TELECOM REGULATORY AUTHORITY OF INDIA

A White Paper on

6 Ghz band

September 2023

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DISCLAIMER: This white paper is for research and analysis. No inference or statement or proposition made in this document should be taken as the recommendations or endorsement of TRAI.

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PREFACE

The evolution of wireless communication technologies has played a pivotal role in shaping the way we connect, communicate, and interact with the world around us. As our reliance on wireless devices and networks continues to grow, the need for spectrum resources capable of delivering higher data rates, increased capacity, and enhanced performance becomes paramount.

With the proliferation of bandwidth-intensive applications such as virtual reality, augmented reality, high-definition video streaming, and cloud-based services, the existing spectrum bands are likely to become more and more congested. 6GHz band presents a unique opportunity to address this concern and unlock a wealth of benefits for the service providers as-well-as the consumers.

This white paper explores the technical aspects and regulatory considerations associated with the 6GHz band. It delves into the intricacies of utilizing this frequency range for various wireless communication technologies, including Wi-Fi, cellular networks, and other emerging wireless standards.

I express my gratitude to the experts, researchers, and industry insiders whose insights and contributions have shaped this white paper. My special compliments to TRAI Centre for Studies & Research team led by Sh. Anil Kumar Bhardwaj for this work. I am sure this paper will be useful for policy makers and researchers as the basic input document on this all-important issue that has been under active discussion in the country for some time now.

TRAI Centre for Studies and Research will bring many more topical papers from time to time.

(Dr. P.D. Vaghela)

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CHAPTER 1
INTRODUCTION

Background

1.1. Spectrum refers to the range of electromagnetic frequencies used for wireless communication. Each frequency within the spectrum has different characteristics and is suitable for specific applications. Spectrum management is the process of regulating and controlling the allocation, assignment, and use of the radio frequency spectrum. It involves activities and policies implemented by government agencies and regulatory bodies and is important to ensure efficient and effective utilization of the limited spectrum resources.

1.2. Key elements of the spectrum management include:

- Spectrum Planning: Spectrum planning involves the strategic management of the spectrum resources. It includes analyzing the current and future demands for spectrum, identifying potential interference issues, and developing long-term plans for spectrum allocation and usage to meet the evolving needs of various wireless services.

- Interference Management: Interference management aims to minimize or eliminate harmful interference between different wireless systems operating in the same or adjacent frequency bands. It involves establishing technical regulations, standards, and mitigation techniques to ensure that wireless services can coexist without adversely affecting each other's performance.

- Spectrum allocation- Spectrum allocation involves the identification and designation of specific frequency bands for various services and

applications. It determines which portions of the spectrum are allocated for telecommunications, broadcasting, mobile services, satellite communications, aviation, and other wireless services.

- Spectrum Licensing: Spectrum licensing is the process of granting licenses to authorized entities, such as telecommunications operators or broadcasters, to use specific portions of the spectrum. Licensing ensures exclusive rights to use the allocated spectrum and helps regulate the entry, operation, and compliance of service providers within the allocated bands.

- Spectrum Monitoring and Enforcement: Spectrum management also involves monitoring the use of spectrum and enforcing compliance with regulations and license conditions. Monitoring helps identify unauthorized or illegal use of the spectrum, detect interference sources, and ensure that license holders adhere to their allocated spectrum rights and technical requirements. In India, Wireless Monitoring Organisation[1] (WMO) under Wireless Planning & Control wing of Department of Telecommunications performs the task of spectrum monitoring.

1.3. Spectrum management plays a crucial role in several ways:

- Efficient Use of Limited Spectrum: The radio frequency spectrum is a finite resource, and it needs to be managed effectively to ensure its optimal use. Spectrum management enables the allocation and assignment of frequencies to different services, including telecommunications and broadcasting, in a way that minimizes interference and maximizes spectrum utilization. By coordinating the use of frequencies, spectrum

[1] Wireless Monitoring Organisation , https://dot.gov.in/wireless-monitoring-organisation# ; For more details on functions and offices of WMO, visit : https://dot.gov.in/sites/default/files/WMO%20its%20functions%2C%20field%20units%2C%20contact%20details%20etc.pdf

management allows multiple services to coexist and operate efficiently without causing harmful interference to one another.

- Interference Prevention: Without proper spectrum management, different wireless services could interfere with each other, degrading the quality and reliability of communication or broadcasting signals. Interference can disrupt wireless networks, leading to dropped calls, slow data speeds, or poor audio and video quality in broadcasting. Effective spectrum management helps prevent interference by assigning frequencies and implementing technical regulations and standards to ensure that different services operate within their allocated spectrum bands without interfering with each other.

- Facilitating innovation: Spectrum management involves planning and allocating specific frequency bands for different services and applications. This process considers factors such as the characteristics of the frequency bands, the requirements of different services, and the demand for spectrum resources. By carefully planning and allocating spectrum, regulators can support the growth of telecommunications and broadcasting sectors, promote innovation, and facilitate the introduction of new wireless technologies and services.

- License Management: Licensing ensures that authorized entities have exclusive rights to use specific frequency bands within defined geographical areas. This approach helps prevent overcrowding of the spectrum, enables fair competition, and provides a framework for resolving interference disputes. License management also allows regulators to enforce compliance with technical and operational rules, ensuring that services operate within the assigned spectrum and meet performance standards.

- International Coordination: Spectrum management is a global concern, as radio waves do not respect national borders. International coordination is crucial to harmonize spectrum usage, avoid cross-border interference and have a common device ecosystem. Through international agreements and conferences, countries collaborate to allocate and assign spectrum bands consistently, enabling seamless global communication and broadcasting services. Spectrum management frameworks such as those established by the International Telecommunication Union (ITU) facilitate this international coordination.

1.4. Spectrum management is a comprehensive framework that governs the allocation, assignment, regulation, and monitoring of the radio frequency spectrum. It ensures efficient use of spectrum resources, minimizes interference, facilitates fair competition, and supports the development of wireless communication and broadcasting services. It is essential for optimizing spectrum utilization, preventing disruptions, and promoting the growth, innovation, and reliable operation of wireless communication systems. Hence, it is essential to prepare roadmaps for spectrum management strategically for full optimization of the scarce resource while maximizing the socio-economic benefits of the same.

1.5. In today's dynamic landscape, technology is advancing at an unprecedented pace. From the proliferation of 5G networks and its use cases like the Internet of Things (IoT) or Metaverse, and the promise of future innovations like 6G, our dependence on wireless communication has never been more pronounced. This rapid technological evolution is not only transforming industries but also challenging spectrum management authorities and regulators to keep pace with the changing demands for radio frequency spectrum. Effective spectrum management is the linchpin that will enable the seamless integration of these technologies into our daily lives while ensuring equitable access, optimal utilization, and the prevention of harmful interference. In this context, the

strategic allocation and utilization of spectrum resources are critical to harnessing the full potential of these evolving technologies and propelling our global connectivity into the future.

1.6. Amidst this dynamic landscape of evolving technologies and increasing demand for spectrum, the spotlight now turns to the 6 Gigahertz (GHz) band, making it a focal point of discussion in the telecommunications sector. As wireless communication and broadcasting services continue to proliferate, the 6 GHz band represents a valuable and untapped resource with the potential to address the escalating spectrum needs of our interconnected world. The upcoming World Radiocommunications Conference 2023 (WRC-23)[2] is set to provide a platform for deliberations on harnessing the potential of this band effectively. This paper discusses the said potential of 6 GHz and the way ahead.

Introduction to 6 GHz band

1.7. 6 GHz band refers to a specific range of frequencies within the radio frequency spectrum, spanning from 5.925 GHz to 7.125 GHz, which is a mid-band frequency range. It is considered a valuable portion of the spectrum as it is said to hold significant potential for wireless communication services. It is stated that 6 GHz band provides a suitable environment for 5G connectivity with decent coverage, capacity, network performance and bandwidth.[3]

1.8. The 6 GHz band is one of the important agenda of discussion in WRC-23[4]. Specific aspects that elicit divergent views on the issue are:

[2] https://www.itu.int/wrc-23/
[3] GSMA Report on, The socioeconomic benefits of the 6 GHz band, Considering licensed and unlicensed options, January 2022
[4] https://www.itu.int/dms_pub/itu-r/oth/0c/0a/R0C0A00000D0002PDFE.pdf

- Spectrum availability: As this spectrum band represents the largest remaining single block of spectrum, it is raising significant attention in the minds of the interested stakeholders. The band is relatively underutilized compared to other frequency bands. Traditionally, it has been primarily used for fixed satellite services and various other licensed applications. However, advancements in wireless technologies and increasing demand for spectrum have sparked interest in exploring the potential use of this band for additional wireless communication services.

- Potential for Wi-Fi (Wireless Fidelity) expansion: The potential of 6 GHz band in expanding Wi-Fi capacity has attracted considerable attention. With the proliferation of connected devices and the growing need for higher data speeds and network capacity, there is a desire to allocate a portion of the 6 GHz band for unlicensed Wi-Fi use. If done so, it could provide a significant boost to Wi-Fi networks, enabling faster and more reliable wireless connections. While 6 GHz is not a substitute of existing 2.4 GHz and 5 GHz bands, it is still stated to be an enabler for Wi-Fi. Traditionally, in US and other countries, Wi-Fi has been used in 2.4 GHz and 5 GHz band.[5] Now with the 6th generation of Wi-Fi standard[6], the devices operating in the 6 GHz band will be working on the technology termed as 'Wi-Fi 6E'.[7] It will drive innovation with higher bandwidth usage at a lower cost. It is estimated that with 6 GHz band, Wi-Fi 6E supporting devices

[5] https://www.fiercewireless.com/tech/6-ghz-and-wi-fi-6-create-buzz-wi-fi-community

[6] Introduced by Wi-Fi Alliance, Wi-Fi 6E is the upcoming standard for an extension of Wi-Fi 6 (also known as 802.11ax), enabling the operation of features in the unlicensed 6 GHz band, in addition to the currently supported 2.4 GHz and 5 GHz bands. Available at: https://www.juniper.net/us/en/research-topics/what-is-wi-fi-6e.html#:~:text=Introduced%20by%20Wi%2DFi%20Alliance,GHz%20and%205%20GHz%20bands. The Wi-Fi Alliance is a wireless industry organization that exists to promote wireless technologies and interoperability. The Alliance also certifies products that comply with its specifications for Wi-Fi interoperability, security and application-specific protocols., Available at- https://whatis.techtarget.com/definition/Wi-Fi-Alliance

[7] https://www.fiercewireless.com/tech/6-ghz-and-wi-fi-6-create-buzz-wi-fi-community. The industry refers to the current generation of Wi-Fi as Wi-Fi 6 (also known as 802.11ax), which operates on the congested 2.4 GHz and 5 GHz unlicensed bands. Wi-Fi 6E device is essentially a Wi-Fi 6 device that is capable of operating in the 6 GHz band. Wi-Fi 6E provides more adjacent spectrum to meet growing business demands, wider channels to deliver on the promise of 160 MHz, and zero interference from other electronic devices, available at: https://blogs.arubanetworks.com/solutions/wi-fi-6e-in-europe-frequently-asked-questions/

will have access to 133% increase of channels, that is, 14 additional 80 MHz channels[8] or 7 additional 160 MHz channels.[9]

- 5G use cases: The demand for 6 GHz band is on rise for both licensed and unlicensed use due to proposed benefits of the band in multiple 5G use cases such as in enhanced mobile broadband (eMBB), fixed wireless access, industrial automation, massive IOT (mIoT), health care innovations, 5G enabled transportation etc.[10] As per research in Asia and Europe, 3.5 GHz band has been considered ideal for 5G networks[11] but not all countries have sufficient availability of spectrum in the 3.5 GHz band for the satellite and mobile operators to support 5G and 6G devices.[12] Now, 6 GHz is being considered as a suitable substitute for the 3.5 GHz because of the benefits of this 1200 MHz frequency range like good propagation characteristics and larger bandwidth.[13]

- Regulatory Considerations: The discussion surrounding the 6 GHz band also involves regulatory considerations. Governments and regulatory bodies need to assess the potential impact of opening the band for unlicensed or 5G use while ensuring that existing licensed services, such as fixed satellite links, are protected from interference. Balancing the need for additional spectrum access with the preservation of existing services is a key aspect of the ongoing debate.

- Industry and Stakeholder Engagement: Various stakeholders, including telecommunications companies, technology providers, and consumer advocacy groups, have been actively engaged in the discussions around the 6 GHz band. They provide inputs on the potential benefits, technical

[8] https://www.hpe.com/us/en/insights/articles/the-6-ghz-network--bigger-channels--stronger-signal--faster-data-2007.html
[9] Supra note 6
[10] https://www.gsma.com/spectrum/wp-content/uploads/2021/05/6-GHz-Capacity-to-Power-Innovation.pdf
[11] https://venturebeat.com/2018/10/23/fcc-expands-3-5ghz-band-to-5g-and-opens-6ghz-band-to-future-wi-fi/
[12] https://techblog.comsoc.org/2021/10/30/6-ghz-band-proposed-for-asia-pacific-region-but-its-not-in-itu-r-m-1036/
[13] *Ibid*

considerations, and regulatory frameworks associated with utilizing this spectrum for different purposes, including Wi-Fi expansion and other wireless communication services.

1.9. However, 6 GHz is not a vacant band due to the existence of incumbent services which are used for public safety services, wireless backhaul, etc. Some countries have already made decisions regarding the management of the 6 GHz band. In April 2020, the US Federal Communications Commission (FCC) adopted the entire 6 GHz band (5925-7125 MHz) for unlicensed use and other countries are also navigating the varied management styles of the band. With these developments, spectrum sharing, and other approaches are being considered in different countries. Hence, the interested stakeholders like Wi-Fi 6E proponents advocates for unlicensed use of this band while mobile broadband service providers are eagerly seeking access to this scarce resource for IMT use.

Objective of the paper

1.10. As a regulator of telecom and broadcasting sector in India, Telecom Regulatory Authority of India (TRAI) aims to create an enabling environment and a level-playing field for all the industry players. With this objective, this white paper discusses the spectrum management of 6 GHz band in India and the various global perspectives. It also tries to identify regulatory challenges and impact on the concerned industries.

CHAPTER 2
6 GHz BAND- POSSIBLE ALLOCATION APPROACHES

Licensed and Unlicensed spectrum

2.1. Due to the limited availability of spectrum, regulatory authorities have established two fundamental approaches to manage its usage: licensed spectrum and unlicensed spectrum.

2.2. Licensed spectrum is set of frequency bands that are allocated to specific entities through a licensing process overseen by regulatory authorities of the country. These entities can either be telecommunications operators or government agencies and are granted exclusive rights to use the allotted frequency bands within defined geographical areas. Licensed spectrum is typically utilized for critical wireless services such as cellular networks, broadcast terrestrial television, and public safety communications. As per the licensing framework, each licensee operates within its assigned frequency range, minimizing the chances of interference with other users and ensures orderly and interference-free operation of wireless services.

2.3. When a portion of the spectrum is made open and available for public use without requiring a specific license, it is referred to as Unlicensed spectrum. It is typically used by a wide range of devices, including Wi-Fi routers, Bluetooth devices, and cordless phones. The unlicensed nature of this spectrum allows for greater flexibility and innovation, as it enables anyone to develop and deploy devices that operate within its frequency bands. It has played a vibrant role in the proliferation of wireless technologies, aiding the growth of wireless local area networks (WLANs) and enabling the Internet of Things (IoT) revolution.

2.4. Both licensed and unlicensed spectrum have their unique advantages and applications. Licensed spectrum guarantees quality of service and enables large-scale wireless networks to operate smoothly. Unlicensed spectrum fosters innovation and provides opportunities for small-scale deployments. The coexistence of both approaches contributes to a vibrant and diverse wireless ecosystem, supporting a wide array of wireless applications and driving the continuous evolution of wireless communications technology.

2.5. Since there are limited radio frequencies in existence, more users on a frequency within a geographical area may lead to more interference in transmission. The benefit of licensing can also be understood as limiting the number of users to a particular frequency to maintain the performance and reliability of services offered in that band. The licensed companies need to pay licensing fee to avail this benefit. On the other hand, unlicensed users are permitted to use only parts of the spectrum which are not licensed. This means that there is more potential of usage and innovation, but also chances of more interference with the transmission due to the lack of exclusivity.

2.6. In India, the unlicensed spectrum available is around 689 MHz which is far lower in comparison to other countries (USA - 15403 MHz, UK - 15404 MHz, China - 15360 MHz, Japan - 15377 MHz, Brazil - 15360 MHz) and is spread across various spectrum bands.[14] The unlicensed spectrum does not provide direct revenue to the government vis-à-vis the licensed spectrum. Yet, there are many indirect benefits to the economy by providing some spectrum band for unlicensed usage. The following bands are license free (for use by low power wireless equipment) in India-

- 26.957 MHz to 27.383 MHz (Citizen Band)
- 335 MHz (for remote control of Cranes)
- 865 MHz to 867 MHz

[14] https://broadbandindiaforum.com/wp-content/uploads/2021/06/The-Economic-Value-of-Wi-Fi-Spectrum-for-India-online-19-MAY-2021-accessible.pdf

- 2.4 GHz to 2.4835 GHz
- 5.825 GHz to 5.875 GHz

2.7. Further, the following bands are designated for industrial, scientific, and medical (ISM) applications. The use of these frequency bands for ISM applications shall be subject to special authorization by the administration concerned, in agreement with other administrations whose radiocommunication services might be affected.[15]

- 6.765-6.795 MHz (centre frequency 6.78 MHz),
- 13.553-13.567 MHz (centre frequency 13.56 MHz),
- 26.957-27.283 MHz (centre frequency 27.12 MHz),
- 40.66-40.70 MHz (centre frequency 40.68 MHz),
- 433.05-434.79 MHz (centre frequency 433.92 MHz) in Region 1,
- 902-928 MHz (centre frequency 915 MHz) in Region 2,
- 2.4-2.5 GHz (centre frequency 2.45 GHz),
- 5.725-5.875 GHz (centre frequency 5.8 GHz),
- 24-24.25 GHz (centre frequency 24.125 GHz)
- 61-61.5 GHz (centre frequency 61.25 GHz),
- 122-123 GHz (centre frequency 122.5 GHz), and
- 244-246 GHz (centre frequency 245 GHz)

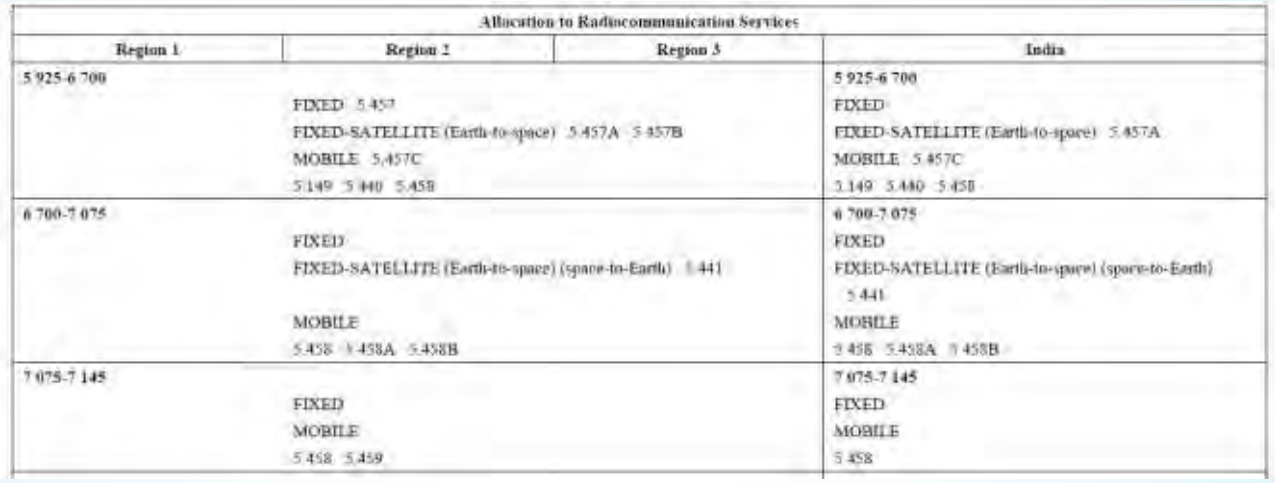
2.8. As per a GSMA Report[16], instead of licensed spectrum, sometimes a country may prefer un-licensing or an alternative approach for spectrum management. Such decision is on the basis of different socio-economic reason, such as lack of market participants for auctions, promoting communication infrastructure development in remote/ unviable areas or where the socio-economic benefits of use cases are not obvious. In these situations, it is free for anyone to use

[15] National Frequency Allocation Plan 2022- https://dot.gov.in/sites/default/files/NFAP%202022%20Document%20for%20e-release.pdf?download=1

[16] GSMA Report on, "The socioeconomic benefits of the 6 GHz band", Considering licensed and unlicensed options, January 2022

such unlicensed range of spectrum subject to the equipment conforming to the standards.

2.9. For any innovator or consumer, an affordable alternative to licensed spectrum is the unlicensed spectrum. They can simply make use of the spectrum by following well-known rules, fostering connectivity, and facilitating innovation. Due to its low cost, standardized deployment and equipment ecosystem, it spurs new business models, innovation and services in millions of unlicensed offerings such as Wi-Fi hotspots, wireless headsets, wireless keyboards, consumer electronics and many others.[17]



Allocation to Radiocommunication Services			
Region 1	Region 2	Region 3	India
5 925-6 700	FIXED 5.457 FIXED-SATELLITE (Earth-to-space) 5.457A 5.457B MOBILE 5.457C 5.149 5.440 5.458		5 925-6 700 FIXED FIXED-SATELLITE (Earth-to-space) 5.457A MOBILE 5.457C 5.149 5.440 5.458
6 700-7 075	FIXED FIXED-SATELLITE (Earth-to-space) (space-to-Earth) 5.441 MOBILE 5.458 5.458A 5.458B		6 700-7 075 FIXED FIXED-SATELLITE (Earth-to-space) (space-to-Earth) 5.441 MOBILE 5.458 5.458A 5.458B
7 075-7 145	FIXED MOBILE 5.458 5.459		7 075-7 145 FIXED MOBILE 5.458

Figure 2.1[18]: 6GHz band-allocation of services

2.10. Figure 2.1 provides details of allocation of services in 6 GHz band in India. To enable the utilization of the 6 GHz band (5925 MHz-7125 MHz) for licensed or unlicensed use alongside the existing fixed satellite services operating in the C-band (5850 MHz-7075 MHz), careful coordination and regulatory measures can be implemented. Adopting advanced spectrum sharing techniques such as Dynamic Frequency Selection (DFS) and Transmit Power Control (TPC) could help. DFS enables devices to detect the presence of incumbent users,

[17] https://broadbandindiaforum.com/wp-content/uploads/2021/06/The-Economic-Value-of-Wi-Fi-Spectrum-for-India-online-19-MAY-2021-accessible.pdf

[18] National Frequency Allocation Plan 2022, DoT

such as fixed satellite services, in the frequency band. If incumbents are detected, devices seeking to operate in the 6 GHz band must vacate the channel or reduce their power levels to avoid interference. TPC ensures that devices adjust their transmission power based on the detected interference environment, thereby minimizing the risk of harmful interference to incumbent services. Geolocation databases could also play a role. Devices seeking to operate in the 6 GHz band would communicate with these databases to determine their geographic location accurately. Based on this information, the database would provide a list of available channels and power levels that the device can use without causing interference to incumbents.

2.11. Clear guidelines, technical standards, and strict certification processes for devices operating in the 6 GHz band will be required to be established to ensure compliance with these sharing mechanisms. Additionally, stakeholders would need to collaborate closely to develop monitoring and reporting mechanisms that detect and resolve instances of interference promptly. This coordinated and technology-driven approach would enable the coexistence of new services in the 6 GHz band while safeguarding the integrity of the existing fixed satellite services operating in adjacent frequency ranges.

6 GHz band allocation approaches

2.12. According to various reports, there can be three 6 GHz allocation approaches that may be adopted by the countries:

- Scenario 1: full 6 GHz band for licensed use.
- Scenario 2: full 6 GHz band for unlicensed use.
- Scenario 3: allocating the lower part of 6 GHz (5925/5945–6425 MHz) for unlicensed and considering the upper part (6425–7125 MHz) for licensed.

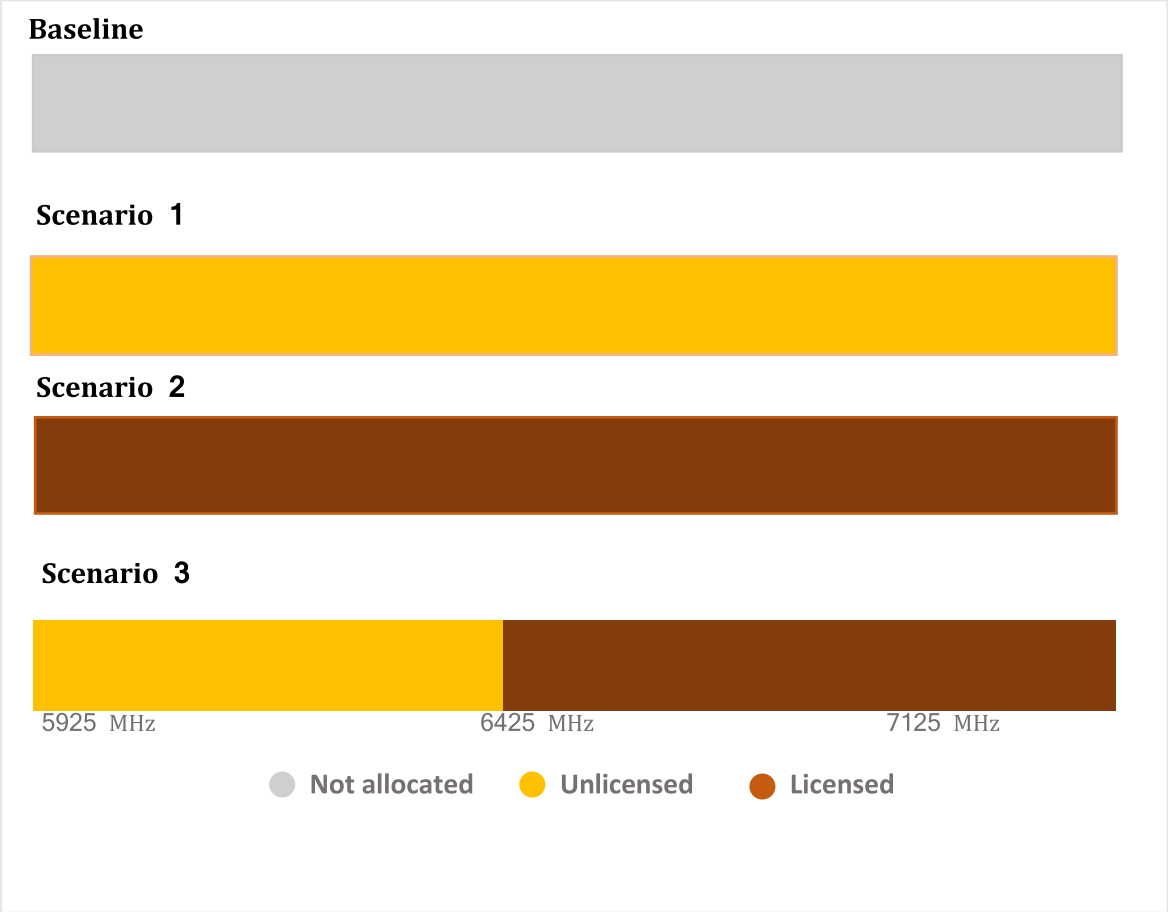


Figure 2.2[19]: 6 GHz policy scenario

2.13. The situation for the spectrum management of 6 GHz band is diverse globally. In USA, FCC adopted rules that made the full 1,200 MHz of spectrum in the 6 GHz band available for unlicensed use.[20] Each scenario in Figure 2.2 is stated to have its pros and cons and each country's regulator requires its own policy analysis and assessment based on its respective socio-economic conditions.

[19] GSMA Report on, "The socioeconomic benefits of the 6 GHz band", Considering licensed and unlicensed options, Jan 2022
[20] https://www.federalregister.gov/documents/2020/05/26/2020-11236/unlicensed-use-of-the-6-ghz-band

CHAPTER 3
GLOBAL SCENARIO

3.1. Before delving into the suitable scenarios for Asian regions and particularly India, the current global scenario should be understood. It is to be noted that Agenda item 1.2 of WRC-23[21] will identify 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.

3.2. The following 6 GHz band proposals prevail in different markets globally:

Table 3.1- 6 GHz band proposals in some global and Asia-Pacific markets

Country/Region	5925–6425 MHz	6425–7125 MHz
Region 1		
European Union (EU)	Unlicensed	Agenda item (AI) 1.2 for consideration at WRC-23
Russia	Unlicensed. 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
Region 2		
United States of America	Unlicensed[22]	
Canada	Unlicensed	

[21] **Agenda Item 1.2:** https://www.apt.int/sites/default/files/2021/04/APG23-2-INF-09Rev.1_Briefing_on_AI1.2.docx
*To consider identification of the frequency bands 3 300-3 400 MHz, 3 600-3 800 MHz, 6 425-7 025 MHz, 7 025-7 125 MHz and 10.0-10.5 GHz for International Mobile Telecommunications (IMT), including possible additional allocations to the mobile service on a primary basis, in accordance with Resolution **245 (WRC-19)**.*

[22] FCC- Unlicensed Use of the 6 GHz Band Report and Order and Further Notice of Proposed Rulemaking ET Docket No. 18-295; GN Docket No. 17-183. Available at: https://docs.fcc.gov/public/attachments/DOC-363490A1.pdf

Region 3		
South Korea	Unlicensed	
Australia	Unlicensed	Current ACMA consultation on use of the 5 and 6 GHz bands[23]
Japan	Unlicensed	Support IMT identification under AI 1.2
Malaysia	Unlicensed	Current public inquiry paper by the MCMC.[24]
New Zealand	Unlicensed	Radio Spectrum Management (RSM) is considering the use of band[25] Support Agenda item 1.2 study of IMT identification.
China	Supports IMT identification	
Indonesia	No decision yet. Issue under study/ analysis	Support Agenda item 1.2 study of IMT identification. Being studied and monitored for IMT ahead of WRC-23[26]
Singapore	No decision yet. Issue under study/ analysis	Support IMT identification under AI 1.2
Vietnam	No decision yet. Issue under study/ analysis	Support IMT identification under AI 1.2 and studies on the sharing and compatibility between IMT and existing primary services in band.

[23] ACMA, *Exploring RLAN use in the 5 GHz and 6 GHz bands*, April 2021

[24] 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.

[25] www.rsm.govt.nz/projects-and-auctions/current-projects/planning-for-wlan-use-in-the-6-ghz- band/

[26] Dr Denny Setiawan, SDPPI, *Indonesia 5G Updates, APT Web Dialogue*, 30 August 2021, page 4

3.3 US FCC's news of making full 6 GHz band available for unlicensed use created a trend in many countries like Brazil and Saudi Arabia.[27] As per GSMA[28], China will use the entire 1200 MHz in the 6 GHz band for 5G. Europe has split the band, with the upper part considered for 5G, but a new 500 MHz tranche available for Wi-Fi. Africa and parts of the Middle East are taking a similar approach.

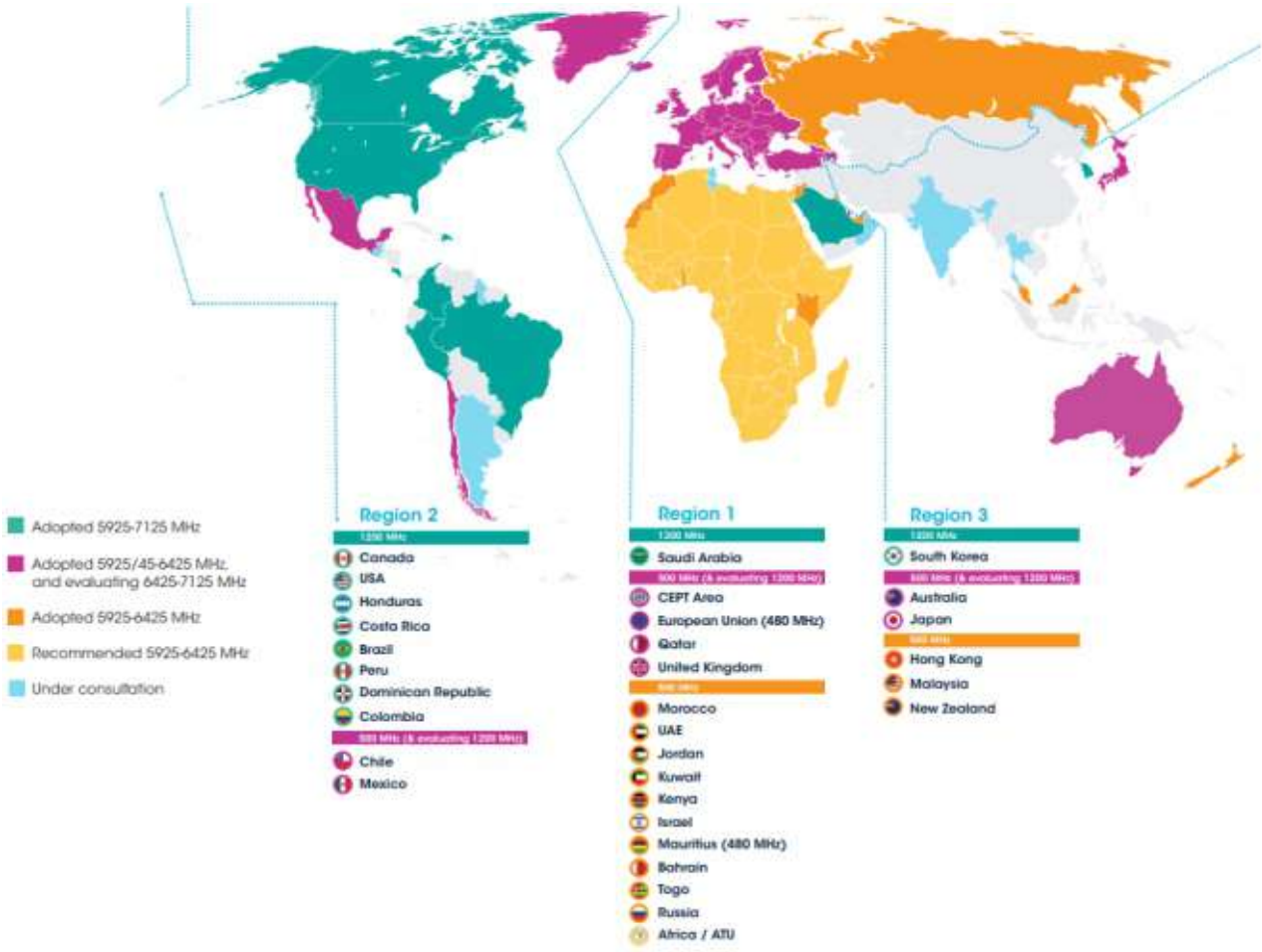


Figure 3.1[29]: Global decisions over license-exempt access to the 6 GHz band as on 5th June 2023

[27] https://www.commscope.com/blog/2021/the-6-ghz-band-wars-who-is-winning/
[28] https://www.gsma.com/spectrum/resources/6-ghz-for-5g/
[29] https://6ghz.info/

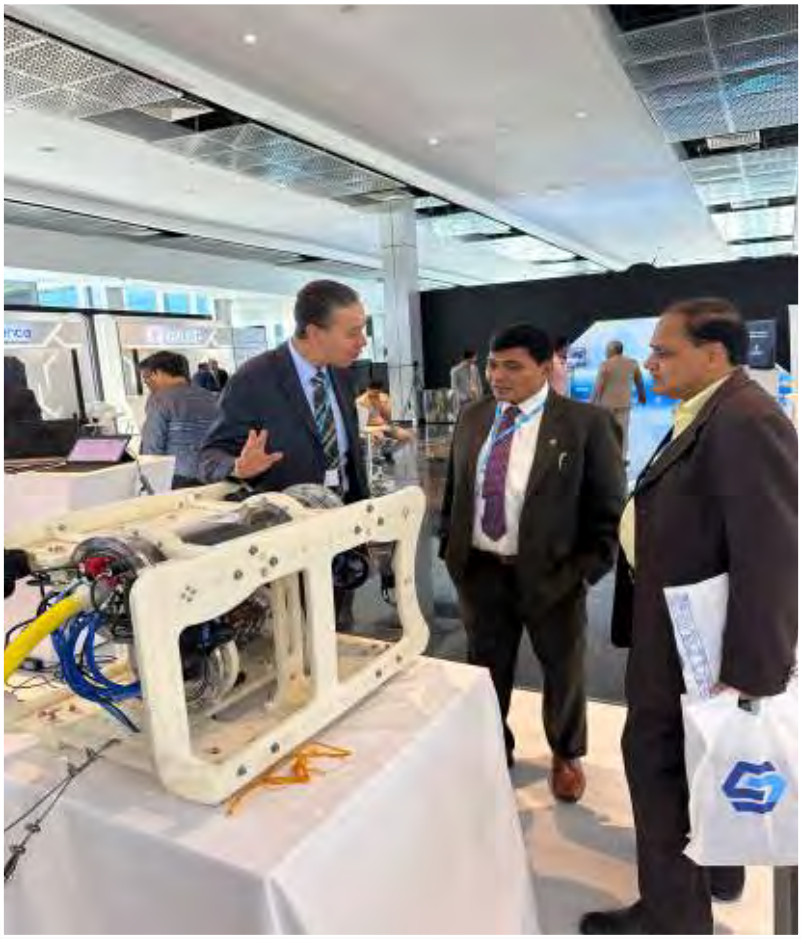
3.4 Countries enabling license exempt usage in 6 GHz band:[30]

Table 3.2 - Latest status of countries that have adopted or are considering adopting unlicensed regime for 6 GHz band for Wi-Fi usage

STATUS	SPECTRUM	COUNTRIES
ADOPTED	5925-7125 MHz	**Region 1**- Saudi Arabia[31] **Region 2**- Brazil[32], Canada, Costa Rica, Colombia[33], Dominican Republic, Honduras, Peru, United States of America **Region 3**- South Korea
	5925-6425 MHz	**Region 1**- Africa, Bahrain, CEPT, European Union[34] (480 MHz), Iceland, Israel, Jordan, Kenya, Kuwait, Liechtenstein, Mauritius (480 MHz), Morocco, Norway, Qatar, Russia, Switzerland, Togo, Turkey, United Arab Emirates[35], United Kingdom[36] **Region 2**- Chile, Mexico, **Region 3**- Australia[37], Hong Kong[38], Japan, Malaysia, New Zealand
	6425-7125 MHz	None

[30] https://6ghz.info/
https://www.wi-fi.org/countries-enabling-wi-fi-in-6-ghz-wi-fi-6e
[31] https://www.cst.gov.sa/en/mediacenter/pressreleases/Pages/2021040101.aspx
[32] https://www.gov.br/anatel/ptbr/assuntos/noticias/anatel-aprova-requisitos-tecnicos-para-wi-fi-6e
[33] https://www.ane.gov.co/SitePages/detnoticias.aspx?p=414
[34] 6GHz harmonisation decision: more spectrum available for better and faster Wi-Fi | Shaping Europe's digital future (europa.eu)
[35] https://tdra.gov.ae/en/media/press-release/2020/thetelecommunications-regulatory-authority-tra-adds-additional-500-mhz-of-6-ghz
[36] OfCom decides Allocation of lower frequency range of 6 GHz band to Wi-Fi 6E. Available at: https://www.ofcom.org.uk/consultations-and-statements/category-2/improving-spectrum-access-for-wi-fi
OfCom releases statement that is not opening the upper frequency range of 6 GHz band to Wi-Fi 6E. Available at: https://www.ofcom.org.uk/spectrum/spectrum-management/6-ghz
[37] Radiocommunications (Low Interference Potential Devices) Class Licence Variation 2022 (No. 1)- ACMA. Available at: https://www.legislation.gov.au/Details/F2022L00249/Explanatory%20Statement/Text
[38] Statement of the Communications Authority Creation of a Class Licence for Regulating the Use of and Trade in 6 GHz Devices for Wireless Local Area Network and Variation to the Class Licence for Provision of Public Wireless Local Area Network Services. Available at: https://www.coms-auth.hk/filemanager/statement/en/upload/591/ca_statement_6GHzDevices.pdf

Considering /Evaluating	5925-7125 MHz	None
	5925-6425 MHz	**Region 1**- Egypt, Oman[39] **Region 2**- None **Region 3**- None
	6425-7125 MHz	**Region 1**- CEPT, European Union, Qatar, Turkey, United Kingdom **Region 2**- Chile, Mexico **Region 3**- Australia, Japan



[39] TRA launched public consultations on releasing the lower part of the 6 GHz band for licence-exempt use. Available at: https://www.tra.gov.om/En/DownloadFile.jsp?type=DocumentList&code=236

CHAPTER 4
SCENARIO 1 - LICENSED

4.1. The allocation of the 6 GHz band for licensing is one of the possible considerations in the field of wireless communication, especially demanded by the TSPs for 5G deployment. 5G technology holds immense importance in today's digital landscape, as it promises revolutionary advancements in wireless connectivity. Its high data rates, ultra-low latency, and massive device connectivity capabilities have the potential to transform industries and enable innovative applications. However, the successful implementation of 5G relies heavily on the availability of suitable spectrum. Adequate spectrum allocation is crucial to unlock the full potential of 5G networks, ensuring sufficient bandwidth for high-speed data transmission and supporting the diverse requirements of various use cases, such as autonomous vehicles, smart cities, and Internet of Things (IoT) devices.

4.2. Efficient and timely allocation of harmonized spectrum for 5G is essential to foster innovation, promote economic growth, and maintain global competitiveness in the digital era. The 6 GHz band is considered ideal for 5G due to its vast spectrum capacity and allocating this band for licensed use holds the potential to revolutionize connectivity and address the increasing demand for high-speed data transmission, enhanced network performance and improved user experiences. Some of the reasons are discussed below.

A. Estimated mid-band spectrum shortfall for 5G in India.

4.3. Mid-band spectrum (1 GHz-6 GHz) is the most sought spectrum around the world to deploy 5G as it delivers both coverage as well as speeds. Spectrum in the range 3.3 GHz to 3.8 GHz range is considered ideal and is designated for 5G in many countries. In India, the mid-band spectrum (3300 - 3670 MHz)

was the most popular and received the highest bids among other bands, accounting more than 50% of the total revenue from the auction.

4.4. But there is a significant challenge in making spectrum available for IMT use in the C-band (3.3 – 4.2 GHz) due to the presence of existing usage and users. Unlike higher frequencies, the C-band[40] is less susceptible to rain fade and is not significantly attenuated by atmospheric moisture. India's weather topography (temperature and rainfall characteristics) combined with the ability of very wide beams which satellites can form using C-band spectrum make this band a preferred choice of the fixed-satellite service (FSS) providers. Further, the device and equipment ecosystem are well-developed including availability of affordable low noise block-converters (LNBs). C-band in Asia, including India, is therefore widely used by satellite operators, for television and radio distribution and VSAT-based services even though there is a migration to HITS satellites operating in Ku and Ka bands.[41]

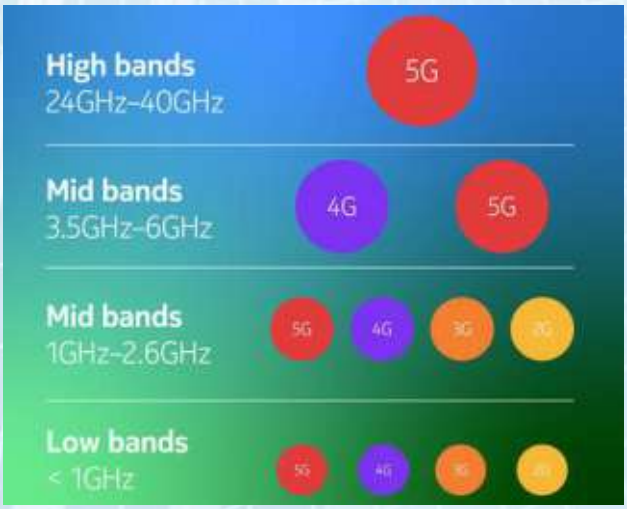


Figure 4.1[42]: Spectrum and possible mobile generations network

[40] Radio frequencies within bands 4 GHz and 8 GHz bands

[41] Report by WPC on *Optimising IMT and Wi-Fi mid-band spectrum allocation: The compelling case for 6 GHz and partitioning in Asia-Pacific*, 11 October 2021

[42] https://www.nokia.com/thought-leadership/articles/spectrum-bands-5g-world/

4.5. The portion from 3.7 GHz to 4.2 GHz has been used by broadcasters for providing television broadcast services for over two decades in accordance with the National Frequency Allocation Plan (NFAP) 2022. It is noted that the NFAP 2022 is aligned with the frequency plan recommended by the International Telecommunication Union's through Radio Regulations group. Part of the C-band from 3.3 GHz to 3.67 GHz, which has been auctioned in India, is the globally coveted mid-band spectrum and is described as a "balancing point between coverage and capacity which provides the perfect environment for the earliest 5G connectivity".

4.6. The television (TV) broadcasting sector in India is important for the nation's communication and entertainment services. As per an industry report, in the year 2021, the Indian TV sector has around 16.8 crore subscribers and consists of approximately 6.7 crore cable TV households, 30 lakh HITS (Headend in the sky) subscribers, 5.5 crore DTH (Direct to Home) households and 4.3 crore Free TV households.[43] The per capita media consumption through TV grew at the rate of 6.7% CAGR from 2018 to 2020, to reach about 4.2 hours per day.[44] Such an important sector requires protection of its basic resources. The satellite TV channels transmit through C-band satellites. The importance of C-band for this sector is huge as it enables an all-weather transmission requirement in the tropical environment of India.

4.7. In some reports it is proposed that for the peaceful coexistence of both the technologies (Broadcasting and IMT) a guard band of at least 100 MHz must be present to avoid any possibilities of interference and degradation of quality of service to customers. However, the recent version of the NFAP 2022 holds the guard band as much lesser than desired. The report states that the frequency range 3600-3670 MHz may be used for implementation of IMT and

[43] https://www.trai.gov.in/sites/default/files/QPIR_03022023_0.pdf
[44] https://www.financialexpress.com/opinion/the-c-band-satellite-and-5g-spectrum-conundrum/2225187/

that the satellite services may use the C band frequencies beyond 3670 MHz after leaving a guard band of 10 MHz. Singapore with climate almost like India has allocated two 5G licensed operators with 225 MHz (3425 MHz to 3650 MHz), thus each having 100 MHz in 3.5 GHz. Additionally, Singapore's regulator has advised the 5G and the satellite operators to use appropriate band pass filters (BPF) to cater to the reduced guard band of 50 MHz between the two services.

4.8. While some regulators in other countries 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. According to C&S services associations, allocating the band for high-powered terrestrial services would disturb the broadcasting services because of the possible interference of terrestrial transmissions with the satellite signals, impacting millions of consumers. Suitability and feasibility of shifting incumbent services to other frequencies and the availability of such frequencies in the Indian scenario needs to be studied well before arriving on a decision. The FCC[45] on 19 May 2023, has announced its spectrum policy on the 12 GHz band. It preserves 500 MHz (12.2-12.7 GHz) for current and future satellite services and 550 MHz (12.7-13.25 GHz) for developing a pipeline of mid-band spectrum for mobile broadband or other expanded uses essential for connecting everyone, everywhere.

4.9. 5G is also extremely important for economic growth and development and it is essential to ensure availability of adequate spectrum resources. At present, telecom companies of India have initiated roll out of 5G services. According to GSMA, to provide effective 5G services an operator should have 80-100 MHz

[45] https://docs.fcc.gov/public/attachments/FCC-23-36A1.pdf

in mid-band. Considering the 100 MHz guard band between 3.6 and 3.7 GHz, there is 3.3 to 3.6 GHz band left for 5G, which is 300 MHz of spectrum. In a particular service area, dividing the spectrum among the country's MNOs, each will get approximately 100 MHz of spectrum. As mentioned by various associations of TSPs, this is the only possible maximum frequency range that telecom operators can get in the 3300 MHz range which might be sufficient for the present, but there is no future possibility of additional spectrum in cases of demand in the future.

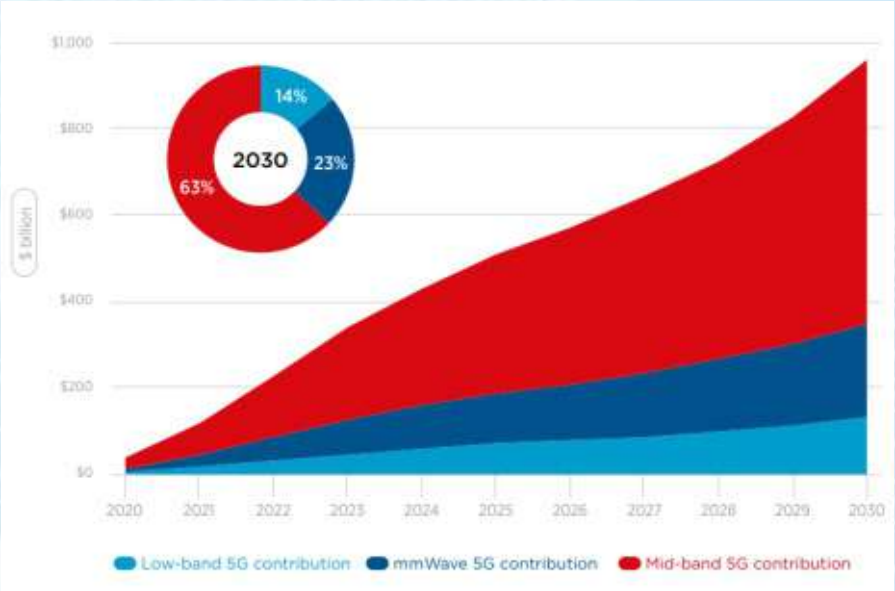


Figure 4.2[46]: Estimated annual impact of 5G on GDP band-wise

4.10. Figure 4.2 above shows the estimated annual impact of 5G on Gross Domestic Product (GDP), by band, 2020-2030.[47] The study estimates 5G to generate $960 billion in GDP in 2030 on a global basis, out of which $610 billion is result of deployments in mid-bands and representing almost 65% of the overall socio-economic value generated by 5G. According to the analysis, up to 40% of the expected benefits of mid-band 5G could be lost if no additional mid-bands spectrum is assigned to mobile services. Given the huge population

[46] Source: GSMA Intelligence
[47] "The Socio-Economic Benefits of Mid-Band 5G Services" (Feb. 2022), GSMA Report

it is imperative to provide the best available and possible spectrum for a revolutionizing technology such as 5G.

4.11. Most markets in Asia-Pacific 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.[48] In a scenario where additional mid-band spectrum is not available and given the lack of availability of C-band spectrum, it could increase the cost of public mobile network deployments. Operators may need to densify networks to an extent that may not be economically feasible. If it reaches the technical limits of network densification it could result in degradation of the network quality.

4.12. Hence, it is suggested by the associations and TSPs that keeping in mind the future aspects of innovation and growth in communication technology, it's important to consider the best suited additional spectrum and the 6 GHz band available in the range of 5925 MHz to 7125 MHz may be reserved for IMT uses.

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

4.13. In a study released in July 2021[49], for the 2025–2030 time-frame, 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[50] (having population densities more than 8000 km^2) including Mumbai from India, was estimated to be 2,020 MHz.

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[48] Report by WPC on *Optimising IMT and Wi-Fi mid-band spectrum allocation: The compelling case for 6 GHz and partitioning in Asia-Pacific*, 11 October 2021

[49] 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/wpcontent/uploads/2021/07/Estimating-Mid-Band-Spectrum-Needs.pdf

[50] Estimating-Mid-Band-Spectrum-Needs.pdf (gsma.com) Page 58

	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

Figure 4.3[49]: Total mid-band spectrum needed in 2025–2030-time frame

4.14. The above Figure 4.3 depicts the total mid-band spectrum needed in 2025–2030-time frame. Spectrum bands that could offer supplementary mid band spectrum for 5G services are limited. To achieve such targets for mid-band spectrum for IMT purposes, given the significant shortfall in 3.5 GHz band allocations (300 MHz auctioned in 2022), the 6 GHz band is thus an important band to meet the 2 GHz spectrum need for 5G and for future 6G services.

C. 5G- Suitability of mmWave as compared to 6 GHz band

4.15. It is suggested that substitutes for mid-band spectrum like the 6 GHz band for IMT services such as mmWave spectrum are far from optimal. This is for both technical and commercial reasons.[51]

4.16. Specifically, the technical challenge is rain rate and rain attenuation in the region. In an academic study in Malaysia of the impact of rain rate and rain attenuation on 5G in the mmWave bands it was found that utilizing 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.[52] The study went to conclude that:

[51] Report by WPC on *Optimising IMT and Wi-Fi mid-band spectrum allocation: The compelling case for 6 GHz and partitioning in Asia-Pacific*, 11 October 2021

[52] 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

"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."

4.17. The second key challenge is commercial. Supporting the increased capital expenditures (Capex) and operating expenditures (Op-ex) necessary for mmWave deployment and operations may be considered a challenge. Consequently, a preference is likely to exist for the lower Capex and Op-ex associated with deploying 5G in the low and mid-band spectrum.

D. Performance perspective of 6 GHz band

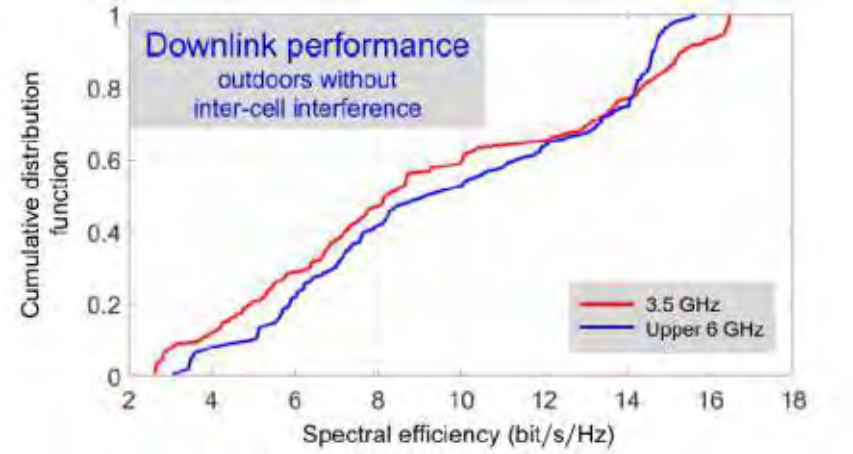

Figure 4.4[53]: Downlink performance of 5G- 3.5 GHz vs Upper 6 GHz

4.18. Early field studies[53] show that the 6 GHz band is a 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

[53] 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=l70MShLI0pg&list=PLw3m3Fi4ZVns7rzgP6JlVdf1IQTDkzfD

3.5 GHz band (reusing the same sites). The above figure 4.4 shows the downlink performance results of the field test.

4.19. The reasons stated above are considered for suggesting the reservation of the entire range of 6 GHz band for IMT purposes by many reports. However, to arrive at an optimal spectrum policy, country needs to first take cognizance of the recommendations of the international regulatory and standards bodies, availability of spectrum in the country, possibility of coexistence of new services with incumbent services, find possible and appropriate alternatives and align and harmonize spectrum usage with global best practices. Discussions challenging the allocation of the entire 6 GHz band for licensed usage are listed below.

A. International perspective of spectrum availability in alternate mid-band/other bands

4.20. Few US operators are planning to re-use some mid-band spectrum (such as the 1800 MHz) currently used for 3G services and use it for 5G.[54] India is also slowly transitioning services to the next generation of communication technologies and will also be able to re-use the mid-band frequencies which are allocated for 2G and 3G services soon. The access spectrum assigned through auction mechanism in India is technology neutral.

4.21. The FCC[55] on 19 May 2023, has announced its spectrum policy on the 12 GHz band. It preserves 500 MHz (12.2-12.7 GHz) for current and future satellite services and 550 MHz (12.7-13.25 GHz) for developing a pipeline of mid-band spectrum for mobile broadband or other expanded uses essential for connecting everyone, everywhere.

[54] https://www.nokia.com/thought-leadership/articles/spectrum-bands-5g-world/
[55] https://docs.fcc.gov/public/attachments/FCC-23-36A1.pdf

- The order states that authorizing two-way, high-powered terrestrial mobile service in the 12.2 GHz band would impose a significant risk of harmful interference to existing and emergent services in the band, including satellite services. Such interference could undermine investments made by incumbent licensees and jeopardize their potential to provide new services to underserved communities, including rural communities. It further investigates the potential to expand terrestrial fixed use or to permit unlicensed use in this 500 MHz of mid-band spectrum.

- The order also states that to make spectrum available for terrestrial mobile service, in the 12.7 GHz band, they propose to repurpose some or all of the 550 MHz of mid-band spectrum for mobile broadband or other expanded use. Industry comments on their consultations have demonstrated substantial support for repurposing these mid-band frequencies for next-generation wireless technologies including 5G, 5G Advanced, and 6G services that will depend on extremely high data rates, and the reliability, low latency, and capacity that the 12.7 GHz band spectrum can provide. Ericsson asserts that the characteristics of the 12.7 GHz band make it a good fit for future 6G technologies and smart-city applications also, and that use of the 12.7 GHz band would complement spectrum in the 3-8 GHz range.

4.22. Table 4.1 depicts some other bands identified by WRC-19 for 5G.

Table 4.1[56] - Bands identified for 5G by WRC-19

New Spectrum bands identified by WRC-19	Amount of Spectrum
24.25-27.5 GHz *(globally)*	3.25 GHz
37-43.5 GHz *(globally)*	6.5 GHz
66-71 GHz *(globally)*	5 GHz
45.5-47 GHz *(in multiple countries)*	1.5 GHz
47.2-48.2 GHz *(in multiple countries)*	1 GHz

[56] https://www.itu.int/hub/2020/01/wrc-19-identifies-additional-frequency-bands-for-5g/

B. 5G- Spectrum availability in India

4.23. Experts, globally, generally agree that to provide effective 5G services, one must have 80-100 MHz per operator in the 3.5 GHz band. Allocation scenarios in countries with tropical climate conditions like India also have similar allocations in the 3.3 GHz band. Hong Kong has assigned 300 MHz (3.3 GHz to 3.6 GHz) for 5G. China is similar, though 3.3 GHz to 3.4 GHz is earmarked for shared use. Singapore with climate almost like India, has allocated two 5G licensed operators with 225 MHz (3425 MHz to 3650 MHz), thus each having 100 MHz in 3.5 GHz. Additionally, Singapore's regulator has advised the 5G and the satellite operators to use appropriate band pass filters (BPF) to cater to the reduced guard band of 50 MHz between the two services. In Malaysia, only a single entity, which is a consortium of multiple licenses, is being awarded 100 MHz of 3.5 GHz.

4.24. Table 4.2 shows the spectrum made available for 5G during 2022 auction in India. In the mid-band range 370 MHz of spectrum is made available. Also, a total of 3.77 GHz of spectrum is available for 5G deployment by telecom operators.

Table 4.2 - Spectrum auction details

Spectrum bands offered in Auction for 5G services in India in 2022	Amount of Spectrum
600 MHz (612-703 MHz)	80 MHz
700 MHz (718-803 MHz)	50 MHz
3.3 GHz (3300-3670 MHz)	370 MHz
26 GHz (24.25-27.5 GHz)	3250 MHz
Total spectrum auctioned	3750 MHz (3.75 GHz)

C. Spectrum harmonization

4.25. Telecom service providers are actively seeking identification of the entire 6 GHz band (5925-7125 MHz) or one of its constituent segments, either the upper band (6425-7125 MHz) or the lower band (5925-6425 MHz), for IMT applications.[57] Also, as shown in Table 3.1 and Table 3.2 of Chapter 3, several major economies have already assigned the spectrum for unlicensed usage either for the entire 6 GHz band or in the 5925-6425 MHz band.

4.26. International coordination is crucial to harmonize spectrum usage, avoid cross-border interference and have a common device ecosystem. Spectrum harmonization has many benefits and is essential because:

- It ensures consistent and compatible use of radio frequency bands across different countries or regions.
- It facilitates international roaming and seamless connectivity for wireless devices.
- It enables economies of scale, as standardized spectrum bands encourage the development and deployment of interoperable technologies.
- It reduces interference issues between neighboring countries or regions, ensuring efficient and reliable wireless communication.
- It promotes competition by creating a level playing field for service providers and encouraging innovation.
- It supports the efficient use of limited spectrum resources, maximizing the capacity and performance of wireless networks.
- It enables better coordination and cooperation among regulatory bodies, industry stakeholders, and international organizations.

[57] https://telecom.economictimes.indiatimes.com/news/industry/telco-group-bats-for-6-ghz-spectrum-band-for-5g-6g-growth/102717285

4.27. It is thus essential to first study and determine if India also requires such spectrum allocation policy for Wi-Fi usage. The following chapter tries to examine whether there is a requirement to allocate frequencies for unlicensed usage in the Indian context.

CHAPTER 5
SCENARIO 2 – LICENSE EXEMPT

5.1. Access to high-speed internet has been found to be especially crucial during the COVID pandemic for services such as Work from Home (WFH), e-learning, healthcare services, and high-definition video consumption, and many others. High-speed connectivity required for these services were enabled and being accessed through Wi-Fi during the pandemic. However certain questions arise concerning Wi-Fi. Were the speeds provided adequate and met the expected standards? Did the underserved and rural areas also have access to this technology? Were there any comparable alternate means of achieving benefits that Wi-Fi offers? Subsequent sections will discuss these issues but most importantly we need to understand what Wi-Fi is and why Wi-Fi holds such significance.

5.2. Wi-Fi is a wireless communication technology that allows devices to connect to the internet without the need for cables. It operates through a wireless router that emits radio signals within specific frequency bands. Devices with Wi-Fi capabilities detect and connect to these signals, undergo authentication, and establish an encrypted connection. Data is then transmitted between devices and the internet via the router, enabling internet access and data exchange.

5.3. Interoperable and scalable Wireless Local Area Networks (WLANs) show the promise of rapidly delivering affordable broadband services at relatively low costs. The term Wi-Fi is commonly used to refer to the array of technical standards (802.11 standards and various amendments to it) developed by the Institute of Electrical and Electronics Engineers' (IEEE) that can be used to create WLANs.[58]

[58] https://www.trai.gov.in/sites/default/files/WiFi_Recommendation_09032017.pdf

5.4. The original Wi-Fi standard was the IEEE 802.11 standard. The standards continuously evolve with their capabilities enhancing with every new upgrade. Wi-Fi 4 (802.11n) operates on both the 2.4 GHz and 5 GHz spectrum bands. In contrast, Wi-Fi 5 (802.11ac) utilizes exclusively the bands within the 5 GHz spectrum. The currently used Wi-Fi standard, Wi-Fi 6 (802.11ax), optimizes the transmission frequencies for both the 2.4 GHz and 5 GHz bands, delivering enhanced performance and efficiency. These improvements to the technology have enabled better speed, reliability, and security in the usage of Wi-Fi networks. Wi-Fi networks can often offer faster speeds compared to mobile data, allowing users to access more data-intensive applications and content.

5.5. Research conducted on Wi-Fi highlights its intrinsic advantages, including operation in unlicensed spectrum, cost-effective performance, user-friendly nature, ease of self-deployment, and its ability to support advanced applications. The significance of Wi-Fi has become paramount in addressing the socio-economic challenges triggered by the Covid-19 pandemic. Certain advantages are:

- Convenience and Mobility: Wi-Fi provides the freedom to connect many devices from anywhere within the network's coverage area and communicate with each other without the need for physical cables, promoting mobility and flexibility.
- Wide Adoption: Wi-Fi has gained widespread adoption and is supported by a vast range of devices, making it a universally compatible and accessible technology.
- High-Speed Data Transfer: Wi-Fi offers fast data transfer speeds, allowing for quick downloads, streaming, and real-time communication.
- Scalability: Wi-Fi networks can be easily expanded and scaled up to accommodate a growing number of connected devices, making it suitable for various environments, from small homes to large enterprises.

- Cost-Effectiveness: Wi-Fi networks are generally more cost-effective to set up due to the reduced need for cabling infrastructure.
- Compatibility with IoT: Wi-Fi integrates seamlessly with IoT devices, enabling connectivity and control over a wide range of smart devices and appliances.
- User-Friendly: Wi-Fi networks are relatively easy to set up and configure, making them accessible to users.
- Continuous Evolution: Wi-Fi technology continuously evolves, introducing new standards and improvements to enhance performance, security, and efficiency.
- Versatility: Wi-Fi can be used for various applications, including internet access, home automation, entertainment streaming, VoIP communication, and more, making it a versatile technology with diverse use cases.

5.6. Consequently, policymakers worldwide are increasingly acknowledging the value and advantages Wi-Fi offers in terms of speed, quality of service, and accessibility, among other parameters such as the projected increase in number of smart IoT devices. Recent studies have also highlighted the economic value of Wi-Fi and its role in improving economic resiliency as a key driver of digital resilience and innovation. Wi-Fi 6E is the latest advancement in Wi-Fi standards in which connected devices shall operate in the 6 GHz band. Recognizing the multiple benefits of Wi-Fi 6E and to accelerate towards improved universal connectivity, several countries have made the entire or a part of the 6 GHz band available for Wi-Fi 6E details of which are tabulated in Table 3.1 and Table 3.2 of Chapter 3.

5.7. The key differences between Wi-Fi 6 and 6E have been tabulated below.[59]

Table 5.1 - Wi-Fi 6 vs Wi-Fi 6E

Parameters	Wi-Fi 6	Wi-Fi 6E
Band	2.4 GHz and 5 GHz bands.	6 GHz band.
Backward compatible	Yes, but the experience might not be optimal if working with incompatible devices.	Not backward compatible and has expensive hardware.
Availability	Already featured prominently in most of the latest smartphones, laptops, and routers.	There are very few devices currently equipped with the Wi-Fi 6E standard.
Benefits & Challenges	It enables more devices to operate simultaneously on the same Wi-Fi channel, improving the wireless network's efficiency, latency, and data throughput. While Wi-Fi 6 is designed to improve the overall performance and reliability of Wi-Fi networks, individual consumer devices will also see wireless speed gains. A lot of the new computational intelligence behind Wi-Fi 6 is devoted to handling streaming to multiple gadgets at once. It is a Wi-Fi for a world crowded with mobile gadgets, Internet of Things (IoT) devices, and connected equipment. It will also support WPA3, a	The 'E' in Wi-Fi 6E refers to the extended spectrum band offered by the 6 GHz band. With the density of Wi-Fi devices and neighboring networks increasing dramatically, Wi-Fi 6E provides pristine spectrum to maintain a great user experience. Unlike existing Wi-Fi channels, Wi-Fi 6E channels do not overlap or cause interference. It also reduces battery drain, courtesy of TWT (Target Wake Time). It brings Wi-Fi improvements to the 6 GHz band, though the top speed of Wi-Fi at 5 GHz and 6 GHz is the same – 9.6 Gbps. However, there will be four times more bandwidth,

[59] https://cuts-ccier.org/pdf/research-report-examining-wi-fi-6e-for-india.pdf

	new security standard that offers more individualized encryption options.	ultimately helping devices get higher-speed internet. However, higher frequencies have more difficulty penetrating solid walls and floors. Also, Wi-Fi 6E has a shorter range than Wi-Fi 6.

5.8. USA[60] was one of the first countries to adopt the unlicensed approach for the entire 1200 MHz spectrum in 6 GHz band. The Report and Order[61] states that:

"Unlicensed devices relying on Wi-Fi and other technical standards have become indispensable for providing low-cost wireless connectivity in countless products used by American consumers. This Report and Order would make 1,200 megahertz of spectrum available for unlicensed use in the 5.925-7.125 GHz (6 GHz) band while ensuring that incumbent licensed services are able to thrive throughout the band. The Further Notice proposes to expand how unlicensed users can access the 6 GHz band and seeks comment on the potential for using higher power levels than those adopted in the Report and Order. Expanding spectrum use by unlicensed devices will advance the Commission's efforts to make broadband connectivity available to all Americans, especially those in rural and underserved areas."

5.9. As per FCC, to promote compatibility between unlicensed devices and the variety of licensed 6 GHz incumbents, the FCC proposed to tailor unlicensed operation by band. To understand the FCC's proposal and the final

[60] FCC- Unlicensed Use of the 6 GHz Band Report and Order and Further Notice of Proposed Rulemaking ET Docket No. 18-295; GN Docket No. 17-183. Available at: https://docs.fcc.gov/public/attachments/DOC-363490A1.pdf
[61] https://www.fcc.gov/document/fcc-opens-6-ghz-band-wi-fi-and-other-unlicensed-uses

authorization, the FCC first laid out the predominant uses of the GHz Band as follows:

Table 5.2- Predominant uses of the 6 GHz band[62]

Sub-band	Frequency Range (GHz)	Primary Allocation	Predominant Licensed Services
U-NII-5	5.925-6.425	Fixed Satellite Services (FSS)	Fixed Microwave FSS (uplinks)
U-NII-6	6.425-6.525	Mobile FSS	Broadcast Auxiliary Services Cable Television Relay Service FSS (uplinks)
U-NII-7	6.525-6.875	Fixed FSS	Fixed Microwave FSS (uplinks/downlinks)
U-NII-8	6.875-7.125	Fixed Mobile FSS	Broadcast Auxiliary Service Fixed Microwave

5.10. FCC states that Client devices communicate using power levels that depend on the type of access point- either 'standard-power' or the 'indoor low- power access point'- to which they are connected. The FCC after review of the technical issues and comments received from the interested parties, decided to authorize two types of unlicensed operations in the 6 GHz band as follows:

- Unlicensed standard-power access points in the U-NII-5 and U-NII-7 bands (totaling 850 MHz) which support a large number of high reliability point-to-point microwave links, through use of an automated frequency

[62] https://www.fcc.gov/document/fcc-opens-6-ghz-band-wi-fi-and-other-unlicensed-uses

coordination (AFC) system.[63] This will permit operations at the same power levels already permitted in the 5 GHz U-NII-1 (5.150-5.250 GHz) band and U-NII-3 (5.725-5.850 GHz) band, enabling synergetic use of both the 5 GHz and 6 GHz bands for unlicensed broadband deployment.

- Authorizing use of the entire 6 GHz band for unlicensed indoor low power access points- this provides opportunities for unlicensed operations to use up to 320-MHz channels to expand capacity and performance capabilities. FCC states this as a 'forward-looking action' that anticipates the next generation of unlicensed devices and advances the country's role as an innovator.

5.11. As different countries are moving towards adopting Wi-Fi 6E, they have relied on different rationales[64] for their own countries. These are listed below.

- Increased reliance during COVID-19 - The COVID-19 pandemic significantly amplified people's reliance on digital technologies worldwide. As a result, internet consumption and the number of connected devices surged, leading to congestion within existing frequency bands. India also witnessed an increase in internet usage due to the pandemic. In response, several countries, including Canada, the United Kingdom, the European Union, Japan, New Zealand, and the United Arab Emirates, recognized the impact of the pandemic and attributed it as a driving factor behind their decision to allocate the 6 GHz band for unlicensed Wi-Fi 6E use.

- Increased internet consumption and growing demand for wireless broadband- The increase in data consumption has led to a rise in demand

[63] The proposal stated that the AFC system would determine the frequencies on which access points could operate without causing harmful interference to incumbent microwave receivers, and then make those frequencies available for use by the access points. (Notice, 33 FCC Rcd at 10505-06, paras. 23, 25).
[64] https://cuts-ccier.org/pdf/research-report-examining-wi-fi-6e-for-india.pdf

for wireless broadband. The FCC in the USA in its Report and Order[65] also recognized the rising demand for wireless broadband as a reason for allocating 1200 MHz of the 6 GHz band for unlicensed use. The report emphasized the projection of an increase in mobile internet consumption by two folds. Another report further suggested that 59 percent of mobile data traffic will be offloaded to Wi-Fi by 2022.[66] Countries like Japan, UAE, Europe, Colombia, etc. mentioned increase in mobile internet consumption as a reason while considering Wi-Fi 6E.

- Reduced interference and Quality of Service- Increased usage and reliance on Wi-Fi leads to high congestion that further causes high latency, lower internet speeds, high power consumption by devices and disrupts multiple access experience, ultimately degrading the overall quality of service. As Wi-Fi 6E is not backwards compatible, it will create low congestion and reduce the load on existing bands. The Wi-Fi 6E addresses the issue of congestion caused by multiple devices thus leading to better multiple access experience and better quality of service. Many countries like the USA, Canada, Peru, the UK, Australia, the UAE, Hong Kong, New Zealand, Qatar have explicitly cited existing congestion in the 2.4 GHz and 5 GHz bands as a driving factor for making the 6 GHz band available for Wi-Fi. [67] Brazil has stated that Wi-Fi 6E leads to better multiple access experience.[68] While Oman is still considering enabling Wi-Fi 6E, its "Consultation Paper on the Use of the 6 GHz Frequency Band for Wi-Fi Technology" discusses the issues of latency and speed, and further highlights the merit of Wi-Fi 6E in providing high-speed internet in

[65] FCC- Unlicensed Use of the 6 GHz Band Report and Order and Further Notice of Proposed Rulemaking ET Docket No. 18-295; GN Docket No. 17-183. Available at: https://docs.fcc.gov/public/attachments/DOC-363490A1.pdf
[66] http://media.mediapost.com/uploads/CiscoForecast.pdf
[67] https://cuts-ccier.org/pdf/research-report-examining-wi-fi-6e-for-india.pdf
[68] https://cuts-ccier.org/pdf/research-report-examining-wi-fi-6e-for-india.pdf

congested areas. [69] "High speed" or "Low latency" is considered by different jurisdictions as a reason for demarcating the 6 GHz band for Wi-Fi usage.

- Digital divide and bolstering rural connectivity- Increasing reliance on technology fuels risks for people to miss out on its opportunities due to the existing digital divide.[70] The COVID-19 pandemic has further accentuated this issue, as the world heavily relies on digital connectivity, leaving those without access to digital technologies at a disadvantage. Developed nations like the USA and Canada acknowledge the digital divide and emphasize that the introduction of Wi-Fi 6E can promote connectivity among people, particularly in rural and underserved areas. This demonstrates that even in technologically advanced countries, the digital divide persists, and Wi-Fi 6E could play a role in bridging this gap. Industry reports[71] highlight the issue of last-mile connectivity, especially for high-speed data, and propose unlicensed spectrum, such as Wi-Fi, as a cost-effective solution to address this challenge.

- Support for emerging technologies/advanced use cases - There has been considerable R&D, innovation, growth, and deployment of advanced use cases like Augmented Reality (AR), Virtual Reality (VR), Telemedicine, E-learning, Gaming, Video streaming, remote working, etc. These developments have given rise to new business models centered around these applications, underscoring the demand for reliable internet connectivity. Countries like Europe, Saudi Arabia, United Arab Emirates, Canada, Qatar have stated the above factors to be drivers in the adoption of Wi-Fi 6E.

[69] https://www.tra.gov.om/En/DownloadFile.jsp?type=DocumentList&code=236
[70] Gap between individuals, households, businesses, and geographic areas at different socio-economic levels about both their opportunities to access information and communication technologies (ICTs) and to their use of the Internet for a wide variety of activities. Available at https://stats.oecd.org/glossary/detail.asp?ID=4719
[71] "The Economic Value of Wi-Fi Spectrum for India". Available at: https://broadbandindiaforum.com/wp-content/uploads/2021/06/The-Economic-Value-of-Wi-Fi-Spectrum-for-India-online-19-MAY-2021-accessible.pdf

- Economic Development- Reports indicate that the internet accounted for over 21 percent of the GDP growth in mature economies over the past five years.[72] The global economic value of Wi-Fi is estimated at more than US$3.3 trillion; by 2025, this value is expected to grow to nearly $5 trillion.[73] Recent studies have also highlighted the role of Wi-Fi in improving economic resiliency and as a key driver of digital resilience and innovation.[74] Further, it is projected that Wi-Fi 6E will contribute 9.5 percent of the total economic value in 2025.[72]

- Wi-Fi 6E complements 5G network - As per the Communications Regulatory Authority of Qatar, the introduction of Wi-Fi 6E will support the mobile telecom market as a complementary technology to the (5G) Networks.[75] In an interview conducted by Wi-Fi Alliance[76], the General Manager of Radio Spectrum Planning at CITC (Saudi Arabia) stated that Wi-Fi is a key facilitator for 5G networks as users depend on Wi-Fi to offload and explore the full capabilities of 5G.

5.12. Most countries around the world have already delicensed a portion or the entire 6GHz band for Wi-Fi, since the current Wi-Fi spectrum in 2.4 GHz and 5GHz is not adequate to meet the increased demand due to increased work from home and roll out of 5G. In addition to this, it is noted that the current Wi-Fi technologies in 2.4 and 5GHz band cannot support new applications such as AR/VR/XR which are critical for usages such as remote surgeries and

[72] McKinsey Global Institute The great transformer: The impact of the Internet on economic growth and prosperity. Available at: https://www.mckinsey.com/~/media/mckinsey/industries/technology%20media%20and%20telecommunications/high%20tech/our%20insights/the%20great%20transformer/mgi_impact_of_internet_on_economic_growth.pdf
[73] Discover Wi-Fi - Value of Wi-Fi. Available at: https://www.wi-fi.org/discover-wi-fi/value-of-wi-fi
[74] COVID-19 AND THE ECONOMIC VALUE OF Wi-Fi. Available at: https://www.wi-fi.org/download.php?file=/sites/default/files/private/COVID-19_Economic_Value_Wi-Fi_202012.pdf
[75] CRA Issues a Class License related to Wi-Fi 6E. Available at: https://www.cra.gov.qa/en/press-releases/cra-issues-a-class-license-related-to-wi-fi-6e
[76] Wi-Fi 6E Insights Issue 5- April 2022. Available at: https://www.wi-fi.org/download.php?file=/sites/default/files/private/Wi-Fi_Alliance_Wi-Fi_6E_Insights_Newsletter_202204_0.pdf

Industrial robotics. While US, South Korea, Brazil, Saudi Arabia, and others listed in Table 3.2 have followed Scenario 2 of license exempt usage of the 6 GHz band, it is often not considered to be the most beneficial approach as an additional 500 MHz of spectrum might have been enough to meet the expected demand. The upcoming sections will analyze whether there is a requirement for India to expand its spectrum allocation to accommodate Wi-Fi usage or if the current spectrum is deemed sufficient.

5.13. Wi-Fi technology uses unlicensed spectrum and serves as a primary means of providing broadband in commercial establishments and large public places like hotels, malls, airports, railway stations etc. Wi-Fi hotspots help in offloading broadband traffic from the cellular networks using licensed spectrum to the unlicensed spectrum. It enables telecom operators to handle the huge quantity of data traffic that mobile Internet access generates without making massive investments in their own infrastructure. Telecom operators find it less costly to offload traffic to bands reserved for unlicensed use than to build more towers and/or increase the number of cells in their networks.[77] With the deployment of 4G networks that support Wi-Fi calling, the issue of poor indoor coverage has been tackled by the TSPs, thereby reaping the benefit of Wi-Fi networks. Wi-Fi here acts as a complementary technology rather than a competing technology. Due to its affordability, scalability and versatility, its popularity has spread to urban as well as rural areas to facilitate quick spread of Internet access. In a country as dynamic as India, where population density and infrastructure requirements can vary significantly from region to region, Wi-Fi offers a cost-effective solution that can be easily deployed and expanded. It is a versatile technology that can be tailored to India's requirements such as providing connectivity to underserved rural communities and remote villages.

[77] https://www.trai.gov.in/sites/default/files/Broadband%3D17.04.2015.pdf

5.14. India has witnessed tremendous growth in internet penetration, and a major part of this success story can be attributed to the increased adoption of Wi-Fi. As part of 'Digital India' vision, under the PM-WANI (Prime Minister's Wi-Fi Access Network Interface) initiative, several Wi-Fi hotspots in metros/tourist spots across the country are being deployed. As on 14th September 2023, more than 1.5 lakh Wi-Fi hotspots have been deployed under this initiative.[78] In a country as diverse and vast as India, where wired infrastructure has been a challenge, Wi-Fi has emerged as a game-changer, bridging the digital divide and empowering individuals, industries, and communities with reliable and accessible internet connectivity. Numerous public spaces, including railway stations, airports, educational institutions, and even villages, have been equipped with Wi-Fi hotspots, bringing connectivity to millions of people. Its impact has been particularly significant in rural areas, enabling educational institutions, healthcare centres, and local businesses to connect to the digital world and unlock new opportunities.

5.15. The transformative power of Wi-Fi extends beyond personal devices and connectivity at home or in public spaces. It has also revolutionized industries such as education, healthcare, and agriculture. In schools and universities, Wi-Fi enables digital learning platforms, online resources, and e-libraries, empowering students, and educators with a wealth of knowledge. In healthcare, Wi-Fi connectivity supports telemedicine initiatives, allowing remote consultations, patient monitoring, and access to medical records. Similarly, in agriculture, Wi-Fi connectivity aids farmers in accessing weather information, market trends, and agricultural best practices, fostering innovation and improved productivity.

5.16. India's commitment to fostering innovation and entrepreneurship has also been strengthened by the widespread availability of Wi-Fi. In recent years, the country has witnessed a surge in digital startups, driven by the accessibility

[78] https://pmwani.gov.in/wani

and affordability of Wi-Fi. It has provided a conducive environment in co-working spaces, incubators, and startup hubs for young entrepreneurs to realize their ideas. Wi-Fi connectivity has become an essential ingredient for the success of these startups, facilitating collaboration, online services, and remote work, while also attracting foreign investments and boosting India's digital economy.

5.17. Delicensing the 6 GHz band for Wi-Fi is considered necessary for several reasons stated above in para 5.10, including additional spectrum to support the growing demand for wireless communication and proliferation of connected devices. In the case of India, the below listed points explore the relevance and applicability of delicensing the 6 GHz band for Wi-Fi.

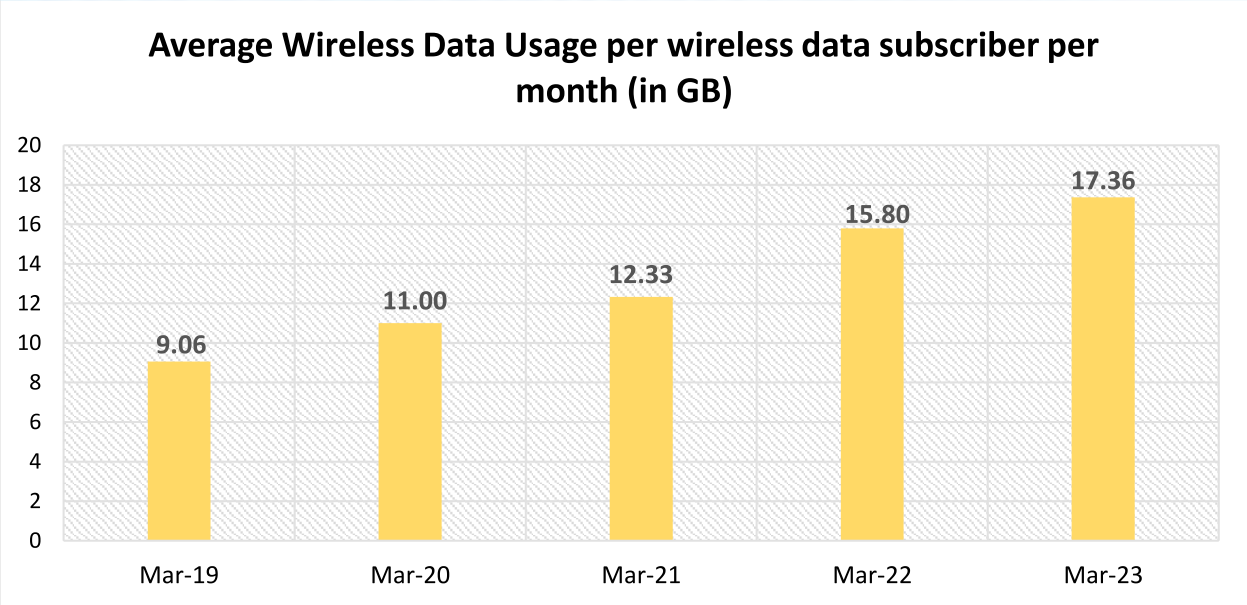

Figure 5.1[79]: Average Wireless Data usage per wireless data subscriber per month (in GB)

- As witnessed globally, the Internet usage in India also increased manifold during the COVID period. Estimates indicated a 50 to 60 percent increase

[79] https://trai.gov.in/release-publication/reports/performance-indicators-reports

in broadband data consumption between February and April 2021, driven by the growing reliance on home internet connectivity.[80] As per TRAI reports, there has been consistent increase in the average wireless data usage per wireless data subscriber per month, as shown in Figure 5.1. The trend in increasing data consumption is quite evident by these figures.

- The National Family Health Survey (NFHS) 2019-21 report[81] reveals a significant digital divide based on geographic area and gender, with a lower percentage of women in both urban and rural areas having used the internet compared to men. Only 51.8 percent of women in urban areas have ever used the internet compared to 72.5 percent of men. Only 24.6 percent of women in rural areas have used the internet compared to 48.7 percent of men. Hence, exploring Wi-Fi 6E in India may have merits in overcoming the digital divide and improving connectivity, particularly in underserved areas.

- Further, in India, Wi-Fi in these unlicensed bands can generate up to INR 12.7 lakh crore economic value.[82] A recent report states that the economic value of Wi-Fi in India's considered unlicensed spectrum bands for 2025 is INR12,69,998 crore (for GDP at current prices), which accounts for nearly 6 percent of the projected GDP in 2025.[83]

- Wi-Fi can act as a key facilitator for 5G networks as users can depend on Wi-Fi to offload and explore the full capabilities of 5G. In a similar fashion,

[80] Covid restrictions push up demand for mobile data, home Wi-Fi. Available at: https://telecom.economictimes.indiatimes.com/news/covid-restrictions-push-up-demand-for-mobile-data-home-wifi/82268737

[81] Ministry of Health and Family Welfare- National Family Health Survey – 5 2019-21. Available at: http://rchiips.org/nfhs/NFHS-5_FCTS/India.pdf

[82] WiFi in unlicensed frequency bands can generate Rs 12.7 lakh crore economic value. Available at: https://telecom.economictimes.indiatimes.com/news/wifi-in-unlicensed-frequency-bands-can-generate-rs-12-7-lah-crore-economic-value-bif/82728076

[83] https://www.mckinsey.com/~/media/mckinsey/industries/technology%20media%20and%20telecommunications/high%20tech/our%20insights/the%20great%20transformer/mgi_impact_of_internet_on_economic_growth.pdf

the recent launch of 5G in India can further be complemented by the introduction of Wi-Fi 6E in India as well.

- To take advantage of 5G's use cases such as improved mobile broadband, extremely low latency, and expanded support for the IoT, consumers will need Wi-Fi 6E installed on their premises. India has a lot of use cases requiring wireless connection.

- To fully utilize the capabilities of Bharat Net, the national optical fibre network, rural consumers need reliable Wi-Fi.

- The government's PM-WANI initiative aims to support regional rural business owners in boosting Wi-Fi availability. As on 14th September 2023, more than 1.5 lakh Wi-Fi hotspots have been deployed under this initiative.[84]

- Wi-Fi hotspots are used by users in homes, offices, and other locations. India needs to improve Wi-Fi hotspots in a subtle way. Using cutting-edge Wi-Fi technology could increase demand, benefit users, and improve the profitability of the service. New Wi-Fi technology, however, requires an unlicensed 6 GHz band.

- Countries like Oman, Brazil, and others have also highlighted the merits of Wi-Fi 6E, including improved multiple access experience, reduced latency, and high-speed internet in congested areas. This provides a compelling case for exploring the possibility of enabling Wi-Fi 6E in India.

5.18. The following table illustrates the average speeds provided by public Wi-Fi networks in significant cities across India. A comprehensive tabular structure

[84] https://pmwani.gov.in/wani

containing the collected data speeds categorized by location is included in the annexure.

Table 5.3[85] – Average Data Speeds of Public Wi-Fi hotspots in major Indian cities

LOCATION	TRAI MYSPEED (MBPS)		OOKLA APP (MBPS)	
	UPLOAD SPEED	DOWNLOAD SPEED	UPLOAD SPEED	DOWNLOAD SPEED
BANGALORE				
Bangalore International Airport	57.50	10.66	50.30	48.20
BLR Cantonment Railway Station	15.62	11.41	11.70	8.89
Majestic/KSR Railway Station	11.45	12.81	22.70	26.90
Mangalore International Airport	4.62	3.93	2.63	3.76
KOLKATA				
Avani Riverside Mall/ shopping mall	111.07	77.96	110.00	83.40
Howrah Railway Station/ Railway station	6.965	6.845	5.85	6.94
Kalighat Metro/ Metro railway	10.78	23.00	18.50	7.78
Rabindra Sadan Metro/ Metro railway	0.35	0.14	0.03	0.05
Airport/ Kolkata	29.47	31.70	23.70	24.20

[85] The field study was conducted by TRAI's regional offices located in Bangalore, Kolkata, Jaipur, Hyderabad, and Bhopal in the month of February 2023 as per the request of TRAI Centre of Studies and Research.

JAIPUR				
Jaipur Airport	0.05	3.49	0.83	3.79
World Trade Park	0.44	0.15	0.06	0.07
SMS Hospital	145.32	141.57	NA	NA
Jaipur Junction Railway Station	Not able to connect[86]	Not able to connect	Not able to connect	Not able to connect
HYDERABAD				
RGI Airport	0.04	1.56	48.30	37.00
Secundarabad Railway Station	12.29	10.74	10.60	9.85
BHOPAL				
Bhopal airport	5.20	4.87	4.70	4.80
DB mall, MP Nagar	0.15	15.14	3.04	32.60
New market	1.15	1.44	1.05	1.12
Bhopal railway station	10.87	6.04	10.90	11.90

5.19. As shown in Table 5.3, the majority of public Wi-Fi in cities surveyed demonstrate alarmingly poor performance, with speeds falling short of even reaching 100 Mbps. Even in the rare instances where locations exhibit relatively better speeds, they fall below the expected level of Wi-Fi performance, failing to reach even a few hundred Mbps. Unfortunately, the observed Wi-Fi speeds in most places recorded fail to meet the standards necessary for efficient online activities. Slow and unreliable Wi-Fi speeds impede productivity, hinder educational opportunities, and limit access to valuable online resources. Moreover, it also affects the potential for technological innovation, entrepreneurship, and the growth of digital services. Given the significance of this issue, it is crucial to address the challenges associated with poor Wi-Fi speeds promptly. Investments should be made in

[86] PM-WANI and RailWire were available but were not able to connect to these networks.

enhancing existing infrastructure, upgrading network capabilities, spectrum availability and implementing policies that prioritize the development of robust and high-speed internet connectivity.

5.20. The reasons stated above are considered and support the reservation of the 6 GHz band for license-exempt usage. Discussions not favoring the allocation of the entire 6 GHz band for license-exempt usage are also listed below.

A. The limit on Wi-Fi speeds in the home and smaller premises is the limit on fixed broadband network speeds not Wi-Fi[87]

5.21. Allocating more spectrum in the 6 GHz band to Wi-Fi may have limited impact on enhancing the actual speeds experienced by users in their day-to-day usage, primarily due to the constrained capacity of the "broadband pipe" leading to their premises. A significant number of households, particularly those in rural areas, might face challenges in accessing high-speed optical fiber connections, which offer gigabit speeds, due to affordability constraints. But in the context of a rural household comprising six individuals, it is worth considering which option would be more economically viable: a single fixed broadband network with unlimited data or six separate individual mobile connections, each equipped with sufficient data plans.

B. The upcoming technological advancements in Wi-Fi (802.11) technology should make spectrum usage by unlicensed Wi-Fi services more efficient[87]

5.22. Ofcom stated: *"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*

[87] Report by WPC on *Optimising IMT and Wi-Fi mid-band spectrum allocation: The compelling case for 6 GHz and partitioning in Asia-Pacific*, 11 October 2021

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."[88]

C. Consumer's real preferences are for secure 4G/5G services when available at a reasonable price and much greater speeds[87]

5.23. Since the Telecom Service Providers are offering unlimited data plans[89] for their consumers, the use of public Wi- Fi network has reduced considerably. Australia's Canberra with one of the largest free Wi-fi network is one such example. Six years after the network was set up, fewer people are using it - raising questions about its long-term utility and economic value.[90] Though in case of India, there are less 4G consumers in rural areas. Public Wi-fi networks in these rural areas are expected to facilitate the usage of digital services.

D. Likely reduced demand for Wi-Fi usage from enterprises given 5G support for industry[87]

5.24. 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."*[91] Furthermore, trials in Europe have found that 5G NR outperforms Wi-Fi 6 in the indoor deployment scenario typically

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

[89] For 4G or 5G Wireless Networks

[90] Refer to: www.abc.net.au/news/2020-08-13/canberra-expands-free-wifi-but-fewer-people-are-usingit/12551266

[91] Edward J Oughton, et al, *Op cit*, page 12

used by enterprises in terms of throughput and latency. In such circumstances 5G is likely to be preferred in a range of enterprise settings including manufacturing, warehousing etc. It would be beneficial to conduct tests to ascertain whether these observations hold true in the Indian context as well.

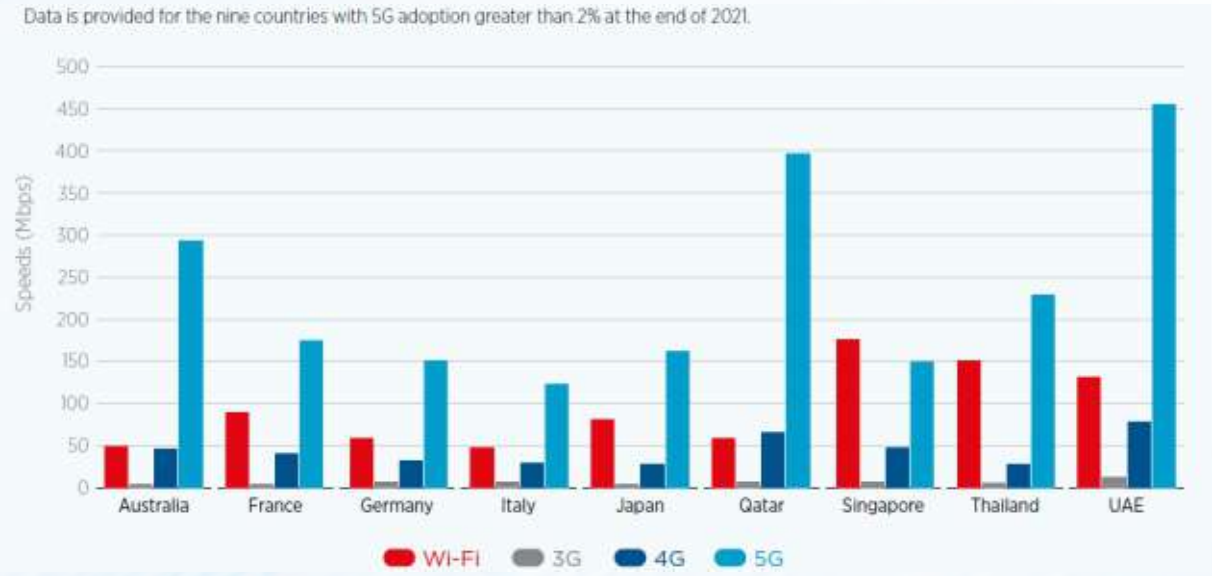

Figure 5.2[92]- Download Speeds comparison for 3G, 4G, 5G and Wi-Fi (2021)

5.25. Figure 5.2 is a speed comparison graph.[93] In 5G markets, consumers are getting significantly better speeds than on 4G and Wi-Fi. Hence, it is highly likely that with introduction to 5G, less traffic will be carried over Wi-Fi as mobile network speed rise, data allowances increase along with mobile network capacity.

E. Does it address the digital divide?

5.26. As per TRAI's data for April 2023[94], 96.02 percent of broadband users in India are wireless, and only 3.98 percent subscribe to fixed broadband. According

[92] GSMA Intelligence analysis based on Speedtest intelligence and data provided by Ookla
[93] The 6GHz IMT Ecosystem, Demand Drives Scale August 2022 report
[94] https://www.trai.gov.in/sites/default/files/PR_No.58of2023_0.pdf

to World Bank data[95], the percentage of households with fixed broadband access is 16.92%. The figure is much higher in China at 37.58% and USA at 37.35%. Therefore, one can argue that the use case for Wi-Fi in India differs as compared to other countries. Moreover, given that large proportion of population may not be able to afford the data subscription, there can be a case for providing last mile connectivity through public Wi-Fi networks.

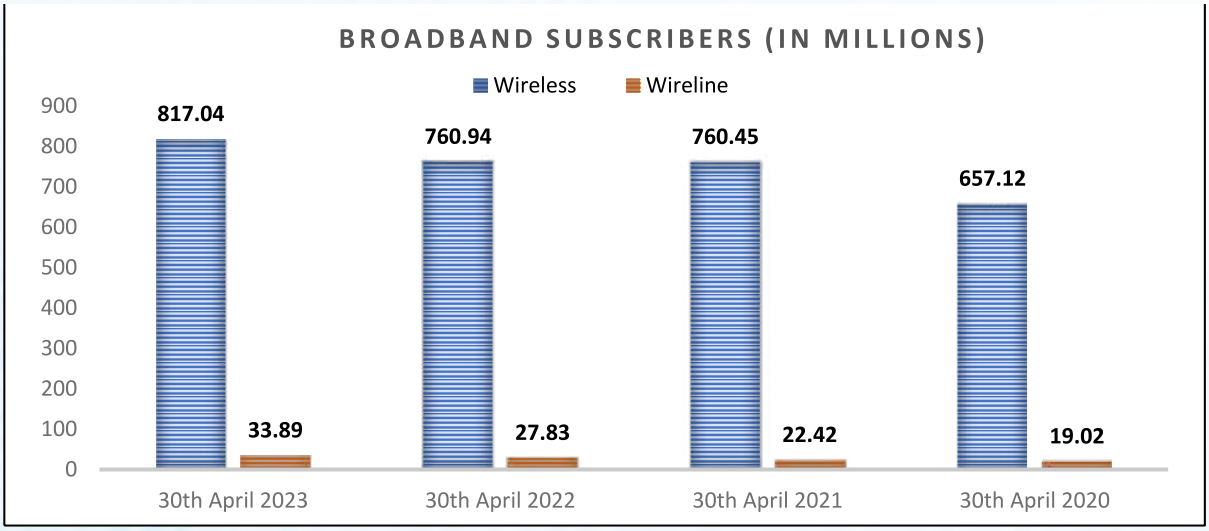

Figure 5.3[96] – Wireless and Wired broadband subscriptions in India

5.27. It is argued that benefits of such large allocation of 1200 MHz are more optimized for advanced markets such as South Korea or the US, with high fibre penetration, not those markets where they are only urban connected or under-connected. Moreover, enhancements in Wi-Fi/low power/short range technologies will improve the connectivity of users who have a home fibre connection within the existing available unlicensed spectrum.

5.28. As shown in Figure 5.3, wired broadband subscriptions have experienced a significant surge, with a remarkable 78% increase observed between April 2020 and April 2023. The ongoing initiatives are expected to bring about considerable improvement that can help bridge the digital divide between the

[95] https://data.worldbank.org/indicator/IT.NET.BBND.P2
[96] TRAI Telecom subscription data reports

rural and urban India. Concerns arise regarding whether India can successfully and expeditiously establish last mile home fiber infrastructure. This prompts the question of whether a portion of the 6 GHz band should be reserved for IMT usage instead. And even if public Wi-Fi hotspots are deployed till the last mile, is the entire 1200 MHz unlicensed spectrum necessary? To address these questions, a detailed requirement study should be conducted to determine if allocating the entire 1200 MHz for unlicensed use is necessary.

F. Fixed Wireless Access (FWA) can support the increased users and usage

5.29. It is said that emerging markets like India have several challenges[98] like:

- fixed line infrastructure is not abundant 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.

Figure 5.4[97] – Countries and territories with identified LTE or 5G based FWA service offers

[97] GSA- Fixed Wireless Access: Market Survey June 2023

5.30. An alternative proposal suggests enhancing Fixed Wireless Access. 5G technology offers an affordable way to improve overall telecommunication service quality with FWA rapidly. 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.[98] Figure 5.4 maps the countries and territories with identified LTE or 5G based FWA service offers.

5.31. 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.[9898]

G. Allocation of entire 1200 MHz to license-exempt regime is an irreversible decision

5.32. Ninety-Six (96%) percent of broadband users in India are wireless networks. Only around four percent (4%) subscribers have fixed line broadband services. The deployment of fiber optic infrastructure to the last mile remains low in India. New technologies like FWA present a promising solution for facilitating widespread last mile connectivity. Considering this perspective, it is argued that allocating the entire 1,200 MHz spectrum to the unlicensed regime does not meet the demand criteria. Moreover, such a decision would be irreversible in nature. Stakeholders emphasize that access spectrum is not an immediate bottleneck for the spread of Wi-Fi services, and hence additional spectrum for wi-fi may not be earmarked.

5.33. Some other stakeholders have emphasized that refraining from de-licensing commercially significant frequency bands that have been completely de-

[98] Optimising IMT and Wi-Fi mid-band spectrum allocation: The compelling case for 6 GHz band partitioning in Asia-Pacific, REPORT BY WINDSOR PLACE CONSULTING PTY LTD, 11 October 2021.

licensed (indoor and outdoor) in few other jurisdictions, could constrain the device ecosystem and modes of Wi-Fi service delivery.

5.34. The discussed advantages of Wi-Fi cannot be ignored. The use of unlicensed spectrum has been one of the key enabling factors in the growth and widespread adoption of the Wi-Fi standard. Recognizing the need for additional spectrum to be de-licensed to expedite the penetration of broadband using Wi-Fi technology, the Authority in its recommendations dated 17th April 2015 on "Delivering Broadband Quickly: What do we need to do?", recommended that "*the de-licensing of the 5.725 - 5.825 GHz band for outdoor usage needs to be carried out in the next 6 months. DoT must release larger quantities of unlicensed spectrum (as has been done in many parts of the world) for better quality of service and reducing the strain on existing networks.*"[99] Further, the Authority in its recommendations dated 9th March 2017 on "Proliferation of Broadband through Public Wi-Fi networks", recommended that "*the DoT may re-visit the TRAI's earlier recommendations and consider de-licensing spectrum in the 5.725 - 5.825 GHz spectrum band for outdoor usage, and expedite decision on allocating E-band (71-76 GHz and 81-86 GHz) and V-band (57-64 GHz) to service providers.*"[100] DoT accepted TRAI's recommendations and made the band available for license-exempt usage.[101]

5.35. It is also true that there are numerous other devices that connect to the unlicensed band via Wi-Fi even for fixed broadband subscribers. Some examples include Smartphones and tablets, laptops and computers, Smart TVs, Smart home devices (speakers, security cameras, lighting systems, etc.), wearable devices (smartwatches, fitness trackers, wireless headphones, etc.), gaming consoles, IoT devices (smart appliances, sensors, home automations

[99] https://www.trai.gov.in/sites/default/files/Broadband%3D17.04.2015.pdf
[100] https://www.trai.gov.in/sites/default/files/WiFi_Recommendation_09032017.pdf
[101] https://dot.gov.in/sites/default/files/License%20Exemption%20for%20SRD%20Device%20G_S_R_1047%28E%29%20dated%2018th%20October%2C%202018_1.pdf?download=1

systems), etc. New developing technologies like Industry 4.0, Smart cities, etc. require increasing number of devices to connect seamlessly with internet. Such devices will have Wi-Fi as the last mile for access even if internet is made available through the wired or wireless networks.

CHAPTER 6
SCENARIO 3 - HYBRID

6.1. As shown in Table 3.2., numerous countries have already designated the lower band of the 6 GHz band (5925-6425 MHz) for license-exempt utilization. Furthermore, certain countries have extended the license-exempt regulations to encompass the upper band of the 6 GHz band (6425-7125 MHz) as well. It is noteworthy that in these countries, several incumbent services are also operating in the 6 GHz band, and stringent technical requirements are implemented to ensure the prevention of any interference.

6.2. As per FCC, to promote compatibility between unlicensed devices and the variety of licensed 6 GHz incumbents, the FCC proposed to tailor unlicensed operation by band. To understand the FCC's proposal and the final authorization, the FCC first laid out the predominant uses of the GHz Band as follows:

Table 6.1- Predominant uses of the 6 GHz band[102]

Sub-band	Frequency Range (GHz)	Primary Allocation	Predominant Licensed Services
U-NII-5	5.925-6.425	Fixed Satellite Services (FSS)	Fixed Microwave FSS (uplinks)
U-NII-6	6.425-6.525	Mobile FSS	Broadcast Auxiliary Services Cable Television Relay Service FSS (uplinks)
U-NII-7	6.525-6.875	Fixed FSS	Fixed Microwave FSS (uplinks/downlinks)
U-NII-8	6.875-7.125	Fixed Mobile FSS	Broadcast Auxiliary Service Fixed Microwave

[102] https://www.fcc.gov/document/fcc-opens-6-ghz-band-wi-fi-and-other-unlicensed-uses

6.3. FCC states that Client devices communicate using power levels that depend on the type of access point- either 'standard-power' or the 'indoor low- power access point'- to which they are connected. The FCC after review of the technical issues and comments received from the interested parties, decided to authorize two types of unlicensed operations in the 6 GHz band as follows:

- Unlicensed standard-power access points in the U-NII-5 and U-NII-7 bands (totaling 850 MHz) which support a large number of high reliability point-to-point microwave links, through use of an automated frequency coordination (AFC) system.[103] This will permit operations at the same power levels already permitted in the 5 GHz U-NII-1 (5.150-5.250 GHz) band and U-NII-3 (5.725-5.850 GHz) band, enabling synergetic use of both the 5 GHz and 6 GHz bands for unlicensed broadband deployment.

- Authorizing use of the entire 6 GHz band for unlicensed indoor low power access points- this provides opportunities for unlicensed operations to use up to 320-MHz channels to expand capacity and performance capabilities. FCC states this as a 'forward-looking action' that anticipates the next generation of unlicensed devices and advances the country's role as an innovator.

6.4. Figure 2.1 shows that India also has similar allocation of spectrum to Fixed Satellite services in C-band for uplink. To enable the utilization of the 6 GHz band (5925 MHz-7125 MHz) for licensed or unlicensed use alongside the existing fixed satellite services operating in the C-band (5850 MHz-7075 MHz), careful coordination and regulatory measures can be implemented, similar to FCC. Adopting advanced spectrum sharing techniques such as Dynamic Frequency Selection (DFS) and Transmit Power Control (TPC) could help. DFS

[103] The proposal stated that the AFC system would determine the frequencies on which access points could operate without causing harmful interference to incumbent microwave receivers, and then make those frequencies available for use by the access points. (Notice, 33 FCC Rcd at 10505-06, paras. 23, 25).

enables devices to detect the presence of incumbent users, such as fixed satellite services, in the frequency band. If incumbents are detected, devices seeking to operate in the 6 GHz band must vacate the channel or reduce their power levels to avoid interference. TPC ensures that devices adjust their transmission power based on the detected interference environment, thereby minimizing the risk of harmful interference to incumbent services. Geolocation databases could also play a role. Devices seeking to operate in the 6 GHz band would communicate with these databases to determine their geographic location accurately. Based on this information, the database would provide a list of available channels and power levels that the device can use without causing interference to incumbents. Clear guidelines, technical standards, and strict certification processes for devices operating in the 6 GHz band will be required to be established to ensure compliance with these sharing mechanisms. Additionally, stakeholders would need to collaborate closely to develop monitoring and reporting mechanisms that detect and resolve instances of interference promptly. This coordinated and technology-driven approach would enable the coexistence of new services in the 6 GHz band while safeguarding the integrity of the existing fixed satellite services operating in adjacent frequency ranges.

6.5. As per EU, in addition to the spectrum already available on a non-exclusive basis in the 2.4 GHz (2400-2483.5 MHz) and 5 GHz (5150-5350 MHz and 5470-5725 MHz) frequency bands; there is a need to harmonize new spectrum resources for the provision of wireless broadband via WAS/RLANs due to the increase in the devices for WAS/RLANs. The below section discusses in detail.

6.6. EU gave its implementing decision (17.06.2021) on the harmonized use of radio spectrum in the 5,945-6,425 MHz frequency band for the implementation of wireless access systems including radio local area networks (WAS/RLANs). The rationale provided by EU is as follows:

"*In accordance with the Commission strategy on the* ***European Gigabit Society****, all main socio-economic drivers (including schools, transport hubs and main providers of public services) as well as digitally intensive enterprises should have access to internet connections with download or upload speeds of 1 gigabit of data per second (Gbit/s) by 2025. All households in the Union should have internet connections with a download speed of at least 100 Mbit/s which can be upgraded to 1 Gbit/s.*

The regulatory framework for WAS/RLANs operating in the 5945-6425 MHz frequency band, that is to say, the lower 6 GHz frequency band, ***should improve wireless connectivity in the Union and allow the internal market to benefit from a spectrum resource potentially available worldwide****,* ***thus generating large economies of scale for equipment manufacturers****. The lower barriers to accessing spectrum resulting from a harmonised regulatory framework will facilitate large-scale deployment of interoperable WAS/RLANs-capable devices and access points, which should serve as an important connectivity infrastructure for services that complement mobile internet services provided by mobile network operators. The recommended framework identifies two WAS/RLANs use cases in the 5945-6425 MHz frequency band as follows: (i)* ***low power indoor ('LPI')*** *the use of which is restricted to and permanently located in buildings, trains with metal coated windows and aircraft; and (ii)* ***very low power ('VLP') which can be used indoor and outdoor****. The VLP outdoor use is intended to cover short-range applications for small area direct communications."*[104]

6.7. Article 3 of the Commission's Implementing Decision states[105]:

[104] https://digital-strategy.ec.europa.eu/en/library/6ghz-harmonisation-decision-more-spectrum-available-better-and-faster-wi-fi

[105] https://digital-strategy.ec.europa.eu/en/library/6ghz-harmonisation-decision-more-spectrum-available-better-and-faster-wi-fi

"By 1 December 2021, Member States shall designate the 5945-6425 MHz frequency band and make it available on a non-exclusive, non-interference and non-protected basis, for the implementation of WAS/RLANs in accordance with the technical conditions set out in the Annex.

When introducing new applications into the 5945-6425 MHz frequency band or into adjacent frequency bands after the entry into force of this Decision, Member States shall not adopt technical and operational conditions applicable to any new application that unduly restrict the continued use of WAS/RLAN in the 5945-6425 MHz frequency band in accordance with this Decision."

6.8. Article 4 of the Commission's Implementing Decision states[106]:

"This Decision shall be subject to review by the end of 2024 taking into account additional studies and measurements as regards the maximum mean EIRP. density limits for VLP WAS/RLANs out-of-band emissions below 5935 MHz"

6.9. This is the status of the EU when it comes to management of the 5925–6425 MHz part of the 6 GHz band. Dealing with the 6425-7125 MHz band, as per Wi-Fi Alliance[107] in its December 2021 (Wi-Fi 6E insights), "The European Conference of Postal and Telecommunications Administrations (CEPT) has begun to explore the potential for Wi-Fi to use the upper 6 GHz band. CEPT's Electronic Communications Committee (ECC) has adopted a work item to study possible technical conditions under which wireless access systems could operate and coexist with existing services in the 6425-7125 MHz band (i.e., co-existence of unlicensed services with other licensed services)."

[106] https://digital-strategy.ec.europa.eu/en/library/6ghz-harmonisation-decision-more-spectrum-available-better-and-faster-wi-fi

[107] https://www.wi-fi.org/download.php?file=/sites/default/files/private/Wi-Fi_Alliance_Wi-Fi_6E_Insights_Newsletter_202112_0.pdf

6.10. As per a 2021 report by Windsor Place Consulting Pty Ltd (WPC)[108], Scenario 3 is a better suited option for Asia-Pacific region as there is a given lack of C-Band and low-band spectrum and such shared allocation of 6 GHz band may maximize the economic benefits where benefits can be derived from both IMT and Wi-Fi services. It was recommended to allocate the lower part of the 6 GHz band (5925-6425 MHz) for unlicensed use and to be restricted to indoor use and the upper part of the 6 GHz i.e. (6425-7125 MHz) should be allocated for IMT use.

6.11. Given the factors discussed in Chapter 4 and 5, the benefits of adopting Scenario 3 could increase, if there is an increased allocation of the 500 MHz of 6 GHz band which represents a doubling in unlicensed Wi-Fi spectrum allocations while simultaneously increasing mid-band IMT spectrum allocations by 700 MHz. This partitioning would ensure and maximize the potential economic benefits derived from improved Wi-Fi and IMT services. Additionally, achieving spectrum allocation harmonization is crucial to establish consistent service applications, foster increased and synchronized manufacturing operations, and reap the advantages of reduced device costs. It helps create global-level economies of scale for manufacturers of chipsets, network equipment and devices.

6.12. Most countries around the world have already delicensed a portion or the entire 6GHz band for Wi-Fi, since the current Wi-Fi spectrum in 2.4 GHz and 5GHz is not adequate to meet the increased demand due to increased work from home and roll out of 5G. In addition to this, it is noted that the current Wi-Fi technologies in 2.4 and 5GHz band cannot support new applications such as AR/VR/XR which are critical for usages such as remote surgeries and Industrial robotics.

[108] Optimising IMT and Wi-Fi mid-band spectrum allocation: The compelling case for 6 GHz band partitioning in Asia-Pacific, REPORT BY WINDSOR PLACE CONSULTING PTY LTD, 11 October 2021.

6.13. The upcoming WRC-23 is considering several mid and low-frequency ranges important for the mobile industry for both 5G growth and the further development of 6G (or IMT-2030). Such identifications are arrived at through consultations, consensus, and multilateral agreements. The management of the 6 GHz band is also an agenda of discussion in Agenda Item 1.2 defined for the conference. Many countries are waiting for decisions due to be taken at the conference before defining licensed or unlicensed policies for the upper 6 GHz range (6425—7125 MHz). The upper 6 GHz band will be considered at WRC-23 for identification for IMT (6425—7025 MHz is being considered for "IMT identification" in ITU-R Region 1 only, while 7025—7125 MHz is being considered globally). Various studies have been carried out globally on the possibilities of sharing the upper 6 GHz band between IMT and other incumbent services. This event will review the results of these studies and look at opportunities for the opening of this band for unlicensed Wi-Fi use.

6.14. A majority of the countries in Region 1 and 2 have already designated either the lower portion or the entire 6 GHz band for license-exempt usage. However, there is no uniform approach across different regions particularly in the Asia-Pacific region. It can differ significantly in terms of ICT adoption, the digital divide, etc. This is evident from the ongoing consultations, or the absence of definitive decisions made by majority of the countries in Region 3, including India. Also, China has put forth a distinct proposition that sets it apart from other countries, advocating for the identification of the entire 6 GHz band for IMT usage. India needs to conduct studies, analyze, and carefully identify its requirements.

CHAPTER 7
CONCLUSION

7.1. In the 21st century, numerous groundbreaking advancements in digital technology have emerged, giving rise to a worldwide demand for comprehensive and meaningful connectivity. This demand stems from the necessity to establish a new benchmark for internet access that can cater to the evolving needs of a connected world.

7.2. The primary objective of spectrum policy should be to assign spectrum to those service providers who will be able to extract most value from such a scarce and finite resource for the benefit of society. The 6 GHz spectrum band is a valuable resource that needs to be utilized and managed in a manner that will maximize national economic benefits. Government thus must take a carefully considered decision as to what would be the most efficient allocation of the spectrum. Additionally, achieving spectrum allocation harmonization is crucial to establish consistent service applications, foster increased and synchronized manufacturing operations, and reap the advantages of reduced device costs. It helps create global-level economies of scale for manufacturers of chipsets, network equipment and devices.

7.3. The Authority in its recommendations dated 9th March 2017 on "Proliferation of Broadband through Public Wi-Fi networks", noted that "while there is merit in considering delicensing of additional spectrum subject to reasonable spectrum usage restrictions, further recommendations on particular spectrum bands can only be made after detailed internal analysis, consultations and coordination amongst Governmental agencies towards harmonizing spectrum allocation policies."[109] In order to determine the most suitable policy approach for spectrum assignment, India should conduct

[109] https://www.trai.gov.in/sites/default/files/WiFi_Recommendation_09032017.pdf

comprehensive studies encompassing technical, operational, sharing, and compatibility aspects of the 6 GHz band. Additionally, careful consideration should be given to the timeframe within which a spectrum will be required, with the aim of maximizing both the social and economic value of this valuable resource. A sustainable policy resolution should strike a delicate balance between respecting the rights of existing stakeholders, and embracing the advancement facilitated by the adoption of new technologies. This balance is essential for formulating an effective and long-term spectrum policy.

7.4. To identify the best policy option for spectrum assignment, further studies as per the technical, operational, sharing and compatibility angles for the 6 GHz band and the timeframe in which spectrum would be needed. The studies require to focus on maximizing social and economic value of spectrum. There is a need to carry out the economic value analysis instead of deciding on the basis of demand by certain stakeholders representing one or the other manufacturing or technology solution group. The policy for 6 GHz spectrum requires evaluation of all the options and finding the right balance for existing users, traffic requirements of TSPs and the larger economic benefits. The most beneficial outcome for the consumers should be paramount.

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LIST OF ACRONYMS

ACRONYMS	ABBREVIATIONS
5G NR	5G New Radio
ACMA	Australian Communications and Media Authority
AI	Agenda Item
AR	Augmented Reality
ARPU	Average Revenue per User
BPF	Band Pass Filters
CAGR	Compound Annual Growth Rate
CAPEX	Capital Expenditures
CEPT	Conference of Postal and Telecommunications Administrations
CITC	Communications and Information Technology Commission
C&S	Cable and Satellite services
DFS	Dynamic Frequency Selection
DPO	Distribution Platform Operators
DTH	Direct to Home
eMBB	Enhanced mobile broadband
EU	European Union
FCC	Federal Communications Commission
FSS	Fixed Satellite Services
FTTH/B	Fibre to the Home/Building
FWA	Fixed Wireless Access
GDP	Gross Domestic Product
GSMA	Global System for Mobile Communications Association
HITS	Headend in the Sky
ICT	Information and Communications Technology
IEEE	Institute of Electrical and Electronics Engineers
IMT	International Mobile Telecommunications (Generic name for 3G/4G/5G given by ITU)
IoT	Internet of Things
ITU	International Telecommunication Union
LNB	Low Noise Block converter

MCMC	Malaysian Communications and Multimedia Commission
MIMO	Multiple-Input-Multiple-Output
mIoT	Massive Internet of Things
MNO	Mobile Network Operators
MSO	Multi System Operators
NFAP	National Frequency Allocation Plan
NFHS	National Family Health Survey
OFDMA	Orthogonal Frequency Division Multiple Access
OPEX	Operational Expenditure
PM-WANI	Prime Minister Wi-Fi Access Network Interface
QoS	Quality of Service
RLAN	Radio Local Area Network
TPC	Transmit Power Control
TSP	Telecom Service Providers
TV	Television
TWT	Target Wake Time
UAE	United Arab Emirates
UK	United Kingdom
USA	United States of America
VR	Virtual Reality
VSAT	Very Small Aperture Terminal
WAS	Wireless Access Systems
WFH	Work from Home
Wi-Fi	Wireless Fidelity
WLANs	Wireless Local Area Networks
WPC	Windsor Place Consulting Pty Ltd
WRC	World Radiocommunications Conference
XR	Extended Reality

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