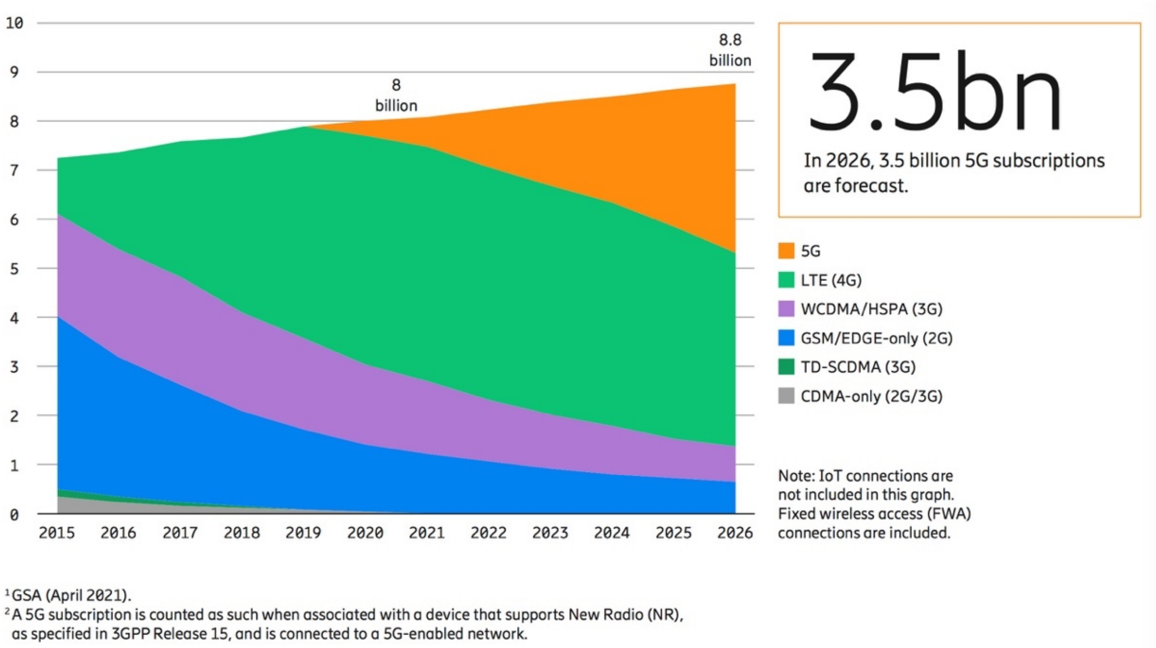
Exhibit 7: Countries/territories with operators known to be investing in 5G



Source: GSA, 5G Market: Snapshot, August 2021

[36] GSA, *5G Market: Snapshot,* August 2021.

Exhibit 8: Mobile subscriptions by technology (billion)[37]



The launch of 5G services which are "spectrum hungry" and operate optimally with larger contiguous blocks of IMT spectrum including new mmWave spectrum has driven a demand for increased IMT spectrum globally and in the region. This demand exists globally, although it is important to note that some countries have been more proactive and licensed significantly more spectrum for 4G and other services than others (see Exhibit 9). 5G has also necessarily resulted in MNOs globally considering whether to switch off their legacy 2G/3G networks and refarm spectrum for 5G, as discussed below.

Exhibit 9: IMT Allocated Spectrum by region ahead of WRC-19, 2019

	Region 1 (EU/ EFTA)	Region 1 (Arab Group)	Region 1 (Africa)	Region 1 (CIS/ Balkans)	Region 2 (Americas)	Region 3 Asia Pacific)
Average spectrum licensed (all countries)	757 MHz	556 MHz	477 MHz	430 MHz	426 MHz	**549MHz**
Percentage of harmonised spectrum licensed	60%	52%	44%	40%	41%	**60%**
Typical amount of spectrum yet to be licensed	300 ~ 400 MHz	500 ~ 600 MHz	500 ~ 700 MHz	600 ~ 700 MHz	500 ~ 600 MHz	**300 ~ 500 MHz**

Source: LStelcom, April 2019[38]

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[37] Ericsson *Mobility Report,* June 2021
[38] LStelecom, *Analysis of World-Wide Licensing and Usage of IMT Spectrum,* April 2019, page 9

4.1.2 The world is seeing an transition from legacy 2G and 3G services to 4G and 5G services

It will be too costly for any MNO to own and operate (including provide spares, staffing etc) 2G, 3G, 4G and 5G services concurrently.[39] Some rationalisation is required.

Exemplar markets in Asia-Pacific including Australia, Japan, New Zealand, Singapore, South Korea, and Taiwan, China are leading the way having switched-off legacy 2G/3G networks and refarming such IMT spectrum for 4G and 5G services. More than 20 networks utilising 2G technology have been switched off since 2010 in Asia and there are plans for many more to do so (see Exhibit 10).[40]

Exhibit 10: Selected announcements of Asia-Pacific switch-off of legacy 2G/3G networks

Markets	MNO	2G Status/Sunset Date	3G Status/Sunset Date
Australia	Telstra	December 2016	June 2024
	Singtel Optus	April 2017	2100 MHz spectrum, April 2022
	Vodafone - TPG	September 2017	2100 MHz spectrum, 2019
Bangladesh	Grameenphone	December 2025	December 2026
China	China Unicom	End 2021	Planned, no date given
	China Telecom	From mid-2020 onwards	From mid-2020 onwards
	China Mobile	From mid-2020 onwards	From mid-2019 onwards
Hong Kong, SAR	3 Hong Kong	30 September 2021 due to re-assignment of 900/1800 MHz	No set date
India	Airtel	December 2023	September 2020
	Vodafone Idea	No plan to switch off	Late 2021
	BSNL	No plan to switch off	December 2024
Indonesia	XL Axiata	December 2022	No set date
	Indosat	No set date	Phased switch-off started
Japan	NTT Docomo	March 2012	March 2026
	Softbank	March 2010	June 2024
	KDDI	March 2008	March 2022
Macao SAR	Hutchinson Telecom	Domestic users no access from June 2015, Roamers Aug 2019	No set date
	SmarTone Macau		No set date
	CTM		No set date
Malaysia	Maxis	No set date	Set by MCMC as part of Jendala program for December 2021
	Celcom	No set date	
	U Mobile	Service not provided	
	DiGi	No set date	
Myanmar	Telenor Myanmar	December 2025	December 2026
Nepal	Nepal Telecom	CDMA July 2021	No set date
New Zealand	Spark	July 2012	No set date
	2degrees	March 2018	No set date
	Vodafone	2025	2023-2025
Pakistan	Telenor Pakistan	December 2025	December 2025
Singapore	Singtel	Country-wide shut down from April 2017 co-ordinated by the IMDA	No set date
	M1		No set date
	StarHub		No set date
South Korea	KT	March 2012	No set date
	SK Telecom	July 2020	No set date
	LG U+	July 2021	No set date
Taiwan, China	Chunghwa Telecom		

[39] Refer to Scott Minehane, *The case for early downbanding to ensure affordable and sustainable 5G services in Vietnam and ASEAN,* ASEAN Conference on 5G, 21 March 2019 and GSMA, *Legacy mobile network rationalisation, Experiences of 2G and 3G migrations in Asia-Pacific,* May 2020
[40] Policy Tracker, *The 2G Switch Off is Happening Faster in Asia,* June 2020.

Markets	MNO	2G Status/Sunset Date	3G Status/Sunset Date
	Taiwan Mobile	Country-wide shut down from June 2017	Planned by 2024, facilitated by single shared 2100 MHz network for voice services[56]
	Far EasTone		
Thailand	dtac	December 2021	December 2025
Vietnam	Viettel	Country-wide shut down from January 2022	No set date
	Vinaphone		No set date
	Mobifone		No set date
	Gtel		No set date

Source: GSMA, Schedule for 2G and 3G network shutdowns for a Sample of APAC operators (in Legacy Mobile Network Rationalisation, 2020, page 6); WPC Research July 2021; Emnify Global 2G and 3G Phase Out/ Sunset: What do We Know so Far? (18 April 2021) and MCMC[41]

Additionally, the switching off of legacy networks allows MNOs to meet the increased demand for higher speed mobile broadband services and to provide connectivity to data-intensive applications from smart devices via the refarming/repurposing of that IMT spectrum.[42]

Even with such switch offs, deploying quality 5G services will require more IMT spectrum. In the *ITU-R Report, M.2290-0 (01/2014)*, *Future spectrum requirements estimate for terrestrial IMT,* predicted that between 1,340 and 1,960 MHz of spectrum would be needed for IMT services based on low and high demand situations by 2020. More recent reports from the GSMA discussed elsewhere in this report provide a compelling case for even more additional IMT spectrum in the mid-band.

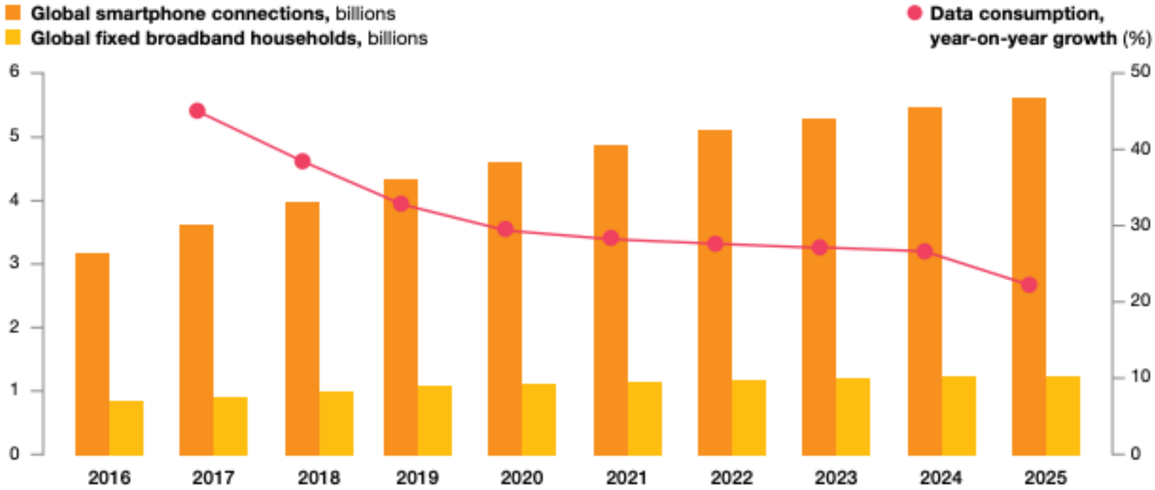
4.1.3 Consumer demands are shifting with the 'new normal' and working from home

During 2020 and 2021, the COVID-19 pandemic created new demands to allocate IMT spectrum to support higher bandwidth, greater speed and capacity, and improved quality of service and quality of experience. Total data consumption increased 30 percent during 2020,[43] and thus countries and regions that had allocated more IMT spectrum were arguably better prepared to minimize the adverse impacts of the pandemic.

The pandemic drove demand for internet access even higher and boosted global data consumption as a result. Some telecommunications providers were 'reportedly carrying up to 60 percent more data on their networks than they did before the crisis'.[44] Global data consumption grew more than 30 percent between 2019 and 2020, and is set to grow nearly as quickly this year (see Exhibit 11).

[41] Refer to: https://myjendela.my/Sitejendela/media/Doc/FAQ_3G_NETWORK_SUNSET.pdf.
[42] GSMA, *Legacy Mobile Network Rationalisation: Experience of 2G and 3G migrations in Asia-Pacific,* 2020 page 2.
[43] PWC, *2021 Outlook Segment Findings: Macrotrends*. Available at: www.pwc.com/gx/en/industries/tmt/media/outlook/segment-findings.html?WT.mc_id=CT1-PL52-DM2-TR2-LS4-ND30-TTA9-CN_GEMO-2021-segments-two
[44] PWC, *2021 Outlook Segment Findings: Data Consumption*.

Exhibit 11: Growth of wired and wireless infrastructure



Source: PwC: *Power Shifts: Altering the Dynamics of the E&M Industry*, page 7.

The trends that emerged last year regarding remote working, learning, shopping and more have continued and are unlikely to be reversed. Of those workers who engaged in remote work during the pandemic, 65 percent wish to remain remote workers.[45] As the pandemic has evolved, experts have predicted that people will develop greater reliance on swiftly evolving digital tools by 2025, further shaping demand.[46] The demand for data will therefore likely stay high and continue to grow strongly. Particularly in emerging economies, it is crucial rapidly to deploy 4G/5G coverage in urban and suburban areas, in order to support pandemic-driven data demand.[47] This is consistent with recent ITU recommendations on post COVID-19 recovery (see Exhibit 12 below).

Exhibit 12: Selected Key ITU COVID-19 recovery recommendations

Accelerate the assignment of available globally harmonized IMT spectrum

COVID-19 has meant that many people are more homebound than ever before, and this created new demands to allocated IMT spectrum to support higher bandwidth speeds, capacity, and improved Quality of Service (QoS) and Quality of Experience (QoE)

Accelerate 4G/5G deployment and the transition from legacy 2G/3G networks

To further support online demand created through the pandemic, there is a need to reform existing 2G/3G spectrum to 4G and 5G services. Such transitions should receive Governmental and regulatory support as it will provide significant additional wireless broadband speed and capacity.

Deployment of FWA and complimentary and substitute broadband networks

This measure was recommended in the COVID 1.0 paper to augment coverage and capacity over cities and urban areas subject to social distancing requirements. FWA services are particularly important in emerging markets due to its quick delivery and affordability.

Facilitate innovative and future technologies to bridge the 'digital divide'

The 'digital divide' has been highlighted during the pandemic because of the essential nature of fixed and mobile broadband service coverage. The resurgence of the pandemic in many parts of the world led to school shut downs and students learning from home, which further spotlighted the need to bridge the divide.

Source: Summary of ITU, GSR-20 Discussion Paper, Pandemic in the Internet Age: communications industry responses, June 2020

[45] World Economic Forum, *This is how much data we're using on our phones* 10 August 2021.
[46] Pew Research Centre, *Experts Say the 'New Normal' in 2025 Will be Far More Tech-Driven, Presenting More Big Challenges* 18 February 2021.
[47] ITU, *Pandemic in the Internet Age: From Second Wave to New Normal, Recovery, Adaptation and Resilience*, May 2021, page 2.

4.2 Evidence that faster broadband services (especially 5G) means reduced Wi-Fi offload

There is one issue to explore in some depth given the inter-relationship with the 6 GHz band. Both globally and regionally in Asia-Pacific, there is strong evidence that fast broadband services especially 5G results in consumers utilising Wi-Fi less, thus resulting in reduced Wi-Fi offload. In its recent paper, entitled *Quantifying the impact of 5G and COVID-19 on Mobile Data Consumption,* Opensignal concluded that:

> "***A faster, better, 5G experience encourages more cellular usage****: In the past, mobile users relied on Wifi and only used cellular connections when Wifi was not available.* ***With high quality 5G, mobile users will rely on their cellular connection more of the time which increases cellular mobile data usage. Opensignal has already seen a marked speed advantage for 5G over public Wifi.*** *Already, Apple offers options for 5G users to set their iPhone to use more data on 5G automatically, rather than restricting cellular mobile data use to be different to Wifi because of 5G's quality. Also, a faster 5G experience makes cellular more viable for users to tether devices to their smartphone and share the cellular connection.*"[48] [Our emphasis]

This is view shared by tefficient in its 2020 review of 105 global operators which it tracks. It found that the data usage per SIM basically grew for all operators and across those operators there was a global growth in mobile data traffic of 38 percent from 2019. tefficient considered this growth actually quite remarkable given the pandemic. It also stated that:

> *"The narrative that no mobile data would be used when people stay at home (and on Wi-Fi) didn't prove right".*[49]

If we examine South Korea which is an early regional 5G adopter, we find that there is decreasing Wi-Fi offload to the MNO's Wi-Fi networks (see Exhibit 13 below) notwithstanding that there is significant growth in wireless traffic.

Exhibit 13: Decreasing Wi-Fi offload to MNO's Wi-Fi networks in South Korea

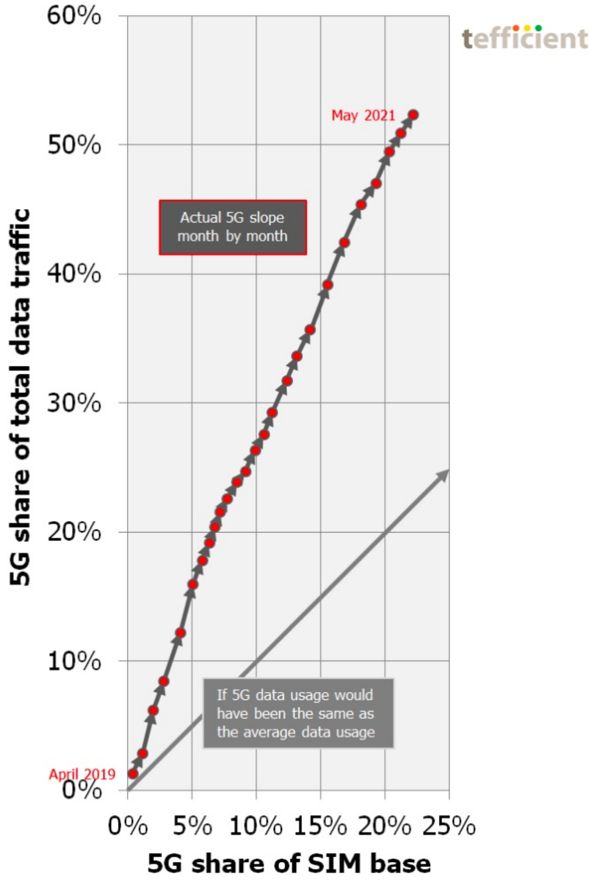
Period	Delivery by IMT services (TB)	IMT as a proportion of total data traffic	Delivery by Wi-Fi (TB)	Wi-Fi as a proportion of total data traffic	Total wireless data (TB)
Dec-15	175,103	92.6%	10,430	5.6%	185,533
Dec-16	254,639	94.2%	12,952	4.8%	267,591
Dec-17	315,152	95.3%	14,495	4.4%	329,647
Dec-18	404,656	96.4%	15,099	3.6%	419,755
Jun-19	479,414	96.9%	15,552	3.1%	494,966
Dec-19	568,375	97.4%	15,110	2.6%	583,485
Jun-20	603,612	97.9%	13,025	2.1%	616,637
Dec-20	701,529	98.5%	10,408	1.5%	711,937
Jun-21	780,662	98.4%	13,051	1.6%	793,713
Jul-21	786,729	98.6%	11,306	1.4%	798,035

Source: Korean Ministry of Science and Technology (MSIT), August 2021.[50] Excludes Wi-Bro traffic 2015 to 2018. IMT services includes 2G, 3G, 4G and 5G as applicable

[48] Opensignal, *Quantifying the impact of 5G and COVID-19 on Mobile Data Consumption*, June 2021, page 5
[49] tefficient, *Industry analysis* #1, 2021, 13 April 2021, page 28
[50] Refer to www.msit.go.kr/SYNAP/skin/doc.html?fn=55f72758d63d2cd4a31b794f513bc265&rs=/SYNAP/sn3hcv/result/

In fact according to tefficient in May 2021, a majority of the mobile data traffic in South Korea, some 52.4 percent mobile data traffic was handled over 5G (see Exhibit 14). This is notwithstanding that 5G represented only 22.2 percent of the total SIM base, indicating that the average mobile data usage per 5G subscriber in South Korea is far higher than for 3G/4G subscribers. In May 2021, 5G users used an average of 27.4 GB per month while 4G users used an average of only 9.4 GB per month.[51]

Exhibit 14: Korean 5G share of total traffic vs. 5G share of SIM base per month since the launch of 5G



Source: tefficient, July 2021

[51] Tefficient, *Industry analysis* #2, 2021, 31 July 2021, page 14

5 WHY THE APPROACH IN ASIA-PACIFIC TO THE 6 GHz BAND SHOULD BE CUSTOMISED FOR THE REGION

5.1 Overview

According to the ITU, the Asia-Pacific region has a population of 4.2 billion and 38 Member States, including 14 classified as small island developing states and 11 classified as least developed countries. It is one of the world's most diverse regions and home to economies that are at the top of digital economy worldwide and that are also global leaders in high-speed broadband access and usage.[52] Conversely, there remains significant segments of the region's population that are either unserved or underserved in terms of mobile broadband coverage.

At the same time, the Asia-Pacific region covering 11 times zones is extremely diverse in terms of income distribution, population size and the geographical features of countries, ranging from rugged mountainous areas in the Himalayas to isolated islands of the Pacific. There are also extreme variations in climate. Much of Asia Pacific experiences a vast annual range of temperatures, particularly in the west.[53] While the north of the region experiences a dryer climate, in the south it is more tropical. In a typical year, 80 to 85 percent of the rain in India and mainland Southeast Asia, often totalling 1.5-2.5 meters, falls during the summer monsoon season.[54]

The Asia-Pacific includes some of the world's most populous countries, such as China, India, Indonesia, Pakistan and Bangladesh, and some of the smallest countries on the planet, especially the small island states of the Pacific. ICT adoption also differs considerably among economies in the region, and Internet usage rates range from more than 90 per cent in the advanced economies to less than 15 per cent in the region's least developed economies. According to the United Nations, seven of the top ten largest cities in the world are located in Asia,[55] and Asia has the most mega cities of any continent. India and China are projected to have 416 and 255 million urban dwellers respectively by 2050.[56]

In this context, it is critical that the Asia-Pacific critically examine its approaches to mid-band spectrum for 5G and its evolutions, especially for the 6 GHz band. As this spectrum band represents the largest remaining single block of spectrum which could be allocated for mobile services in the mid-band, it is critical to get right. While informed by the approaches in North America and Europe to the 6 GHz band, the unique characteristics of the region including the legacy allocations of spectrum in ITU Region 3 necessitate the early partitioning of the 6 GHz band between IMT and Wi-Fi uses.

The reasons for such an approach would include the need for additional mid-band spectrum in the region given the relative lack of C-Band and low band spectrum, a large allocation to Wi-Fi does not of itself help bridge the digital dividend, the allocation of 1,200 MHz to Wi-Fi is not supported by demand analysis, the strong regional FWA growth supports additional IMT spectrum and the likely economic benefits arising from a shared allocation of the 6 GHz band. These reasons and others are explored below.

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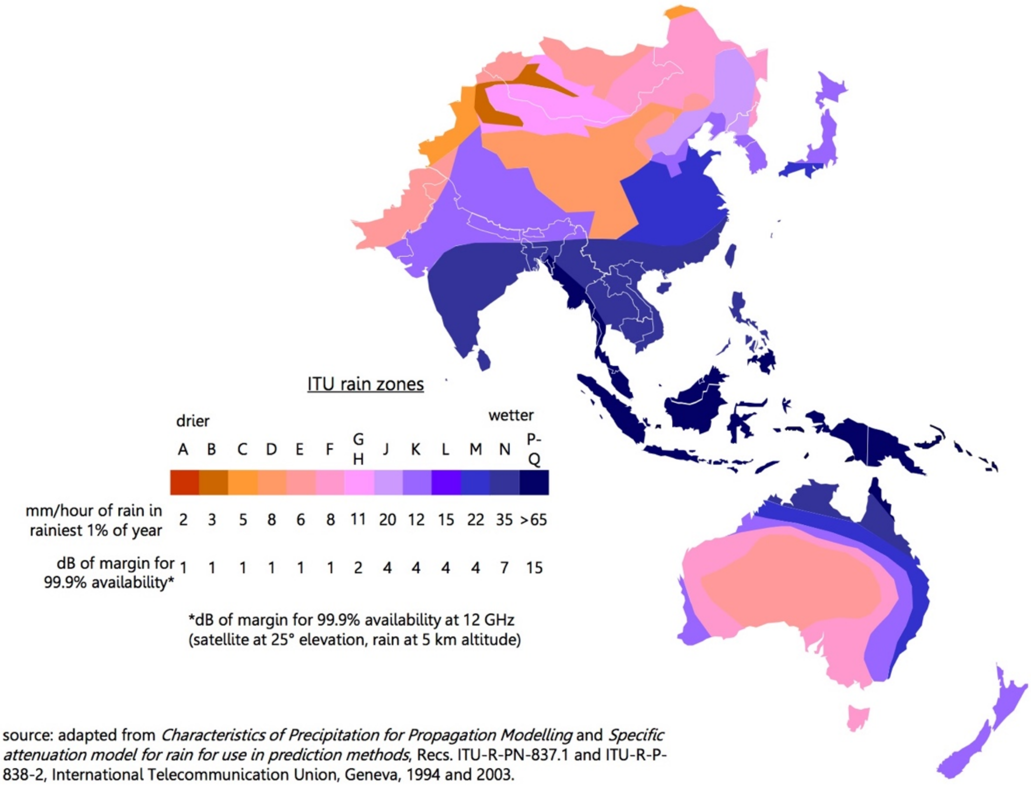
[52] ITU, *Digital trends in Asia and the Pacific 2021, Information and communication technology trends and developments in the Asia-Pacific region, 2017-2020*, page 4
[53] Britannica, *Climate of Asia.*
[54] EOS, *Evolution of the Asian Monsoon*, 25 June 2020
[55] United Nations, *The World's Cities in 2018 Data Booklet*.
[56] United Nations Department of Economic and Social Affairs, *68% of the world population projected to live in urban areas by 2050, says UN,* 16 May 2018

5.2 Acute need for additional mid-band spectrum in Asia-Pacific given lack of C-Band and low-band spectrum

Unlike higher frequencies, the C-band[57] is not significantly attenuated by atmospheric moisture. This matters particularly in Asia, where most of Asia's more than 4.3 billion people reside in areas subject to monsoons or to frequent heavy rainfall. As estimated by Euroconsult, this includes 14 countries in their entirety namely Bangladesh, Indonesia, Lao PDR, Malaysia, Myanmar, Papua New Guinea, the Philippines, Singapore, Sri Lanka, Thailand and Vietnam,– along with over half of India's population, perhaps one-third of China's, and the southern end of Japan.[58]

Exhibit 15 shows a simplified map of precipitation and rain fade patterns. Importantly, it should also be noted that climate change modelling indicates a consistent increase in monsoon rainfall and its variability under global warming. It is estimated that every additional degree of warming is likely to increase monsoon rainfall by 5 percent.[59]

Exhibit 15: Rain attenuation in Asia



Source: Euroconsult, *Assessment of C-Band usage in Asian Countries*, June 2014

This physical attribute combined with (i) the ability of very wide beams which satellites can form using C-band spectrum (a key advantage in large archipelagos like Indonesia) and (ii) affordable low noise block-converters (LNBs), made this particular spectrum band favoured by fixed-satellite service (FSS) providers. C-band in Asia is therefore widely used by satellite operators, for television and radio distribution and VSAT-based services even though there is a migration to HTS satellites using Ku and Ka bands. [60]

[57] Technically, the C-band corresponds to frequencies of 5.8-6.4 GHz for transmission and 3.6-4.2GHz for reception. In addition, satellite systems can also make use of the "extended-C-band" (transmission 6.4-6.7GHz, reception 3.4-3.6GHz).
[58] Euroconsult, *Assessment of C-Band usage in Asian Countries*, June 2014
[59] Katzenberger, A., Schewe, J., Pongratz, J., and Levermann, A.: *Robust increase of Indian monsoon rainfall and its variability under future warming in CMIP6 models*, Earth Syst. Dynam., 12, 367–386, https://doi.org/10.5194/esd-12-367-2021, 2021.
[60] For example, Brunei Darussalam, Cambodia and the Philippines are the only ASEAN countries that do not to have one or more national satellites.

5.2.1 Estimation of the low and mid-band band shortfall for 5G in Asia-Pacific

The presence of existing uses and users in the C-band (3.4 – 4.2 GHz) in Asia-Pacific has presented national regulators with a significant challenge in making spectrum available in this band for IMT use, even though the band was first identified in WRC-15. While some regulators have been able to clear the band (or parts of it) by migrating existing users to alternative bands or technologies and others have explored the ability to accommodate both mobile and existing (satellite) users through sharing, there remains significant restraints on the freeing up of this band for IMT services in the region (see the example in Exhibit 16 below).

Exhibit 16: Potential availability of 3.3-3.8 GHz band for 5G in ASEAN

Source: GSMA, Roadmap for C-Band spectrum in ASEAN, August 2019

Further across the region, while developed countries in North America and Europe have been able to secure two digital dividends of between 120 to 140 MHz in the UHF band, the same cannot be said of countries in Asia Pacific (ITU Region 3). Many Asia-Pacific countries, perhaps due to their extensive use of terrestrial television compared with markets with deployed cable television networks, or concerns about the costs to users of migrating from analogue to digital television, are still to complete the analogue television switch-off (ASO) and/or to allocate 700 MHz spectrum. Securing a second digital dividend available in the 600 MHz band is, with only a couple of regional exceptions (eg Hong Kong, SAR and New Zealand), a minimum of 5 to 10 years away.

Expanding such an analysis across all of the major Asia-Pacific markets as detailed in Exhibit 17 over, we find that the majority of markets (exceptions include Japan) have only made between 0 to 200 MHz of 3.5 GHz spectrum available for IMT services. This is significantly less than 400 MHz of 3.5 GHz band spectrum mandated and made available for 5G in the European Union, the United Kingdom and the USA.

Similarly there is a shortfall of up to 120 to 140 MHz of low band spectrum being made available for 5G in the Asia-Pacific region.

Exhibit 17: Low and mid-band 5G spectrum allocations in major Asia-Pacific markets versus Europe and USA

Country/ Region	2nd Digital Dividend *(700 MHz in ITU Region 1) and 600 MHz in ITU Region 3*	1st Digital Dividend *(800 MHz in ITU Region 1) and 700 MHz in ITU Region 3*	IMT allocations in the C-Band (3.5 GHz band)
Europe	*Available across the EU and allocated in 50+% markets*	*Auctioned*	*Mainly allocated – 400 MHz*
United Kingdom	*Auctioned*	*Auctioned*	*Auctioned – 400 MHz*
United States	*Auctioned*	*Auctioned.*	*Allocated – 280 MHz + 100 MHz FCC auction starting Oct 2021*
Australia	Nil. Subject to broadcasting review.	Allocated.	Allocated – 125 MHz in 3.6 GHz with further refarming of the 3.4 and 3.7-4.2 GHz bands underway
Bangladesh	Nil	Nil. Vacant but not allocated	Reserved for future assignment.
Cambodia	Nil	Nil. ASO still to occur.	Planned assignment. Approx 300 MHz available.
China	Nil	Allocated to CBN	Allocated 200 MHz + 100 MHz for shared use
Hong Kong, SAR	Nil. Auction in progress -restricted to indoor use	Nil. Auction in progress	Auctioned 300 MHz.
India	Nil. Planned and the subject of submissions to APT AWG.	Nil. Attempted auction but no demand due to high spectrum prices	Temporary trial now. 300 MHz to be auctioned in 2022
Indonesia	Nil. Unlikely given free to air TV demand.	ASO occurring. Scheduled to be available early 2023.	Undertaking studies, likely limited amount maybe only 100-200 MHz post 2023.
Japan	Nil	Allocated.	Allocated – 500 MHz.[61]
Malaysia	Nil	Allocated to SWN	200 MHz only. Allocated to SWN
Myanmar	Nil. ASO still to occur.	Nil. Vacant currently.	Part of Spectrum Roadmap but only 180 MHz available. Post 2023
New Zealand	Nil. Available.	Auctioned to MNOs	Allocated – short term licences to October 2022 for 210 MHz + 60 MHz in 3.6 GHz
Pakistan	Nil.	Nil. Recommended allocation.	To be refarmed – Post 2024. Only 110 MHz before 2024.
Philippines	Nil. ASO still to occur	Allocated to MNOs	Allocated - 300 MHz.
Singapore	Nil	Auctioned.	Allocated 200 MHz only.
South Korea	Nil.	Auction + assignment to public safety	Allocated – 280 MHz.
Sri Lanka	Nil	Nil. ASO still to occur.	Planned assignment post refarming.
Thailand	Nil	Auctioned.	Planned assignment post 2023 but could only be 200 MHz
Vietnam	Nil. Planned only post 2029.	Nil. Vacant currently.	Planned assignment/temporarily assigned to trial.

Source: WPC analysis, September 2021. NB In Region 1 (ie EU and UK), first digital dividend in 800 MHz is 2 x 30 MHz and second digital dividend in 700 MHz is 2 x 30 MHz. In Region 3 (Asia-Pacific), first digital dividend in 700 MHz is 2 x 45 MHz (n28) and second digital dividend in 600 MHz band. SWN is the single wireless network provider in Malaysia namely Digital Nasional Berhad (DNB).

[61] Refer to www.soumu.go.jp/main_content/000613734.pdf

Therefore it is possible to say that many key markets in the Asia-Pacific region, have a "shortfall" of up to 340 MHz or more IMT spectrum compared with other global regions.[62] Individual countries like Indonesia, and Pakistan which have not assigned IMT bands like the 2.6 GHz (n41) due to satellite use and litigation respectively are even in a more challenging position. This is where preserving a significant proportion of the 6 GHz band for IMT purposes rather than it being made available for unlicensed use becomes very critical for the region.

5.2.2 Overall mid-band spectrum needs analysis for quality 5G services

Addressing the material Asia-Pacific mid-band shortfall, given the heavy use of C-band in many markets in the region is even more pressing, given the overall total mid-band spectrum needs for the 2025-2030 time frame recently estimated by the GSMA. In a study released in July 2021, the total mid-band spectrum needs for 5G users to experience mobile data rates of 100 Mbit/s in the downlink and 50 Mbit/s in the uplink and accommodate 1 million connections per km^2 when averaged over all 36 examined cities was estimated to be 2,020 MHz. This was for the 2025-2030 time frame. More granular information from the study is detailed in Exhibit 18 below. In these cities, substantial amounts of mid-band spectrum were found to be required by the GSMA to deliver the 5G vision in an economically feasible manner, taking different national income levels into consideration.

Exhibit 18: Total mid-band spectrum needs 2025-2030 time frame

	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: GMSA, July 2021[63]

In order to achieve such targets for mid-band spectrum for IMT purposes, given the significant shortfall in 3.5 GHz band allocations in the Asia-Pacific region, 700 MHz of 6 GHz band being allocated to IMT purposes for 5G and future 6G services is essential.

5.2.3 Early studies show that 6 GHz band is a very good substitute for the 3.5 GHz band in terms of performance

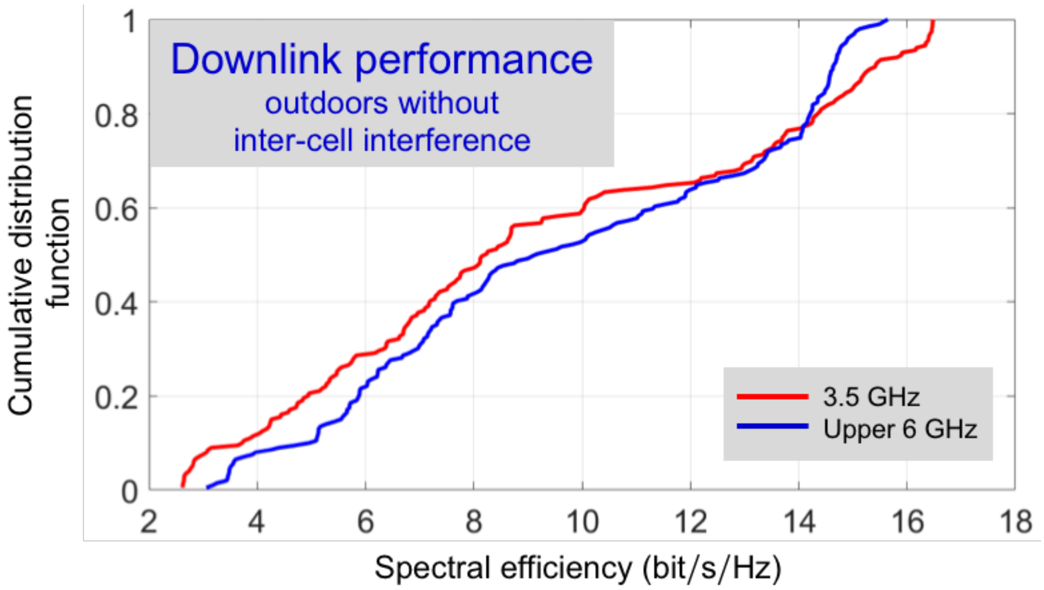
Early field studies show that the 6 GHz band is a very good substitute for the 3.5 GHz band. In 6 GHz prototype field tests in March 2021, advanced technology enhancements allow similar performance using 6 GHz spectrum rather than 3.5 GHz band (reusing the same sites) (see Exhibit 19 over). These field tests involved *inter alia*:

- 6 GHz macro base stations co-sited with C-band macro base stations;
- Inter-site distance: 350-600 m;
- Typical downtown area: Non-Line of Sight (NLOS) > 80%, average building height of approximately 20 m; and
- All parameters used for the test were the same for C-band and 6 GHz, except for the greater number of antenna elements in the active antenna system at 6 GHz (leveraging smaller wavelengths) to compensate for the propagation difference between the two bands.

It is understood that further field trials on coverage and capacity are being undertaken in the second half of 2021.

[62] Another alternative band which has been proposed or allocated in certain regional markets is the 4.7 GHz band (n79).
[63] GSMA, *Estimating the mid-band spectrum needs in the 2025-2030 time frame: Global Outlook,* A report by Coleago Consulting Ltd, July 2021, page 1. Available at www.gsma.com/spectrum/wp-content/uploads/2021/07/Estimating-Mid-Band-Spectrum-Needs.pdf

Exhibit 19: 6 GHz versus 3.5 GHz prototype field tests – downlink performance



Source: 6 GHz IMT Opportunity for Society, June 2021[64]

5.2.4 mmWave is not a good substitute for the 6 GHz band in most of the region

Lastly, it is important to highlight that substitutes for mid-band spectrum like the 6 GHz band for IMT services such as mmWave spectrum are far from optimal in Asia-Pacific context. This is for both technical and commercial reasons.

Specifically, the technical challenge is rain rate and rain attenuation in the region. In major academic study in Malaysia of the impact of rain rate and rain attenuation on 5G in the mmWave bands it was found that that utilising the 26 GHz in tropical regions can only support short path lengths. In the case where operators would like to use it for a longer path length, the transmitted power and antenna gain must be increased to cover the targeted area.[65] The study went to conclude that:

> *"From the presented and examined results, it was found that at 0.01%, the rain rate was 120 mm/hr, the specific rain attenuation was 26.2 dB/km, and the total rain attenuation over 1.3 km was 34 dB. Furthermore, the worst month statistic obtained from the real measurements was lower than what was predicted by the ITU model; around 51% and 34% for the rain rate and rain attenuation, respectively."*

The second key challenge is commercial. In the emerging markets of Asia-Pacific significantly lower mobile ARPU (even with larger relative populations) may it challenging to support additional capex and opex required for mmWave deployment and operations. As shown in the ITU statistics (see Exhibit 20 below), some 16 countries in the region, with exceptions being smaller landlocked and Pacific markets have met the UN Broadband Commission affordability target of 2 percent of gross national income per capita (GNI p.c.). Therefore, the lower capex and opex costs of deploying 5G in the low and mid-band spectrum is going to likely to be preferred in emerging Asia-Pacific.

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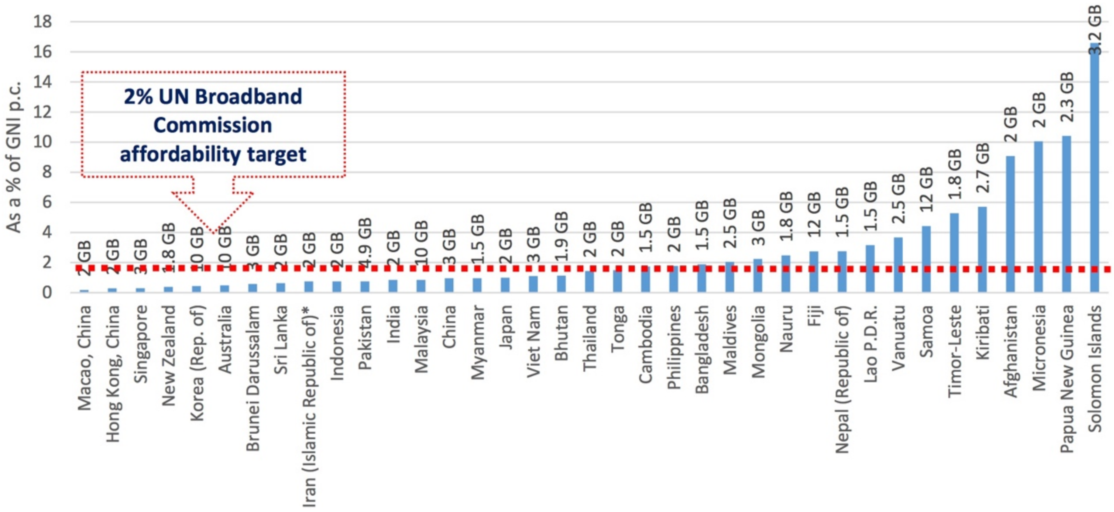
[64] Reza Karimi, Ericsson, Huawei, Nokia and ZTE, 16th European Spectrum Management Conference, *6 GHz IMT Opportunity for Society,* 24 June 2021, page 3 and Huawei presentation at the 16th European Spectrum Management Conference, starting at 24.15. www.youtube.com/watch?v=I70MShLI0pg&list=PL-w3m3Fi4ZVns7rzgP6JlVdf1IQTDkzfD

[65] Ibraheem Shayea, Tharek Abd. Rahmani, Marwan Hadri Azmi and Md. Rafiqul Islam, *Real Measurement Study for Rain Rate and Rain Attenuation Conducted Over 26 GHz Microwave 5G Link System in Malaysia,* 2019. Available at www.researchgate.net/publication/334828789_Rain_attenuation_and_worst_month_statistics_verification_and_modeling_for_5G_radio_link_system_at_26_GHz_in_Malaysia ..

Exhibit 20: Mobile-data prices as a percentage of GNI p.c., and monthly data allowance, Asia-Pacific region, 2019



Source: ITU, 2021[66]

The other positive of partitioning the 6 MHz band and allocating 700 MHz to IMT services is that quantum of mmWave spectrum which is needed in the region for IMT use may be able to be reduced as it is a close substitute. Asia-Pacific markets (such as Indonesia) could then focus on making available the 26 GHz band (n258) for IMT purposes allowing the 28 GHz band to be used by fixed satellite services according to the needs of the specific country.

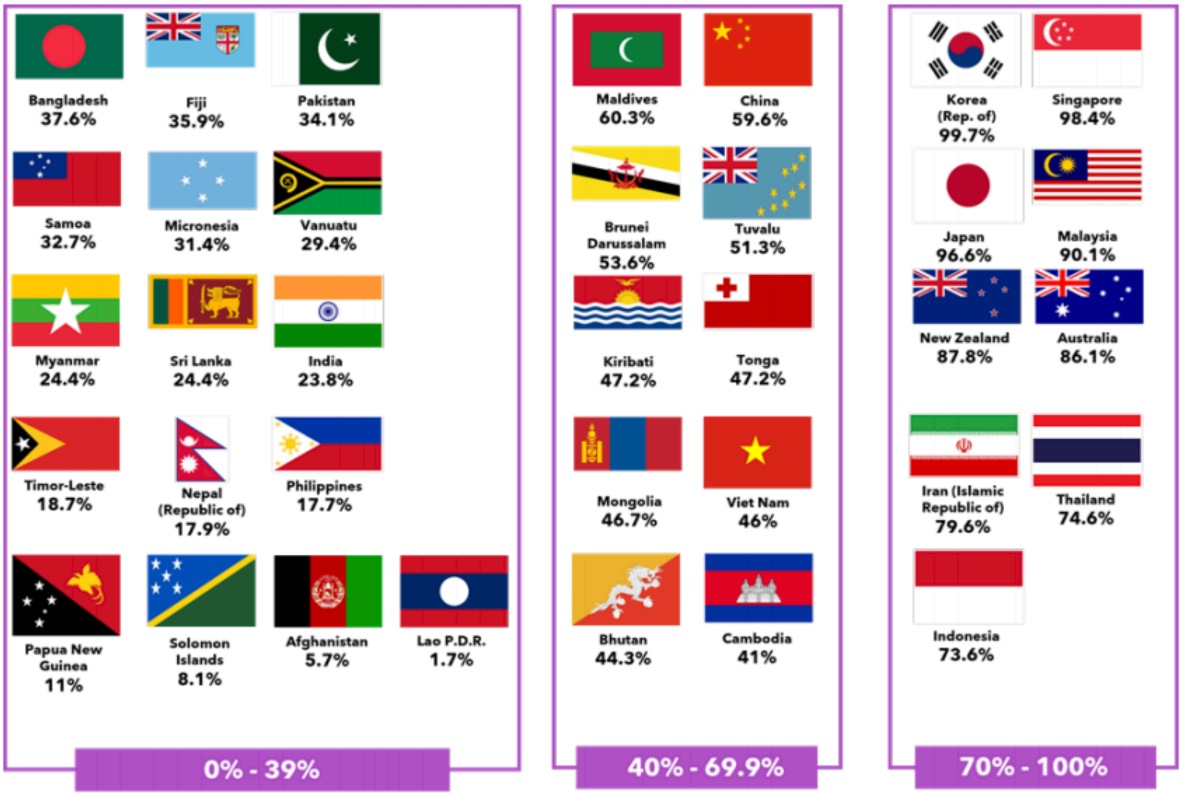
5.3 A large Wi-Fi allocation does not of itself address the urban digital divide in Asia-Pacific

According to the United Nations, although over 98 percent of the population in the region is covered by a mobile network, nearly 52 percent of Asia Pacific's 4.3 billion people are offline.[67] This is not spread evenly across the region: Huawei's 2020 Global Connectivity Index (GCI) shows that Singapore ranks second out of 79 countries surveyed globally, but in contrast Indonesia ranked 58th, the Philippines 59th and India 63rd.[68] The divide is also uneven between urban and rural areas: only 37 percent of rural households had access to the Internet in 2019 compared with 70 percent of urban households.[69]

In a positive development, the gender gap has decreased, with a difference of only 7 percentage points remaining between women's and men's internet use in the Asia-Pacific, at 41 percent and 48 percent respectively.[70] The proportion of households with internet access is depicted in Exhibit 21 below.

[66] Refer to www.itu.int/dms_pub/itu-d/opb/ind/D-IND-DIG_TRENDS_ASP.01-2021-PDF-E.pdf and www.itu.int/en/ITU-D/Statistics/Documents/publications/prices2019/ITU_ICTpriceTrends_2019.pdf
[67] United Nations, *Bridging Asia-Pacific 'Digital Divide' Vital to Realise Tech Benefits'* 18 August 2020; ITU News, *Managing Spectrum to Bridge the Digital Divide in the Asia-Pacific Region,* 29 October 2020.
[68] Huawei, *Global Connectivity Index*, available at: www.huawei.com/minisite/gci/en/.
[69] ITU, *Digital Trends In Asia and the Pacific 2021: Information and Communication Technology Trends and Developments in the Asia-Pacific Region, 2017–2020,* page 4.
[70] *Ibid*.

Exhibit 21: Proportion of Households with Internet Access



Source: : ITU, based on the ITU WTI Database, 2020. Data for 2019 were available for the following countries only: Bangladesh, Brunei Darussalam, Cambodia, Malaysia, Pakistan, the Philippines, Singapore, South Korea and Thailand.

It is well documented that COVID-19 has highlighted the importance of addressing the digital divide as millions of people globally began to work, study, shop and have medical appointments online as part of the lockdowns and social distancing rules.[71] The pandemic has emphasised the importance of digital infrastructure. The ITU has found that in the medium term, countries with top connectivity infrastructure could mitigate up to half of the negative economic impact of the COVID-19 pandemic.[72] Many millions of migrants across Asia-Pacific who returned home to rural areas suffered from a lack of connectivity, which further hampered children's learning opportunity without internet access.[73]

In this context it is critical to highlight that in and of itself allocating the entire 6 GHz band, of some 1,200 MHz to Wi-Fi does not bridge the digital divide. While low band spectrum is best able to address the rural digital divide, IMT services utilising the 6 GHz band, (which has a similar footprint to the 3.5 GHz band using MIMO antennas) will greatly enhance the 5G service offerings in urban areas in terms of the number of users supported, their bandwidth and quality of service.

In contrast, improved Wi-FI/low power/short range unlicensed services are likely to only improve the connectivity of users who have a home fibre connection. As such they will arguably have more spectrum to utilise for their Wi-Fi in their house or apartment. The benefits of such a large allocation are more optimised for advanced markets such as South Korea with high fibre penetration, not those markets where there are urban unconnected or under-connected.

[71] *Ibid*; ITU Reports *Pandemic in the Internet Age: communications industry responses: GSR Discussion paper on ensuring connectivity and business continuity key lessons learned* (June 2020) and *Pandemic in the Internet Age: From second wave to new normal, recovery, adaptation, and resilience* (May 2021). Available at https://reg4covid.itu.int
[72] ITU, *Digital Trends In Asia and the Pacific 2021: Information and Communication Technology Trends and Developments in the Asia-Pacific Region, 2017–2020,* p 35.
[73] United Nations, *Bridging Asia-Pacific 'digital divide' Vital to realize tech benefits'* 18 August 2020.

The benefits could accrue to both developed and emerging markets where there is an increased allocation of say 500 MHz of 6 GHz spectrum which represents a doubling in unlicensed Wi-Fi spectrum allocations while simultaneously increasing mid-band IMT spectrum allocations by 700 MHz. We also consider that bandwidth "delivered" via IMT will generate greater economic efforts than Wi-Fi service delivery in the region.

5.4 Allocation of 1.2 GHz of prime spectrum to Wi-Fi is not supported by demand analysis

Firstly, it is important to highlight that IEEE 802.11 compliant products normally sold under the Wi-Fi brand currently occupy, with some market exceptions up to 650 MHz of spectrum (not including other unlicensed spectrum in the 900 MHz, 3.5 GHz, 4.9 GHz and 60 GHz ranges depending on the market). The current main Wi-Fi bands are detailed in Exhibit 22 below.

Exhibit 22: Selected Asia-Pacific markets - Current main Wi-Fi bands: 2.4 and 5 GHz bands

		Indoor Use Only	Radar Bands (DFS Band)		
Region	**2400 to 2483.5 MHz**	**5.15 to 5.25 GHz**	**5.25 to 5.35 GHz**	**5.47 to 5.725 GHz**	**5.725 to 5.85 GHz**
Australia, New Zealand	Ch. 1-13	Ch. 36, 40, 44, 48	Ch. 52, 56, 60, 64	Ch. 100, 104, 108, 112, 116, 132, 136, 140	Ch. 149, 153, 157, 161, 165
China	Ch. 1-13	Ch. 36, 40, 44, 48	Prohibited	Prohibited	Ch. 149, 153, 157, 161, 165
Hong Kong, China	Ch. 1-13	Ch. 36, 40, 44, 48	Ch. 52, 56, 60, 64	Ch. 100, 104, 108, 112, 116, 132, 136, 140	Ch. 149, 153, 157, 161, 165
Japan	Ch. 1-13	Ch. 36, 40, 44, 48	Ch. 52, 56, 60, 64	Ch. 100, 104, 108, 112, 116, 120, 124, 128, 132, 136, 140	Prohibited
South Korea	Ch. 1-13	Ch. 36, 40, 44, 48	Ch. 52, 56, 60, 64	Ch. 100, 104, 108, 112, 116, 120, 124, 128, 132, 136, 140	Ch. 149, 153, 157, 161, 165
Taiwan, China	Ch. 1-13	Prohibited	Ch. 52, 56, 60, 64	Ch. 100, 104, 108, 112, 116, 132, 136, 140	Ch. 149, 153, 157, 161, 165

Source: Laird Connectivity Blog, May 2015[74]

Importantly this quantum of spectrum is larger than the IMT spectrum allocations in most Asia-Pacific markets except those countries that have already allocated significant 5G spectrum.

Asia-Pacific markets with large populations including Bangladesh, Indonesia, Myanmar, Pakistan, and Vietnam all have total IMT allocations below the current total Wi-Fi allocations as would a number of smaller regional markets. If an additional 1,200 MHz in the 6 GHz band was also allocated to Wi-Fi usage then only developed country markets including Australia, Japan, Singapore, South Korea, or rapidly emerging, such as Thailand who had allocated mmWave spectrum for 5G would have more IMT spectrum allocated than proposed quantum of Wi-Fi spectrum proposed. However, as discussed in section 5.2.4, the mid-band spectrum like the 6 GHz band for IMT services cannot be substituted by mmWave spectrum in Asia-Pacific context.

[74] Available at www.summitdata.com/blog/channels-supported-in-2-4-and-5-ghz-in-most-countries/

While many arguments are made globally about the need to allocate the entire 1.2 GHz to Wi-Fi the key supporting document for this need is the now outdated 2016 paper from Qualcomm entitled *A quantification of 5 GHz Unlicensed Band Spectrum Needs.*[75] While reaffirmed in its filing to the FCC in 2019,[76] the Qualcomm paper does not seem to be have been updated. The other paper widely relied upon is the Report by Quotient Associates entitled *Wi-Fi Spectrum Needs Study:, Final Report to Wi-Fi Alliance, February 2017*. Importantly, the latter actually only recommended*:*

> *"… that between 500 MHz and 1 GHz of new spectrum will be needed in 2025 to satisfy the anticipated busy hour, with [more spectrum] required if demand exceeds the busy hour prediction … due to novel and as yet un-anticipated applications, or the further concentration of traffic into fewer busy hours than the present four hours per day."*[77]

There are four major factors which support the contention that these 2016/2017 estimates from the Wi-Fi industry materially over-estimate the demand for Wi-Fi spectrum in 2021 (above the additional 500 MHz for Wi-Fi proposed in this report) and reduce the need further unlicensed spectrum by 2025. Those factors are:

(i) The limit on Wi-Fi speeds in the home and smaller premises is the limit on fixed broadband network speeds not Wi-Fi;

(ii) The upcoming technology advancements in Wi-Fi (802.11) technology should make spectrum usage by unlicensed Wi-Fi services more efficient;

(iii) Consumer's real preferences are for secure 4G/5G services when available at a reasonable price and much greater speeds; and

(iv) Likely reduced demand for Wi-Fi usage from enterprises given 5G support for industry.

5.4.1 The limit on Wi-Fi speeds in the home and smaller premises is the fixed broadband network speeds not Wi-Fi

As shown in Exhibit 23 below, the three latest versions of the Wi-Fi standard can support a data rate from 600 Mbps to Gigabyte speeds. As such the limitation on "Wi-Fi speeds" in the home and smaller premises is not Wi-Fi itself but rather the fixed broadband speeds into such premises. This is shown in the May 2021 UNESCAP study on Visualising Broadband Speeds in the Asia-Pacific region (see Exhibit 24 over).

Only 9 markets namely, China, Hong Kong, SAR, Japan, Macao, SAR, Malaysia, South Korea, Singapore. Taiwan, China and Thailand according to Ookla have average fixed broadband speeds above 100 Mbps.[78] As such allocating more spectrum in the 6 GHz band to Wi-Fi will do nothing to improve the real life speeds encountered by users given the limited size of the "broadband pipe" to their premises. Most households in the region are not going to be able to afford gigabyte speeds optical fibre connections to their homes.

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[75] Available at www.qualcomm.com/media/documents/files/a-quantification-of-5-ghz-unlicensed-band-spectrum-needs.pdf

[76] Refer to https://ecfsapi.fcc.gov/file/1021644462961/Qualcomm%20Comments%20on%206GHz%20NPRM.pdf

[77] Refer to www.wi-fi.org/download.php?file=/sites/default/files/private/Wi-Fi%20Spectrum%20Needs%20Study_0.pdf , page 29

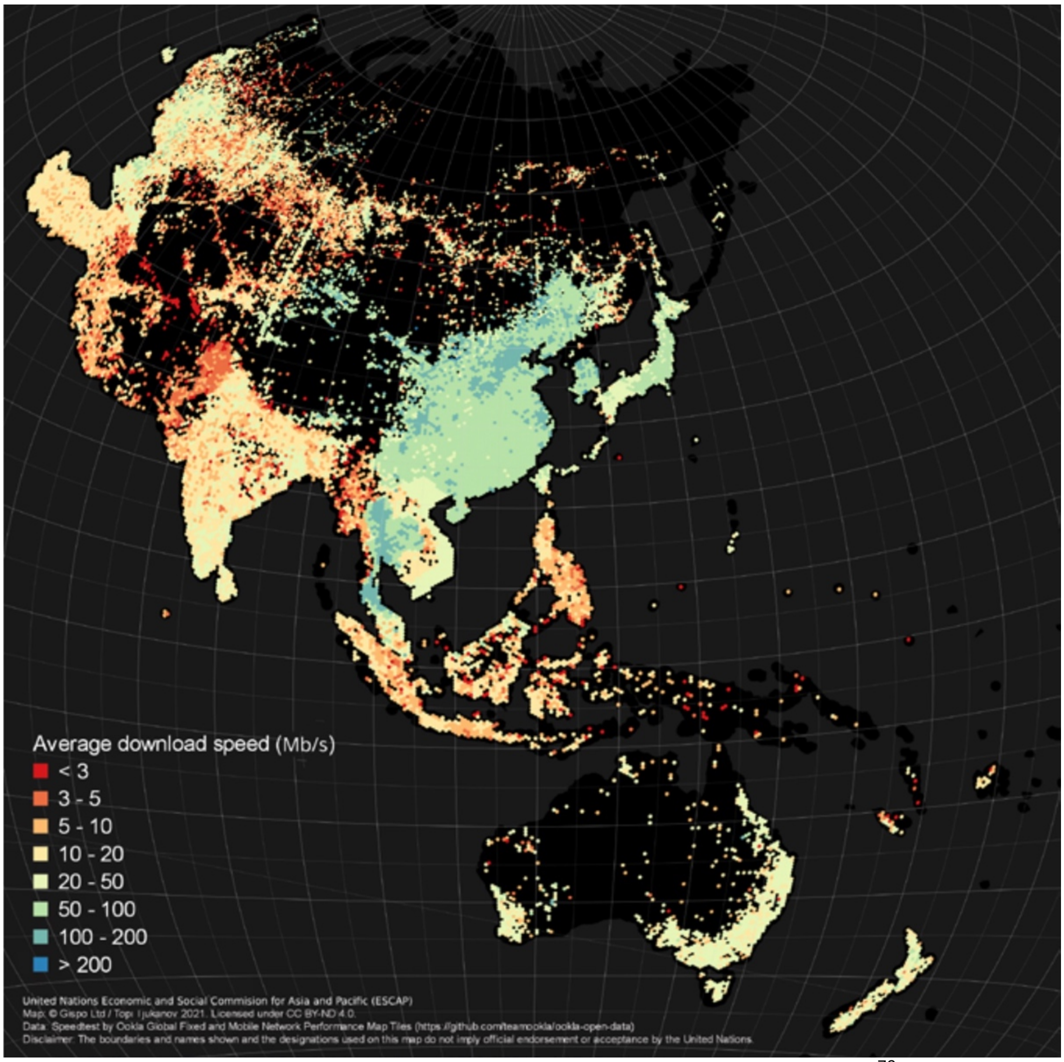
[78] Refer to www.speedtest.net/global-index/

Exhibit 23: Technical capabilities across legacy and wireless standards for Wi-Fi

Features	Wi-Fi 4 (802.11n)	Wi-Fi 5 (802.11ac)	Wi-Fi 6/ Wi-Fi 6E (802.11ax)
Data rate	Up to 600 Mbps	Up to 7 Gbps	Up to 9.6 Gbps
Carrier Frequency	2.4, 5	5	2.4, 5, 6
Channel Bandwidth	20, 40	20, 40, 80, 80 +80, 160	20, 40, 80, 80 +80, 160
Frequency multiplexing	OFDM	OFDM	OFDM and OFDMA
OFDM symbol time (µs)	3.2	3.2	12.8
Guard interval (µs)	.04, .08	.04, .08	.08, 1.6, or 3.2
Total symbol time (µs)	3.6, 4.0	3.6, 4.0	13.6, 14.4, 16.0
Modulation	BPSK, QPSK, 16-QAM, 64- QAM	BPSK, QPSK, 16-QAM, 64-QAM, 256- QAM	BPSK, QPSK, 16-QAM, 64-QAM, 256-QAM, 1024- QAM
MU-MIMO	N/A	DL	DL and UL
OFDMA	N/A	N/A	DL and UL
Radios	MIMO (4x4)	MU-MIMO (DL) (8x8)	MU-MIMO (DL & UL) (8x8)

Source: Revisiting Wireless Internet Connectivity: 5G vs Wi-Fi 6, Telecommunications Policy 45 (2021) 102127

Exhibit 24: Fixed broadband speeds in the Asia-Pacific region



Source: UNESCAP, Visualising Broadband Speeds in Asia and the Pacific, May 2021, page 7[79]

[79] Available at www.unescap.org/sites/default/d8files/knowledge-products/Visualizing%20Broadband%20Speeds%20in%20Asia%20and%20the%20Pacific_0.pdf

5.4.2 The upcoming technology advancements in Wi-Fi (802.11) technology should make spectrum usage more efficient

As shown in Exhibit 23 above, a number of technical advances have been made in relation to Wi-Fi 6 which will permit the more efficient use of the proposed 500 MHz of 6 GHz band. Importantly, this 6 GHz spectrum reserved for unlicensed services, should be, as stated by Ofcom:

> *"… used by more efficient Wi-Fi technologies from the outset. The latest Wi-Fi standard (Wi-Fi 6 (or 802.11ax) has been designed to support large numbers of users in congested environments through new techniques such as multi- user MIMO, OFDMA and BSS colouring. The result is a more efficient use of spectrum, improvement in throughput, better latency and less congested environments for Wi-Fi and other RLAN use. This will provide notable benefits in comparison with usage in the 2.4 GHz and 5 GHz bands, which are currently used by a wide variety of devices using earlier Wi-Fi/802.11 standards (e.g. 802.11a/b/n/ac)".*[80]

In the forthcoming Wi-Fi 7 standard (expected 2024), further improvements will be made including making Wi-Fi a full-duplex system, having coordination among the APs to further utilise available resources and improve spatial reuse in dense deployments. Multi-band aggregation, where channels in different frequency bands could be aggregated and used for data transmissions, is also under consideration for Wi-Fi 7.[81]

5.4.3 The real life consumer preference for secure 4G/5G services

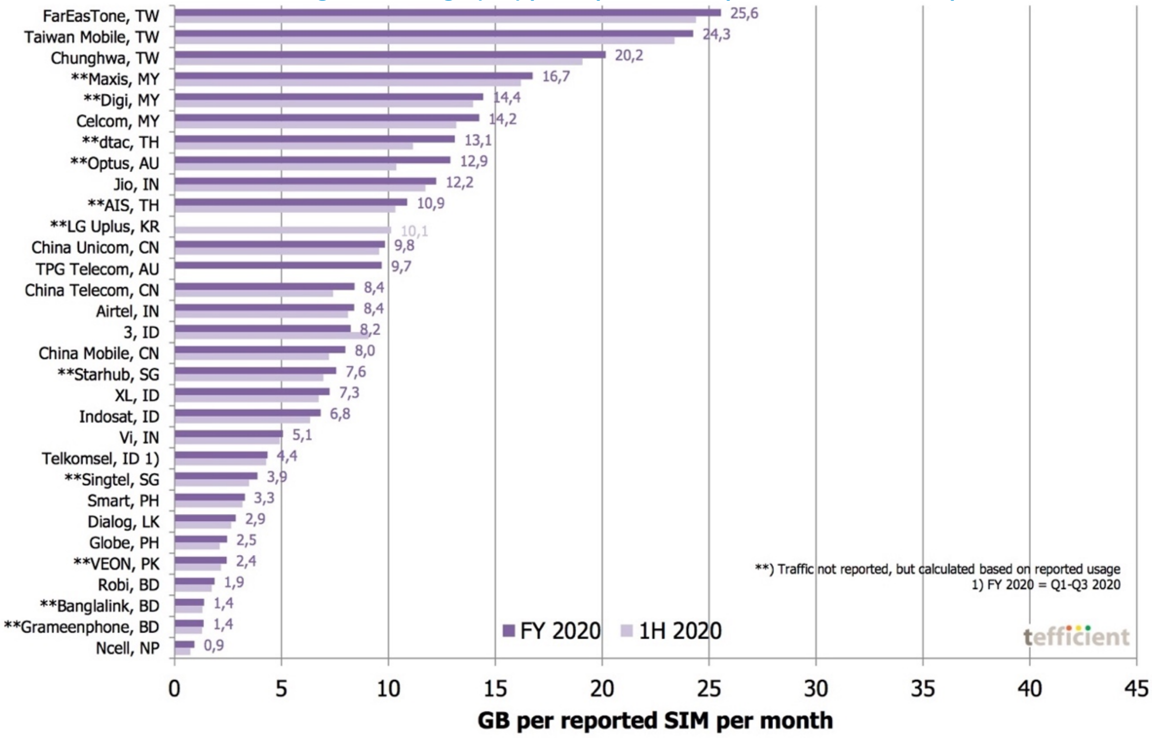
There is now a growing body of evidence that consumers have a strong preference for utilising mobile cellular services especially 5G services when available at a reasonable price and much greater speeds.

Globally according to tefficient (see Exhibit 25 below), of the top 25 global operators out of the 105 MNOs assessed by them in terms of monthly usage per SIM per month, 10 were from Asia (namely the 3 largest MNOs in each of Taiwan, China, Malaysia, 2 Thai MNOs, Singtel Optus from Australia and Jio from India). FarEasTone recorded the 7th highest average data usage globally. The data usage of Smart Cambodia has reach up to 30GB in Q2, 2021, which shows that some developing countries in Asia Pacific heavily rely on mobile network connections.

[80] Ofcom, *Improving spectrum access for Wi-FI: Spectrum use in the 5 GHz and 6 GHz bands*, 24 July 2020. Page 14

[81] Refer to www.actiontec.com/wifihelp/evolution-wi-fi-standards-look-802-11abgnac/ and *Revisiting Wireless Internet Connectivity: 5G vs Wi-Fi 6,* September 2020

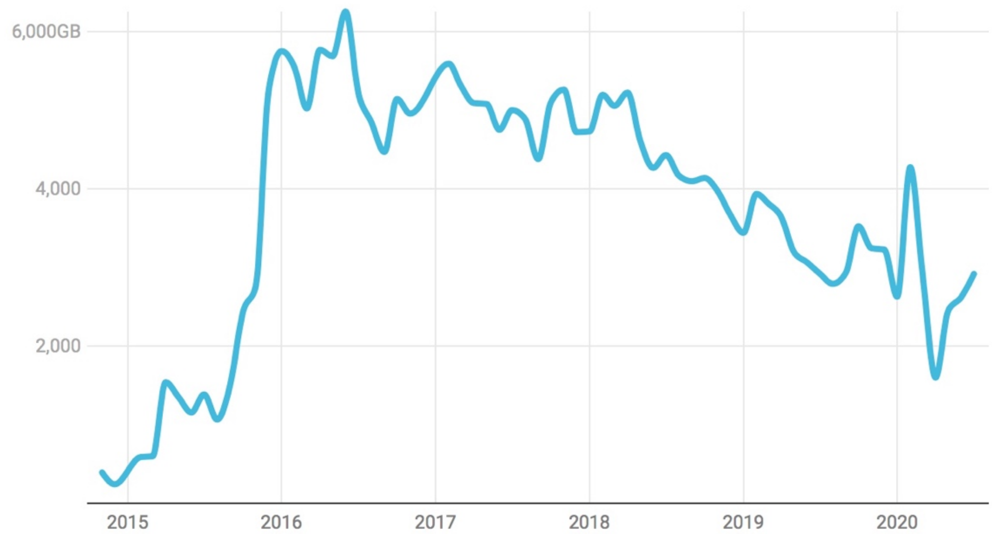
Exhibit 25: Average data usage (GB) per reported SIM per month – Asian operators



Source: tefficient, Industry analysis #1 2021, April 2021

It is also important to note that the fast take up of 4G and 5G with significantly improved performance, and the broad availability of unlimited data plans for consumers, the usage of public Wi-Fi networks has fallen considerably in recent years. One example is In public Wi-Fi Canberra in Australia. Canberra has the largest free Wi-Fi network[82] of any Australian city. According to the ABC, Australia's national broadcaster, 6 years after the network was set up, far fewer people are actually using it — raising questions about its value (see Exhibit 27 below). Further, the number of Canberrans using the service had almost halved before the coronavirus outbreaks, as the cost of mobile internet fell.[83] Security concerns are also likely to play an important role in such decisions.

Exhibit 26: Total traffic (gigabytes) per month – Canberra Free Public Wi-Fi



Source: ABC, *Canberra is expanding Australia's biggest free public Wi-Fi network, but how many people use it?* 13 August 2020

[82] Refer to www.cmtedd.act.gov.au/digital/cbrfree-public-wifi
[83] Refer to www.abc.net.au/news/2020-08-13/canberra-expands-free-wifi-but-fewer-people-are-using-it/12551266

5.4.4 Likely reduced demand for Wi-Fi usage from enterprises given 5G support for industry

It is important to note that some of the enterprise demand previously expected to use Wi-Fi 6 may now utilise 5G and its evolutions. As noted in *Revisiting Wireless Internet Connectivity: 5G vs Wi-Fi 6*:

> *"Meanwhile, 5G is allowing the next generation of cellular technology to target new private and standalone networking opportunities, especially in industrial vertical sectors, that were previously the niche of a wide variety of legacy Wi-Fi or other proprietary radio systems."*[84]

Furthermore, trials in Europe have found that 5G NR outperforms Wi-Fi 6 in the indoor deployment scenario typically used by enterprises in terms of throughput and latency.[85] In such circumstances 5G its likely to be preferred in a range of enterprise settings including manufacturing, warehousing etc.

5.5 Strong regional FWA growth supports an IMT allocation in the 6 GHz band to support increased users and usage

Globally, fixed wireless broadband access ('FWA') is forecasted to exceed 180 million connections by the end of 2026, accounting for more than 20 percent of total mobile network data traffic globally. In 2021, FWA is likely accelerating into a significant growth phase in both emerging and developed country markets with a forecasted annual growth rate of over 70 percent for 5G FWA connections.[86]

It is estimated that at least 460 operators investing in FWA based on 4G/LTE or 5G. Of the 169 operators that had announced 5G launches worldwide as of June 2021, the GSA has catalogued 63 operators that that are marketing residential or business 5G FWA broadband services, up more than 43 percent from 44 in six months.[87] Countries/ territories with LTE or 5G-based FWA service offers identified by the GSA in the region are shown in Exhibit 27 below. Most of those operators currently offering 4G FWA services, will in time, migrate to 5G FWA.

[84] Edward J Oughton, et al, *Op cit*, page 12
[85] Reza Karimi, Ericsson, Huawei, Nokia and ZTE, 16th European Spectrum Management Conference, *6 GHz IMT Opportunity for Society,* 24 June 2021, page 5
[86] Refer to https://techblog.comsoc.org/category/5g/
[87] GSA, *Networks, Technologies & Spectrum Snapshot: June 2021,* page 2

Exhibit 27: Countries/territories with identified LTE or 5G-based FWA service offers (focusing on Asia-Pacific)

Source: GSA, June 2021

There has been rapid increase in the number of 5G rollouts in the Asia Pacific region between 2018 and 2020, which has resulted in 23 commercial networks, including four FWA networks in 12 countries.[88] The highest growth of 5G FWA connections in 2021 has been in regions with the lowest fixed broadband penetration – including in the Asia-Pacific. The region grew 12 percentage points in the span of 6 months and Southeast Asia and Oceania witnessed 5G networks' launch for FWA. Looking forward, the emerging economies in the Asia-Pacific region are expected to propel the market for fixed wireless access.[89] For emerging markets where:

- fixed line infrastructure is far from ubiquitous and is not deployed nationwide;
- the cost of deploying better fixed line infrastructure is high;
- securing the required land and local government approvals for fixed deployments is difficult;
- undertaking the required civil works is complex, slow and expensive; and

5G technology offers a way to improve overall telecommunication service quality with FWA rapidly and at affordable cost.[90] It is both a viable substitute as well as complement to FTTx fixed services. Early FWA provisioning not only makes emerging country businesses more competitive but also offers a way to quickly and cost effectively bring high-speed broadband services to high-rise residential buildings in urban centres in emerging economies. Given the demand for video streaming and other content services, the delivery of higher speed broadband services with good quality service at a lower cost is desired by many subscribers.

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[88] GSMA, *The Mobile Economy Asia Pacific 2021*
[89] Ericsson, *Ericsson Mobility Report, Fixed Wireless Access Outlook: April 2021*
[90] Refer to www.linkedin.com/pulse/fixed-wireless-access- reaches-more-than-100-million-users-minehane/

In Philippines, Globe Telecom's launched its 5G fixed-wireless service in 2019, becoming the first operator in South East Asia to launch 5G FWA. Between Q1 2020 and Q3 2020, Globe acquired 1.4 million new FWA subscribers, bringing the total to at most 2.8 million FWA subscribers. FWA is now the main technology for 80 percent of Globe Telecom's total home broadband subscribers.[91]

In developed country markets there is also considerable demand for 5G FWA. For example, in Australia, there has been an immediate and notable impact of access to 5G spectrum in the market for home broadband services. MNOs are able to offer 5G home broadband services on their mobile network, albeit in a limited number of areas currently, which offer comparable speeds, data allowances and price to fixed line services. 5G technology enables MNOs to have a stronger presence by offering services comparable to those offered on the NBN network. The three major Australian MNOs – Telstra, Singtel Optus, and TPG Telecom - have all launched 5G FWA products.[92]

What does all of this FWA growth mean for spectrum management in relation to the 6 GHz band? From a spectrum management perspective, Asia-Pacific regulators should acknowledge the growing use of FWA, and include such services in their spectrum roadmaps and demand analysis. For example, the wholesale data-only base in Austria and Finland averaged over 75 GB per month, with French FWA services averaging over 165 GB per month according to tefficent in July 2021.[93] Asia-Pacific may see higher usage for FWA services per month, depending on retail pricing.

It must also be recognised that 5G to work best needs additional IMT spectrum to be assigned to licensees in larger contiguous blocks. Larger spectrum allocations–if they can be done at reasonable prices–allow mobile operators to deploy wireless networks which can be shared for both mobile and FWA applications. This provides something of a 'silver bullet' for the problem of encouraging competitive pressures in the broadband markets. Given the challenges described earlier in securing mid-band spectrum in the region, the strong regional growth of FWA emphasises the need for a significant proportion of the 6 GHz band should be allocated to IMT purposes to support the growth in this market segment.

5.6 Likely economic benefits are maximized with the shared allocation of the 6 GHz band to IMT and Wi-Fi services

5.6.1 Spectrum and economic benefits

Maximising the economic benefits derived from a particular band of spectrum requires considering and comparing alternative uses for than band of spectrum. For example, one option is to simply not allocate 6 GHz spectrum band at this time because the level of technological uncertainty is high. Alternatively, spectrum in the 6 GHz band could all be either allocated for IMT (ie for 5G and its evolutions) services or it could all be allocated to unlicensed (ie Wi-Fi) use. Further, once broadly allocated the 6 GHz spectrum could be assigned to many operators in smaller blocks or allocated in large blocks to say, two, three or four operators.

The spectrum allocation options for the 6 GHz band need to be evaluated in the light of the economic benefits each generates. From this perspective we can define a few principles as follows:

- Although technological uncertainty is high, this is almost always the case in ICT industries. High levels of uncertainty suggest that delaying decisions about spectrum use is desirable until the trajectory of current trends is clear because this avoids making decisions which, in retrospect, turn out to be wrong. This rational concern needs to be set against the material economic benefits foregone by delaying the use of spectrum.

[91] Refer to www.fiercewireless.com/wireless/fwa-boosting-ran-industry-voices-pongratz
[92] ACCC, *ACCC Communications Market Report 2019-20: December 2020*
[93] tefficient, *Industry analysis #2, 2021*, 31 July 2021, page 11

- There are clear advantages arising from allocating spectrum in large contiguous blocks to operators because the predominance of 5G in forward-looking infrastructure and service rollouts, and the fact that 5G NR operates much more efficiently when assigned in large contiguous blocks, means that allocating this spectrum in a fragmented way would be an inefficient use of spectrum.
- In relation to the question of how much of the 6 GHz spectrum band should be allocated respectively to IMT and Wi-Fi use, a more detailed analysis is required which is provided below.

More detail on each of these principles is provided in the following sections.

5.6.2 Managing uncertainty in spectrum management decisions

Uncertainty is inescapable for any decision-maker but in the ICT sector the rapid pace of technological change means that effective planning requires a great deal of focus on the ways in which current technological trends are more likely to unfold.

Currently both 5G and Wi-Fi both offer great promise in terms of their capacity to deliver greatly enhanced wireless broadband services to users. But the performance of both is predicated on a wide number of variables which vary from region to region and from country to country. For example, there is not much point in deploying high-speed Wi-Fi in areas where users do not have and are not able to acquire the kind of equipment that will enable them to use it. In such cases and where users are more likely to have smartphones it is like to be more beneficial to deploy 5G to optimally use the scarce spectrum.

In addition to future technological uncertainty, there is significant uncertainty about how communications consumers will use new technologies. It is not unusual for turning points in consumer behaviour to occur that are a surprise to regulators, vendors and operators. The explosion of Zoom, and other video conferencing services due to working from home due to COVID-19 lockdowns is a recent case in point.

In the context of such uncertainty it may be reasonable for regulators to delay scarce spectrum allocation decisions in some circumstances, for example, if a particularly significant technology standard is to be finalised in the near future in order to avoid the lock-in of the spectrum to a legacy technology.

On the other hand, if the costs of delaying a decision rise so will the pressure to allocate and start using such scarce spectrum. This is arguably the case currently in the context of the COVID-19 pandemic particularly in the context of Southeast Asia and South Asia more generally. The pandemic has accelerated the digitisation of society and placed significant demands on existing infrastructure and services. In these circumstances, the cost of not allocating and using important mid-band spectrum such as 6 GHz spectrum band to support such economic and social activity have certainly risen. More specifically, the costs from an economic perspective are the opportunity costs to Asia-Pacific countries that arise from not using the spectrum.

Generally speaking (although with significant exceptions), Asia-Pacific is more reliant than Europe and North America on mobile/wireless broadband systems where fixed infrastructure is typically more developed. This means that a greater proportion of economic activity is reliant on mobile IMT spectrum in Asia-Pacific and again, this raises the opportunity cost of delaying key spectrum allocation decisions.

One response to uncertainty is to diversify. In the context of the current discussion this would imply allocating 6 GHz spectrum to both IMT (5G) and Wi-Fi purposes. As discussed below, this will provide the scope for the most valuable applications of both 5G and Wi-Fi to both be adopted by end users. Further, a 5G connection on a smartphone can be shared locally with other users and devices by means of a Wi-Fi hotspot.

Another rational response to uncertainty is to maintain flexibility in future decision-making. In the case of key 6 GHz spectrum allocation this is critically important. It would imply licensing spectrum in ways that enable licensing conditions and parameters to be changed in the future at relatively low cost. In this regard is important to note that conditions associated with the allocation of the 6 GHz band to unlicensed (Wi-Fi) usage are inherently more difficult to change or undo than conditions for licenced IMT spectrum. Allocating a particular band to unlicensed use is a one way gate as any future ability of provide clear spectrum to licensed users is gone as it is almost impossible to unwind. This consideration, of itself, would therefore tend to push spectrum allocation in the 6 GHz band in direction of supporting an IMT allocation of because it preserves further flexibility in relation to the spectrum band.

5.6.3 Allocation of 6 GHz spectrum to IMT and Wi-Fi uses

Each country faces different spectrum supply and demand conditions. For example, if a particular country is experiencing high levels of demand for IMT spectrum, especially in the mid-band, this would suggest a preference for more IMT allocation in the 6 GHz band. An economic perspective would suggest that a mix of uses is likely to result in the greatest economic benefit. The fundamental reason for this is that if there is ranking of greatest economic benefit to that use there would be a point where some users (eg those with a fibre connection to the home) would gain more economic benefit then the most marginal IMT (5G) use.

In a situation where only a small piece of spectrum was allocated to 5G, the individual or organisation which valued that IMT spectrum most highly would be willing to pay the greatest amount to use it. That is, the first units of spectrum made available would go to the highest value used first. If the availability of 5G spectrum was then increased, additional users would be willing to pay progressively less for each additional (marginal) unit reflecting the smaller benefit they perceive. Each additional unit of 5G spectrum made available therefore contributes increasingly small additional benefits to society.

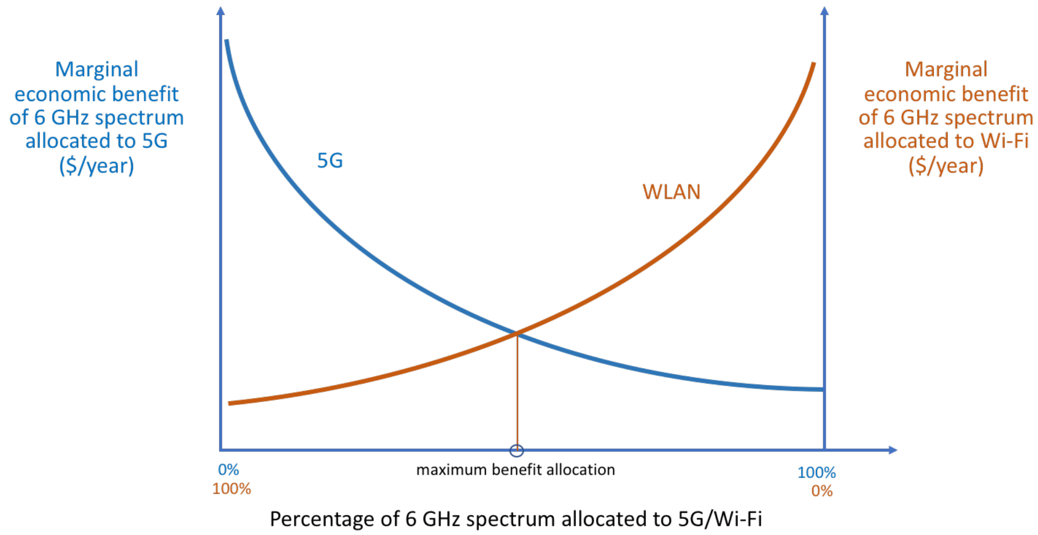
A downward sloping marginal economic benefit curve is very common in economics and, in fact, forms the basis for downward sloping demand curves. At the point where 100 percent of the available spectrum is allocated to unlicensed uses (Wi-Fi), the marginal benefit is quite low. Exactly the same argument can, of course, be made for allocating all spectrum to 5G.

Importantly, this framework, can be used to investigate the interaction between increasing and decreasing allocations of spectrum to IMT and unlicensed uses. In Exhibit 28 below, the horizontal axis measures, at the same time, the increasing proportion of the 6 GHz spectrum band allocated to one use which implies a decreasing proportion allocated to the alternative use. It is worth emphasising that this is hypothetical. In practice, the actual values associated with these curves would be very difficult to identify.

As the allocation of spectrum to IMT (5G) increases, the allocation to unlicensed (Wi-Fi) increases until a point is reached identified on the horizontal axis as 'maximum benefit allocation' where the marginal benefit from additional 5G 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.

Because this analysis is hypothetical and is not based on actual data, it does not indicate exactly what that allocation is, but it does strongly suggest that the optimal allocation of spectrum in the 6 GHz band will not be all IMT or unlicensed services. Allocating all spectrum to, say, Wi-Fi would mean that society would have to forego all of the significant high value use cases for 5G (and vice versa).

Exhibit 28: Declining marginal benefit for 5G and Wi-Fi



5.6.4 Benefits of future proofing spectrum allocations from an economic perspective

It is not difficult to sustain the argument that the current period represents one of high uncertainty in both the global and national economies. COVID-19 and the economic uncertainty associated with it means that there is a premium on diversifying across economic options where possible and building in as much flexibility into decision making. The pandemic has already accelerated the shift to digital practices and processes everywhere and in all aspects of the economy. It is far from clear that this transformational process has reached any natural maximum extent at this stage.[94] As discussed above allocating spectrum to unlicensed (Wi-Fi) use is very difficult to undo largely because of the extensive set of user-based equipment that accumulates to utilise of unlicensed spectrum.

Where spectrum is allocated to IMT purposes, on the other hand, operators can relatively quickly and cheaply upgrade equipment to make use of new standards such as will occur in the shift from 5G and its evolutions to 6G. It also provides an opportunity to allocate further of 6 GHz band to Wi-Fi and/or other purposes if future demand so warrants it.

5.6.5 Economic summation

The preceding sections provided high-level principles for maximising the economic benefits of 6 GHz spectrum allocation within the region. Economic theory strongly supports an approach where the 6 GHz band would be partitioned between IMT (5G) and unlicensed (Wi-Fi) usage. The lack of C-Band for 5G services in many Asian markets and an overall shortfall in mid-band IMT spectrum detailed above strongly suggests that the partitioning should favour more 6 GHz band spectrum being allocated to IMT services rather than Wi-Fi.

Likewise the lack of deep fixed fibre infrastructure in many Asia-Pacific markets, which means that mobile/wireless services need to do more of the 'heavy lifting' in relation to data traffic (as seen in the growth of FWA and increasing monthly GB usage statistics) also supports the thesis that more than half of the 6 GHz band should be allocated to IMT services in any partitioning. Delivering bandwidth with more 6 GHz band spectrum allocated to IMT services rather than unlicensed use is therefore the policy approach that generates greater economic benefits to Asia-Pacific countries. This is perhaps reinforced for empirical studies on the impact of consumer welfare from the release of IMT spectrum (see Exhibit 29 below).

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[94] ITU, *Pandemic in the Internet Age: From second wave to new normal, recovery, adaptation, and resilience*, May 2021, page 32*ff*

Exhibit 29: The impact of spectrum assignment policies on consumer welfare

In their 2019 paper, Kalvin Bahia and Pau Castells[95] investigated whether policies regarding spectrum assignments had an impact on consumer welfare in 64 countries during the 2010—2017 period. The core finding of their study was that reduction in the amount of spectrum available to operators negatively affected network coverage and quality. This in turn negatively impacts consumer welfare.

As a general-purpose technology, mobile communications can drive competition across a plethora of industries as well as improve productivity and living standards. Therefore, countries that assign more spectrum may be able to deliver greater benefits to consumers and the overall economy.

The amount of spectrum licensed to operators had a significant impact on network quality. Over the period of analysis, an additional 20 MHz of 4G spectrum increased average download speeds by 1–2.5 Mbps (equivalent to an increase of up to 15 per cent).[96] Importantly, operators do not have a fixed set of spectrum needs that do not vary — their decision on how much spectrum to acquire can be influenced by government policy on price and availability. Operators may choose to acquire less spectrum depending on policy choices. Consequently, network quality was found to be impacted by the choice of spectrum assignment polices.

The paper concludes that primary objective of spectrum policy should be to assign spectrum to those users that will be able to extract most value from this scarce and finite resource for the benefit of society as a whole.[97] These findings have important ramifications for policy makers – especially those trying to prioritise improved coverage and increased investment in 4G and 5G technologies.

5.7 Partitioning the 6 GHz band assists in future proofing for future 6G services

Another key advantage of having 700 MHz of spectrum available for IMT services in 6 GHz band is that assists in future proofing for 5G advanced[98] and 6G services. It does this by having a significant single block of mid-band spectrum available. 6G is being worked by the 3GPP and globally and is expected in 2030 timeframe (see Exhibit 30 on what is 6G?).

As noted earlier the GSMA's report entitled , *Estimating the mid-band spectrum needs in the 2025-2030 time frame: Global Outlook,*[99] the total mid-band spectrum needs for 5G users to experience mobile data rates of 100 Mbit/s in the downlink and 50 Mbit/s in the uplink and accommodate 1 million connections per km^2 when averaged over all 36 examined cities was estimated to be 2,020 MHz.

It should be highlighted that China has specifically listed the 6 GHz band as a key spectrum band for 6G in June 2021 paper entitled (translated) *6G Overall Vision and potential Key technology White paper*.[100]

95 Bahia, Kalvin and Castells, Pau, *The Impact of Spectrum Prices on Consumers* (July 26, 2019). TPRC47: The 47th Research Conference on Communication, Information and Internet Policy 2019, Available at SSRN: https://ssrn.com/abstract=3427173 or http://dx.doi.org/10.2139/ssrn.3427173
96 *Ibid* page 4.
97 *Ibid* page 20
98 The 3GPP has already announced 5G advanced in July 2021. Refer to www.3gpp.org/news-events/2210-advanced_5g
99 Refer to www.gsma.com/spectrum/wp-content/uploads/2021/07/Estimating-Mid-Band-Spectrum-Needs.pdf
100 Refer to www.caict.ac.cn/kxyj/qwfb/ztbg/202106/P020210604552573543918.pdf page 24

Exhibit 30: What is 6G?

6G, a term used for the globe's "sixth-generation mobile" wireless internet network, will be the successor to 5G. It is not clear yet what 6G will entail. Previous generations of mobile networks have enabled existing wireline applications to be mobile at a reasonable cost. 6G involves applications that do not yet exist in any form. [101] It will include relevant technologies considered too immature for 5G or which are outside the defined scope of 5G. The University of Oulu in Finland released a paper based on the views of 70 experts following a first 6G Wireless Summit in Finnish Lapland in March 2019. The paper, Key Drivers and Research Challenges for 6G Ubiquitous Wireless Intelligence, says that research should look at the problem of transmitting up to 1 Tbps per user. The paper claims that this can be possible through the efficient utilization of the spectrum in the THz range.

Technical success of 5G has relied on new developments in many areas and will deliver a much wider range of data rates to a much broader variety of devices and users, while 6G will require a substantially more holistic approach to identify future communication needs, embracing a much wider community to shape the requirements of 6G. Nevertheless, there will also be major challenges including physical layer and radio hardware needs great improvement in order to cope with faster speeds. It also highlights the issues of increased energy consumption and data processing.

Despite these challenges, however, there have been significant 6G developments in 2020. Next G is an industry intuitive that aims to advance North American mobile technology leadership over the next decade through private sector-led efforts was launched in October 2020. Its founding members include industry giants such as Apple, Google, Ericsson, Facebook, and T-Mobile. [102] Much 6G work today is in the form of laboratory explorations and discussions among industry consortia. In Asia, South Korea seeks to become the first country to launch 6G commercial services, with Samsung and LG Electronics setting up research centres and Seoul considering a 976 billion won (USD800 million) development project. Similarly, Beijing unveiled a research and development program in November, while Chinese tech giants such as Huawei, ZTE and China Unicom have started research in 6G independently. [103] The Japanese Government announced that it will earmark ¥50 billion to promote research and development on 6G advanced wireless communications services. [104]

In the EU, Nokia is leading a group of companies and universities in a new European 6G flagship research project called Hexa-X to help jump-start 6G. The project brings together a strong consortium of major ICT, industry and academic stakeholders to lay 6G groundwork and set the direction for future research and standardisation focus areas. The group includes Ericsson, Orange, Telefonica SA, Intel and Siemens, the University of Oulu and the University of Pisa. The Hexa-X project starts on 1 January 2021, with a planned duration of 2.5 years. [105]

As the leading international organization, ITU-R is initiating a new cycle for 6G, named IMT toward 2030 and beyond. ITU-R Working Party 5D has started the study of Future Technology Trend and VISION for next generation IMT standards. According to the current schedule, ITU-R will complete the VISION study in mid-2023, before WRC-23. The study will provide a framework and overall objectives for 6G, including usage scenarios and key capability requirements.

[101] Larry Goldman, *6G Networking is Starting to Take Shape*, Analysys Mason, 24 February 2021.
[102] https://nextgalliance.org/faq/
[103] https://internationalfinance.com/china-is-aiming-at-6g-what-next/; https://asia.nikkei.com/Business/Technology/Race-for-6G-South-Korea-and-China-off-to-early-leads
[104] www.japantimes.co.jp/news/2020/12/10/business/japan-earmark-%C2%A550-billion-6g-development/.
[105] www.ericsson.com/en/news/2020/12/6g--hexa-project; www.smh.com.au/technology/nokia-leads-a-6g-wireless-project-for-european-union-20201208-p56lgm.html

5.8 Making more IMT spectrum available in the 6 GHz band supports strong mobile/wireless competition

For the past 20 plus years, one of the key features of the global cellular industry has been sector competition. Such mobile competition has been at the forefront of the market, technical, pricing and service innovations which enabled the success of the industry and for cellular to be the dominant connectivity technology globally. Such large increases in service penetration have resulted in significant increases in consumer surplus as well as the creation of the global and regional app economy.

Unfortunately, in the Asia-Pacific region there are currently two cases, namely Singapore and Malaysia where the perceived lack of suitable 5G spectrum especially in the C-Band (3.5 GHz) band has prompted Governments and regulators to mandate a reduction in sector competition. More broadly as described in section 5.2.1 of this report, there is a "shortfall" in low and mid-band IMT spectrum in the region.

Specifically, in Singapore in 2020, as the Infocomm Media Development Authority (IMDA) was only able to offer *inter alia* 200 MHz of 3.5 GHz spectrum it offered only two nationwide 5G SA licences in the initial years. This was done via a call for proposals.[106] In 2021, Malaysia announced that it would be launching 5G services by the end of 2021 through a monopoly Single Wireless Network (SWN).[107] One of the key reasons for this decision, is understood to be the fact that the Malaysian Communications and Multimedia Commission (MCMC) was able to only release 100 MHz of 3.5 GHz band spectrum to the market in a timely manner.

In order to avoid such spectrum limitations and to continue to strengthen mobile/wireless competition in Asia-Pacific (and to ensure that MNOs are also capable of providing a high quality FWA service), making available of 700 MHz of additional mid-band spectrum in the 6 GHz band as a result of band partitioning results at least 3 to 4 MNOs in a market have sufficiently large IMT spectrum portfolios. Such additional mid-band spectrum will enable each of them to provide high speed, high quality wireless broadband and to be viable/sustainable in commercial terms.

5.9 Possible additional financial proceeds to Government arise from the allocation of IMT spectrum in the 6 GHz band

The recommended approach means that an additional 700 MHz spectrum of 6 GHz band would be available for assignment by country/region regulators. Such 6 GHz spectrum could be assigned by way of a beauty contest or a spectrum auction. While estimating reserve prices is not possible at this time and depends on too many unknown variables, it should be noted that technology enhancements will allow similar performance at 6 GHz as in 3.5 GHz band (reusing the same sites) so the 6 GHz band will become a substitute for 3.5 GHz spectrum.

[106] Refer to www.imda.gov.sg/regulations-and-licensing/Regulations/consultations/Consultation-Papers/2019/Second-Public-Consultation-on-5G-Mobile-Services-and-Networks. The IMDA has subsequently, via a further public consultation identified the next wave of 5G spectrum that would be suitable for 5G in Singapore, namely the using the 2.1 GHz spectrum band.
[107] Digital Nasional Berhad (DNB) is a wholly Government owned special purpose vehicle. It has been directly allocated spectrum in the 700MHz, and the 3.5 and 28 GHz bands. Refer to www.digital-nasional.com.my

6 RECOMMENDED APPROACH: UNDERTAKING THE EARLY PARTITIONING OF THE 6 GHz BAND BETWEEN IMT AND WI-FI USE

6.1 Recommended Approach

As the 6 GHz spectrum band represents the largest remaining single block of spectrum which could be allocated for IMT services in the mid-band, it is critical to get right. ***While informed by the approaches in North America and Europe to the 6 GHz band, the unique characteristics of the region including the legacy allocations of spectrum in ITU Region 3 necessitate the early partitioning of the 6 GHz band between IMT and Wi-Fi uses.***

This WPC report finds there is a compelling case for policy makers, regulators and mobile network operators (MNOs) in Asia-Pacific to allocate only the lower part of the 6 GHz band (5925-6425 MHz) for unlicensed use with the upper part of the band (6425-7125 MHz) to be allocated for IMT services in Asia-Pacific as soon as practicable.

Critically such an approach preserves future flexibility as any assignment of the 6 GHz band to unlicensed use is not a decision that can be reversed, this is quite different to the assignment of the 6 GHz band to licensed uses. Importantly, a decision to allocate the upper part of the band (6425-7125 MHz) to IMT services can be made now before 2023 at the WRC-23. Full global harmonisation of the band can follow in WRC-23 (with even greater support for the ecosystem development and its availability).

The major reasons for this recommended approach are *inter alia*:

(i) An acute need for additional mid-band spectrum in Asia-Pacific given lack of C-Band and low-band spectrum which could be partially addressed by the partitioning of the 6 GHz band. Early field studies show that the 6 GHz band is a very good substitute for the 3.5 GHz band in terms of performance; and

(ii) A large allocation to Wi-Fi does not of itself address the digital divide: The allocation of the entire 6 GHz band for unlicensed use does not provide additional coverage and help bridge the region’s urban digital divide which COVID-19 pandemic has highlighted is a key public policy issue;

(iii) The allocation of 1.2 GHz of prime spectrum to Wi-Fi is not supported by any demand analysis. Further, such a decision would be premature as experience and studies are showing that faster broadband services (especially 5G)/larger data allowances/ recharges mean reduced Wi-Fi offload;

(iv) Strong regional FWA growth supports an IMT allocation in the 6 GHz band: Growth in 4G and 5G FWA in Asia-Pacific region (which has underdeveloped fixed network infrastructure especially fibre deployments) would be supported by reservation of additional mid-band spectrum in the 6 GHz band to support additional users and higher download usage patterns;

(v) The likely economic benefits are maximised with shared allocation of the 6 GHz band spectrum as the short and long term economic benefits of improved IMT and Wi-Fi services can both be secured;

(vi) Partitioning the 6 GHz band assists in future proofing for future 5G advanced and 6G services;

(vii) Making more IMT spectrum in the 6 GHz band supports strong mobile/wireless competition by making available 700 MHz of additional mid-band spectrum. This will ensure at least 3 to 4 MNOs in a market have sufficiently large IMT spectrum portfolios to provide high speed, high quality wireless broadband and to be viable/sustainable in commercial terms; and

(viii) Possible additional proceeds to Government arise from the allocation of IMT spectrum in the 6 GHz band.

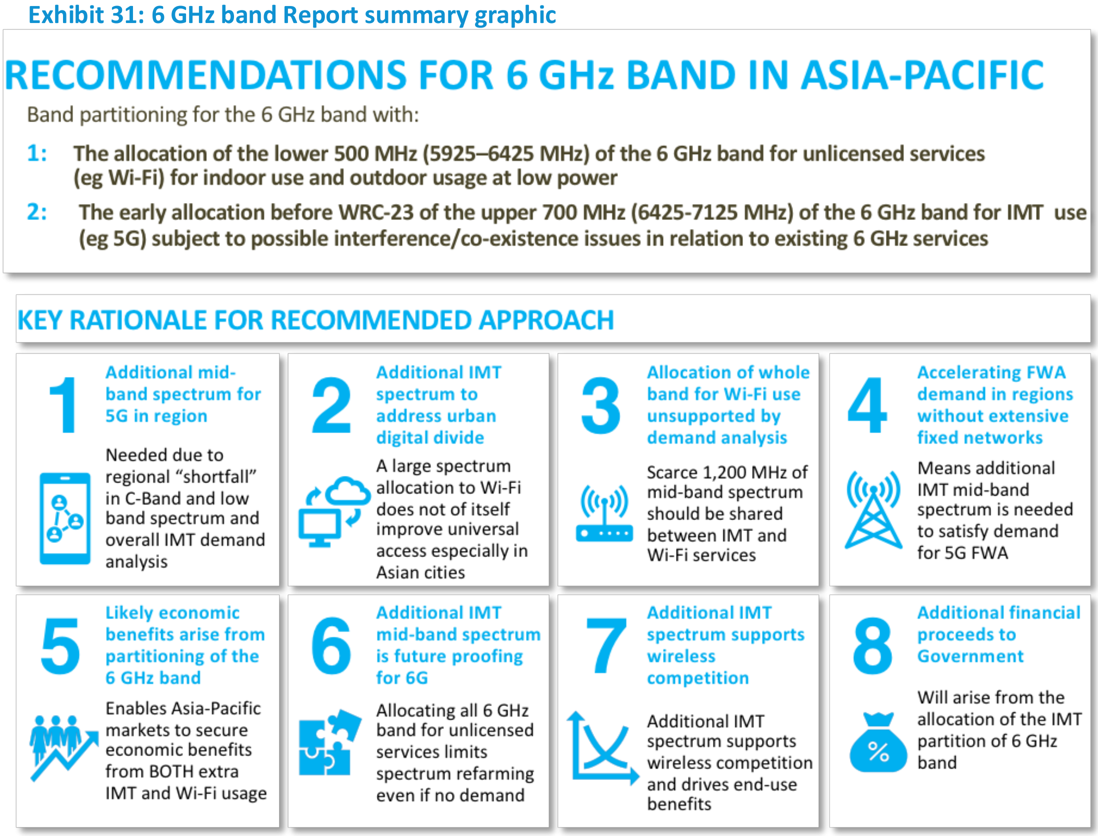
Importantly, there wide industry support as it is a high priority band for many MNOs and vendors. The 3GPP has already started standardisation work and with at least China and Russia supporting the band (both announced trial plans in 2021), there will be affordable network and device ecosystem for 6 GHz band.

In terms of technical issues, it is further recommended that:

- ***Lower part of the band:*** The allocation of the lower part of the 6 GHz band (5925-6425 MHz) for unlicensed use should generally be restricted to indoor use with a maximum mean EIRP 250 mW (23 dBm), or very low power 25 mW (14 dBm) outdoor;[108] and
- ***Upper part of the band:*** The allocation of the upper part of the 6 GHz band (6425-7125 MHz) for IMT use, will be subject to addressing the possible interference/co-existence issues in relation to existing 6 GHz services, namely FSS and FS services (see the discussion on the transition issues in section 6.2 below).

The recommended approach is summarised in Exhibit 31 below.

Exhibit 31: 6 GHz band Report summary graphic



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[108] Further, deployment of Wi-Fi in lower part of the 6 GHz band should not result in undue restrictions to the deployment of IMT 5G NR in upper part of 6 GHz band (i.e., Wi-Fi receiver characteristics at the 6425 MHz boundary should take this into account).

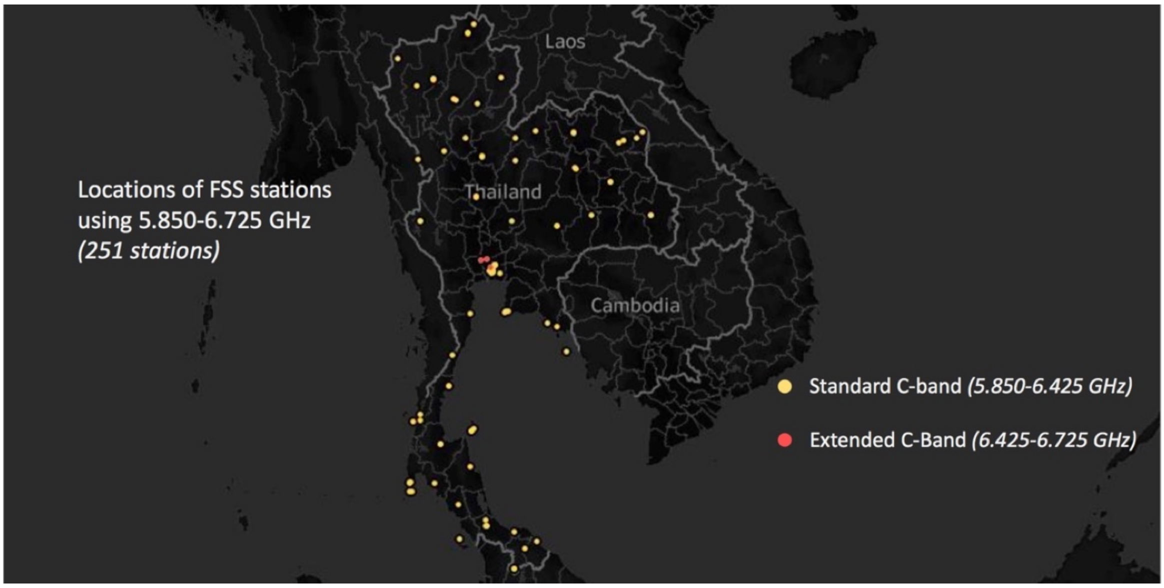
6.2 Transition issues - Possible harmful interference to existing 6 GHz services

The above recommendations raise some transition issues. Specifically, an early allocation of 6 GHz for unlicensed usage raises questions about coexistence between Wi-Fi and incumbent services (including FSS and fixed microwave backhaul links (especially long hops)). Exhibit 32 and Exhibit 33 detail the FSS and FS links respectively currently using the 6 GHz band in Thailand from a study from the National Broadcasting and Telecommunications Commission (NBTC) in May 2021. The density of such links varies considerably across markets in the Asia-Pacific region.

We note this has not been studied at ITU-R level (only at regional/country level), and as such the protection from Wi-Fi cannot be guaranteed. While the use of IMT in 6 GHz is being considered under WRC-23 AI, the protection from IMT services will be well studied in ITU-R.

The protection of fixed links from Wi-Fi is still debatable. Ofcom in the United Kingdom has undertaken a technical analysis which shows that no harmful interference to fixed links is likely to be caused by the allocation of unlicensed use (Wi-Fi) the lower part of the 6 GHz band. [109] However, the Fixed Wireless Communications Coalition (FWCC) filling to FCC petition showed a test result that Wi-Fi will cause severe interference to fixed links.[110] Another test performed in July 2021 in Georgia in the United States also confirmed that FCC-certified unlicensed LPI devices will cause harmful interference to licensed fixed microwave systems.[111] Further, AT&T in concert with a range of utility providers and others have instituted litigation against the FCC because of their concerns that their existing fixed link operations will be affected by harmful interference from Wi-Fi users using the 6 GHz band.[112]

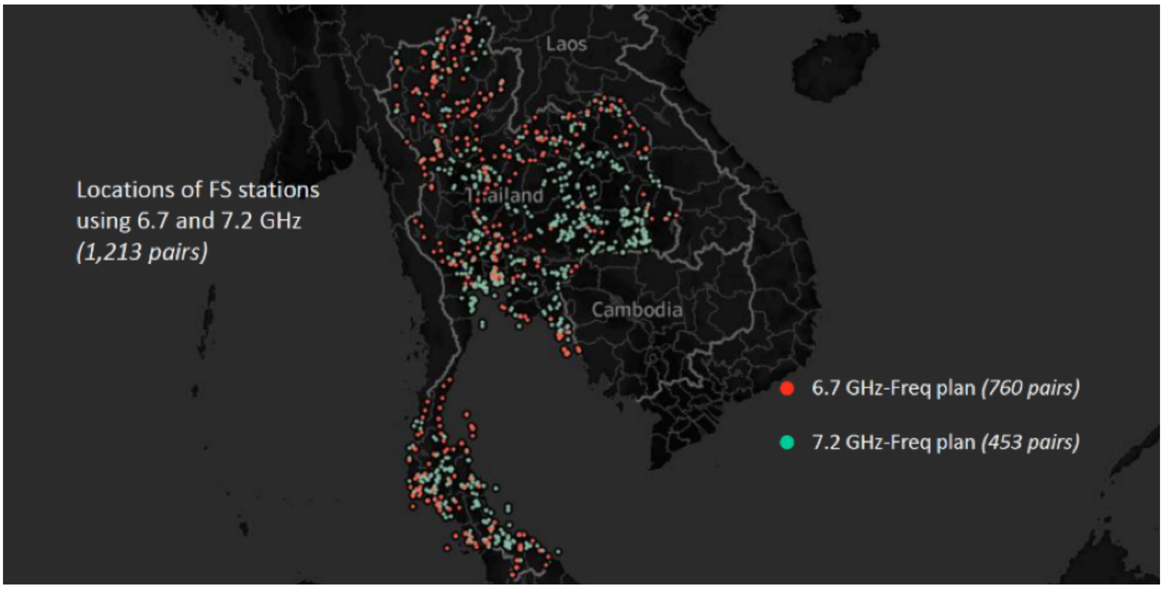
Exhibit 32: Example of FSS stations using the 6 GHz band in Thailand



Source: NBTC, Thai 6 GHz Focus Group, *Guidelines for using the 6 GHz frequency band to support new technologies in the future,* 18 May 2021, page 10

[109] Refer to www.ofcom.org.uk/__data/assets/pdf_file/0036/198927/6ghz-statement.pdf
[110] Refer to https://ecfsapi.fcc.gov/file/106040035611332/01432982.PDF
[111] Refer to https://ecfsapi.fcc.gov/file/106231367519302/6%20GHz%20Columbus%20Test%20Report%20-%20June%202021.pdf
[112] Refer to www.lightreading.com/5g/atandt-takes-fcc-to-court-over-5g-backhaul/d/d-id/772166

Exhibit 33: Example of fixed links using the 6 GHz band in Thailand



Source: NBTC, Thai 6 GHz Focus Group, *Guidelines for using the 6 GHz frequency band to support new technologies in the future,* 18 May 2021, page 11

In relation to the recommendation that the upper part of the 6 GHz band should be allocated to IMT use, we note that the IMT parameters and propagation models for WRC-23 studies have been finalised in the ITU. Sharing studies will commence in October 2021 and will last until October 2022. A number of sharing studies have been submitted to the ITU. They indicate that sharing is feasible with both of FSS uplink and FS based on IMT latest advanced Active Antenna Systems with beamforming (Massive MIMO) technologies, the latest and most accurate clutter loss, building entry loss and propagation models etc.

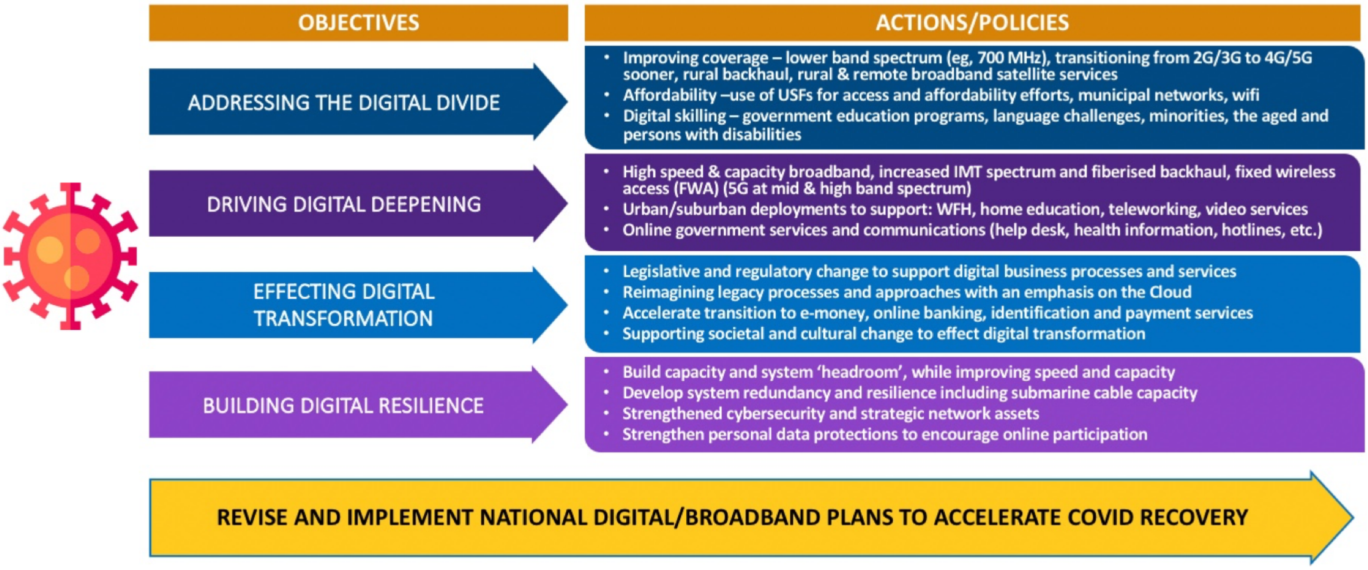
The good news is that the density of fixed links differs across Asia -Pacific countries in both the lower part (5925-6425 MHz) and upper part (6425-7125 MHz) of the 6 GHz bands. It is noted that the FS links are deployed at known locations and known characteristics. As such co-ordination is possible between IMT and FS. The FSS uplink in 6GHz is paired with FSS downlink in C-band. As many Asia-Pacific countries are attempting to clear further C-band FSS for 5G use, the paired FSS link in the 6 GHz band might be cleared as well.

6.3 Why a decision on allocating the upper part (6425-7125 MHz) of the 6 GHz band to IMT should not wait until WRC-23

While arguing for a delay in any decision on the upper part of the 6 GHz band until WRC-23 is a conservative approach and may be supported academically, certainty is needed in the Asia-Pacific region in a period where all Governments are trying to devise plans to emerge stronger after the adverse impact of COVID-19 pandemic and its global disruptions to *inter alia* trade, travel and investment.

Revised digital economy and broadband plans and policies to strengthen ICT sectors (especially to cater for the digital transformation which has been accelerated during the pandemic) all form part of the current public policy parameters being reviewed and revised globally and in Asia-Pacific (see Exhibit 34 below). In this context, clarity in relation to the optimal approach to the 6 GHz band is optimal.

Exhibit 34: Digital responses to COVID-19



Source: ITU, *Pandemic in the Internet Age: From second wave to new normal, recovery, adaptation and resilience,* June 2021 [113]

It is for this reason, that there is a compelling case to adopt band partitioning for the 6 GHz spectrum band and that this should form part of a broader approach of maximising IMT and Wi-Fi future options for mid-band spectrum. Such an approach would see Government/regulators endorsing a new unlicensed band (for Wi-Fi) from 5925 to 6425 MHz and securing the majority of the benefits highlighted by its supporters whilst allocating/reserving the majority of the 6 GHz band (6425 to 7125 MHz) to IMT usage in Asia-Pacific which has even greater economic, societal and industry value. The approach for our region needs to be customised taking account of that fact key industry parameters differ from North American and other markets supporting a broad allocation of some 1,200 MHz to Wi-Fi in the 6 GHz band.

In addition, it is hoped and the Asia-Pacific region should support efforts at the WRC-23 (refer to WRC-23 AI 1.2) to ensure spectrum harmonization of the upper part of the 6 GHz band (from 6425 – 7125 GHz) for IMT usage globally. Such approach will further facilitate the development of the 6 GHz IMT ecosystem. Given the existing global mobile primary allocation, other countries will be able to assess the needs and requirements based on the outcomes of WRC-23.

[113] Available at https://reg4covid.itu.int

7 ALTERNATIVE RECOMMENDED APPROACH

If administrations in the Asia-Pacific region do not support immediately reserving the upper part of 6 GHz band (6425-7125 MHz) for IMT services in advance of the WRC-23 decisions on harmonising the band, then the ***alternative recommended approach is for only the lower part of the band (5925-6425 MHz) to be reserved for unlicensed use (Wi-Fi) prior to 2023 and the WRC-23 decisions.***

Such an approach creates options post WRC-23 for any Asia-Pacific market to either decide to allocate the upper 6 GHz band either to IMT services or to unlicensed services (Wi-Fi). Unfortunately, the reverse is not true, as if a decision is taken by Government or a spectrum regulator to allocate the entire 1.2 GHz to unlicensed usage in 2021/22 it will be almost impossible to reverse such a decision.

Taking a decision to allocate only the lower part of the 6 GHz to Wi-Fi is consistent with the precedents in the European Union, the United Kingdom and the stated early preference of Australia.