A Balanced Approach for Spectrum Allocation

Support for a thriving 5G/IMT & Satellite sector in India

SIAINDIA
Satcom Industry Association

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About Us

SatCom Industry Association (SIA-India) is a not-for-profit body created to represent the interests of the satellite communication ecosystem in India. As a vibrant body, SIA-India represents satellite operators, satellite systems, launch vehicles, ground and terminal equipment manufacturers and application solutions providers to the Government, Regulators, Policymakers, and domestic & international standards' bodies. As the apex representative body for the satellite communications ecosystem, we aim to present the industry's interest to the highest Government levels for policy-making, regulatory and licensing matters.

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Preface

Dr. Subba Rao Pavuluri
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The move to transform the space sector from being ISRO-centric to opening the sector to commercial businesses, both Indian and international, in the country's space journey is revolutionary. The Hon'ble Prime Minister has firmly stated that the Space sector would be a revolutionary medium of progress for 1.3 bn Indians. The finance minister too has affirmed the key role of private sector participation in the Indian space sector expected to capture a larger share of the global space economy.

Satellite and related applications of communications, Earth Observation and Navigation play a significant role in the nation's economy. Satellite broadband proliferation in the country has the capability to contribute to the National GDP by up to USD 184.6 billion in the next 10 years. Government and policymakers need to look at various such parameters and adopt a balanced and tech-neutral broadband policy with a combination of all the disruptive technologies to bridge the digital divide and meet the increased demand.

The broadband policy further needs to be supported by a balanced spectrum allocation policy that is developed in close co-ordination with industry stakeholders, is harmonized to international standards and follows international best practices. Spectrum being a scarce national resource, should be allocated optimally between all the service types and for the benefits of all the citizens. An spectrum allocation policy that allocates parts of spectrum, that ITU identified for satellite communication, to 5G/IMT services will result in Indian citizens being denied the benefits of high-demand, advanced satellite broadband services.

Satellites can be a game-changer to fill in the broadband India gaps. Several world-class models suggest that satellite technology is the only cost-justified and rational method to connect to the internet in areas unserved/underserved by terrestrial broadband and can play an excellent model in achieving the Digital India goals [PM WANI and Bharat Net Targets] complementing the terrestrial modes. Satellite in combination with other terrestrial methods as a mode of delivery entails a significantly lower cost for ubiquitous connectivity in India, as against terrestrial modes alone.

Billions of dollars in investment have gone into the sector in the last few years and several start-ups, MSMEs and manufacturing industries, and Pvt Companies' business decisions rely on a stable and certain spectrum environment. A large number of companies, including ISRO have launched several satellites into orbit that are dependent on the 28 GHz band to receive information transmitted to them from the ground in this frequency band. Since these satellites are already in orbit, any discrepancy in their availability or any type of inefficient segmenting would jeopardize the Satcom missions on a big scale.

This debate is very pertinent and SIA-India has come out with this Position Paper with critical suggestions based on relevant international studies to help the Industry and Policymakers to make suitable policy and business decisions based on it.

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FOREWARD

I am happy to learn that the Satcom Industry Association, a not-for-profit body created to represent the interests of the satellite communication ecosystem in India, has brought out a publication entitled "Spectrum Allocation Strategy – support for a thriving 5G/IMT Satellite sector in India". This publication attempts to study the need for spectrum requirements for satellite and IMT sectors, and solutions that allow the nation to benefit from co-existence of these diverse technologies in internationally harmonised spectrum bands without impacting either of the services.

Currently India ranks low on the Global Index in Connection Speed and Quality with more than 35000 habited villages without 3G/4G mobile internet coverage. With lack of connectivity, rural areas do not have access to essential government to citizen services, such as tele-health, tele-education, disaster response systems and Television services. To redress this situation, policies and programmes like National Digital Communications Policy 2018, Prime Minister's Wi-Fi Access Network Interface (PM-WANI), project Bharatnet and the supported Spacecom policy are being vigorously implemented.

However, no single technology can fill the existing connectivity gap. Fixed line telephony, satellite connectivity, Wi-Fi and mobile broadband are all crucial for an inclusive penetration that addresses the dynamics of providing connectivity not just in urban towns but also the rural and remote areas. Satellite communication plays a significant role in enabling the IMT mobile and Wi-Fi networks to reach out to users in these areas.

The role of connectivity to every section of the nation's populace in enhancing the GDP growth rate is established through various studies and experiences. It is estimated that increase in broadband adoption as a result of satellite coverage in un-served and under-served regions will contribute an additional US$ 72.0-184.6 billion in GDP per annum by 2030.

This publication by SIA-India has come at an opportune time, as the authorities deliberate on identifying spectrum for the various wireless options of IMT, Satellite etc. I convey my best wishes to all the office bearers of Satcom Industry Association in bringing out this publication. It is sincerely hoped that this publication will be received very well by all the stakeholders.

VK Saraswat

(DR. V.K. SARASWAT)

New Delhi
08.03.2022

स्वच्छ भारत
एक कदम स्वच्छता की ओर

Message by Director General SIA-India

Anil Prakash
Director General, SIA-India

Increased demand for connectivity makes efficient spectrum use critical in this day and age of easy communication The upcoming terrestrial (5G/IMT, Wi-Fi 6/6E etc.) and non-terrestrial technologies (HTS/VHTS/UHTS Satellites in LEO, MEO and GEO orbits) have intensified the need to access spectrum in different bands. This calls for well-planned strategic decisions in identifying and allocating spectrum for these diverse technology options.

The baseline for these decisions across countries has tried to address the following imperatives

- Facilitate evolution and growth of diverse services and technologies
- Interference-free operation of incumbent and new services
- Promote Optimum & Efficient Spectrum Use
- International best practice and harmonization

This paper underscores the need for a holistic assessment of the spectrum requirements for satellite and IMT sectors. A balanced and multi-technology approach enables the creation of ubiquitous connectivity infrastructure in the country for achieving 'Digital India' and 'Broadband for All' targets. Digital India's development needs to leverage the sustainable development of various technologies, with a strong ecosystem of private players along with a conducive regulatory and policy regime creating a favorable business environment in the country. Terrestrial technologies alone cannot achieve the desired outcomes in regard to the current connectivity gaps in India and a mix of Terrestrial and Satellite technology is urgent and imperative for providing reliable and universal connectivity.

This paper distills various international decisions, policies, and case studies to highlight the solutions that allow the nation to benefit from the co-existence of these diverse technologies in internationally harmonized spectrum bands without impacting either services. A mismatch in the demand and supply of critical spectrum resources will result in a costly regulatory failure for India causing loss of substantial overall economic opportunities.

Billions of dollars in investment decisions have been taken and several start-ups, MSMEs, and manufacturing industries, and Pvt Companies' business decisions depend on a stable and certain spectrum environment.

SatCom Industry Association (SIA-India) brings out this timely study with the key objective to promote the adoption of a non-discriminatory, technology-neutral spectrum policy with the hope that this will help create policies to facilitate the entry of new technologies and competitors into the market, encouraging and promoting innovation.

Executive Summary

Radio spectrum is essential to provide all forms of wireless communications and services. Its value and contribution to the economy and society have risen tremendously over the last two decades. However, spectrum is a scarce national resource that should be utilised for the benefits of all the citizens and allocated optimally.

ITU Article 4.1 of the Radio Regulations states that "*Member States shall endeavour to limit the number of frequencies and the spectrum used to the minimum essential to provide satisfactorily the necessary services. To that end, they shall endeavour to apply for the latest technical advances as soon as possible.*" Allocating excessive spectrum for a given service can be as inefficient as allocating too little.

It is of utmost importance for the policymakers to acknowledge that no one solution can fill the broadband connectivity gap in the country. A right mix of access technologies, including fixed-line, satellite, Wi-Fi and mobile broadband, to ensure a more inclusive penetration is necessary. With the advent of IMT-2020 5G radio technologies, policy-makers and regulators are facing considerable pressure from terrestrial mobile operators to repurpose spectrum to meet new technical requirements. It is important to note that 5G advances are not unique to terrestrial networks. Satellite broadband is already using many of these advances and has been doing so for many years. These 5G type advances include the use of low latency radio interfaces, network slicing, and edge computing or caching.

Any digital policy would have to account for the dynamics of providing connectivity in rural and remote areas from those of urban areas as the strategies, which work in urban areas, are not suited for rural areas. Each technology option comes with its capabilities and limitations, and, of course, spectrum requirements. Earmarking enormous resources for a single technology and relying solely on it is not only an imprudent strategy to achieve the Digital India goals but also impacts the business ecosystem for other service providers and technology alternatives. The result will be limited options, less innovation and likely higher prices for consumers. This will also limit the scope of FDI, manufacturing and employment generation in the country.

The drawback of a terrestrial mobile focus instead of a multi-technology approach is highlighted by the drafted response of former Hon. Minister of State for communications, Shri Sanjay Dhotre in Lok Sabha on 10th Feb 2021 that an estimated 37,439 inhabited villages in the country do not have 3G/4G mobile internet coverage.[1] In those villages which have connectivity, the quality is subpar. The country ranks very low at 131 out of 140 nations on the Global Index in connection Speed and Quality.

The importance of addressing this issue cannot be underestimated, and an action plan with technology choices and execution timelines needs to be there in place.

With lack of connectivity, it's not just that these villages do not have access to essential government to citizen services, such as tele-health, tele-education, disaster response systems, but also that for lack of satellite-based delivery, would deprive the citizens from TV services that are crucial for information dissemination of the government, welfare schemes besides entertainment and information. The ability of satellite-based services to provide connectivity to these unserved and many other underserved areas is demonstrated amply, and the solutions are available now instead of alternatives with a multi-year rollout period. Thousands of such villages are in landlocked, hilly and inaccessible terrain and need to be connected with appropriate technology solutions.

Hon. Finance Minister Smt. Nirmala Sitharaman Ji in her budget speech mentions "Our vision is that all villages and their residents should have the same access to e-services, communication facilities, and digital resources as urban areas and their residents." It may not be possible to assess the scale of economic impact that comes with broader socio-economic benefits of digital inclusion and general wellbeing through better access to health facilities, education and other essential services.

Furthermore, article 4.4 of the Radio Regulations continues by stating that: "*Administrations of the Member States shall not assign to a station any frequency in derogation of either the Table of Frequency Allocations in this Chapter or the other provisions of these Regulations, except on the express condition that such a station, when using such a frequency assignment, shall not cause harmful interference*[2] *to, and shall not claim protection from harmful interference caused by, a station operating in accordance with the provisions of the Constitution, the Convention and these Regulations.*"

1 See http://164.100.24.220/loksabhaquestions/annex/175/AU1383.pdf

2 Article 1.166 of the Radio Regulations defines interference as "The effect of unwanted energy due to one or a combination of emissions, radiations, or inductions upon reception in a radio communication system, manifested by any performance degradation, misinterpretation, or loss of information which could be extracted in the absence of such unwanted energy."

In line with this, any new service has had to ensure the continued availability of existing services in the same or adjacent spectrum bands. The same principle needs to be applied while allocating spectrum for the new services of 5G being introduced to ensure that the 5G operations do not interfere, impact or hamper the existing operations of satellite services.

There has been substantial investment by the Satellite sector to support a variety of applications, including video distribution businesses like Cable TV, Headend in the sky (HITS) and DTH, video broadcasting businesses, In-flight and Maritime Communications (IFMC), Disaster management, Tele-education, Tele-health, agriculture, animal husbandry etc. Each of these businesses, solutions and application areas has invested and established under existing laws, rules, and regulations. These investments must be kept secure from disruption by any alternative or adjacent use of the spectrum bands.

While researching the ability of mobile operators to launch 5G services in mid-band, OFCOM, the UK communications regulator, found that[3] "*... there was no evidence that 5G could not be delivered with smaller [e.g. 40 MHz blocks] or non-contiguous carriers in other frequency bands [i.e. spectrum other than C-band].*" This suggests that the 300 MHz of spectrum in 3.3-3.6 GHz band barring the specific locations or districts where ISRO is using the 25 MHz (3400 MHz - 3425 MHz) of spectrum for NavIC constellation maintenance, identified in the NFAP 2018 provides enough spectrum to satisfy India's mid-band 5G requirements while ensuring a competitive auction. For the mmWave bands, the Cellular Operators Association of India (COAI) recommended a spectrum block size of at least 400 MHz per 5G operator[4]. The 26 GHz band (24.25 to 27.5 GHz) that is globally harmonised with 3.25 GHz of the available spectrum should be ample for the four mobile operators in India. Besides this, a study conducted by LS Telcom[5] indicates that there are around 400 MHz of spectrum identified for IMT in Region 3 that have not yet been licensed and utilized in India.

The international best practice for rationally planning spectrum use for different applications examines alternative uses to identify which use maximises the value of that spectrum. At the previous World Radio-communication Conference in 2019 (WRC-19), a total of 17.25 GHz of the spectrum was identified for IMT services to support 5G development that is more than enough to cater to the existing requirement of 400 MHz per operator with abundant headroom for future growing needs, if any. The majority of the new spectrum

3 See, Ofcom, A7.39, Award of the 700 MHz and 3.6-3.8 GHz spectrum bands: Annexes (13 March 2020), available online at https://www.ofcom.org.uk/data/assets/pdf_file/0017/192410/annexes-award-700mhz-3.6-3.8ghz-spectrum.pdf

4 Page 20, Para 23 Report on "India's Preparedness for 5G" presented by the Parliamentary "Standing Committee on Information Technology (2020-21)" to the Indian Parliament on 08 Feb. 2021

5 https://www.lstelcom.com/fileadmin/content/lst/marketing/media/2019_Study_LicensingUseofMobileSpectrum.pdf

identified for IMT was in the high-band range (or mm-wave frequencies), including 24.25–27.5 GHz (3GPP n258 band), 37–43.5 GHz, 45.5–47 GHz, 47.2–48.2 GHz and 66–71 GHz.

The policymakers should carefully assess the situation, reallocating spectrum from other services/ applications to facilitate only one option, i.e. terrestrial mobile, will negatively impact a whole range of alternatives that are already serving the connectivity and information dissemination needs of the country, and will dis-incentivise the adoption of the latest technologies in these sectors that add to FDI, GDP and employment generation.

Offering excessive spectrum resources in the upcoming 5G auction will result in Indian citizens being denied the benefits of high-demand, advanced satellite broadband services, and risk lost GDP increases per annum to India's economy of up to USD 184.6 billion by 2030.[6] Similarly, the impact of the loss of C-band spectrum in the 3.6-3.67 GHz band will be felt across the entire Indian broadcasting industry.

Satellite backhaul technology can play an excellent model in achieving the PM WANI Wi-Fi hotspot targets and can provide the vital 'backhaul' or connectivity to ensure uninterrupted Wi-Fi as last mile connectivity. It is the only cost-justified and rational method to connect Wi-Fi access points to the internet in areas unserved/underserved by terrestrial broadband.

The ambitious PM-WANI targets a four-fold increase in the Wi-Fi hotspots to 2 million Wi-Fi hotspots by 2022-23 from the current total of 500,000 hotspots. Although deploying Wi-Fi access points makes the last mile affordable, it still requires a broadband backbone to carry traffic to and from the Internet connection point. Studies have shown that the satellite and Wi-Fi combination as a mode of delivery entails a significantly lower cost for ubiquitous connectivity in India, as against using 5G/IMT in the mmWave band.

As indicated by the ITU decisions and the European 5G Roadmap, choosing one technology over another is not an issue. A wide range of opportunities exist to accommodate 5G/IMT in the spectrum that has been specifically identified for 5G/IMT, and that would not have any of the adverse effects the ITU considered in deciding where to accommodate 5G/IMT spectrum needs.

This paper attempts to study the need for spectrum requirements for satellite and IMT sectors, and solutions that allow the nation to benefit from co-existence of these diverse technologies in internationally harmonised spectrum bands without impacting either of the services.

6 Plum Consulting, Expanding Digital Connectivity through Satellite Broadband in the 28 GHz Band (Oct. 2021), at https://plumconsulting.co.uk/expanding-digital-connectivity-through-satellite-broadband-in-the-28-ghz-band/.

Spectrum Allocations - A Balanced Approach

Expectations from Spectrum Policy

The value and contribution of Radio spectrum to the economy and society has risen tremendously over the last two decades. Spectrum being a scarce national resource should be utilised for the benefits of all the citizens and allocated optimally between all the service types.

Spectrum allocation must be carefully planned based on the following parameters:

- Radio Waves have different properties and not all waves are suitable for all service types.
- Availability of technology for different application and use cases take time.
- Spectrum assignment must be Tech-Neutral.

In view of the increasing global data requirements and millions of unserved and underserved population; government, policymakers and corporations are looking to leverage a mix of technologies for facilitating internet access to meet the increased demand.

The increased demand for connectivity makes efficient spectrum use critical. Upcoming terrestrial (5G/IMT, Wi-Fi 6/6E etc.) and non-terrestrial technologies (HTS/VHTS/UHTS Satellites in LEO, MEO and GEO orbits) with potential use cases have also increased the requirement to access spectrum in different bands. With spectrum demand continually growing by various disruptive technologies, the competition for particular frequency bands between technology options has intensified and the need for efficient use of that spectrum has become even more important.

5G advances are not unique to terrestrial networks. Satellite broadband is already using many of these advances and has been doing so for many years. These 5G type advances include the use of low latency radio interfaces, network slicing, and edge computing or caching; and these unique capabilities can expand to more inaccessible regions with the help of non-terrestrial satellite networks.

It is of utmost importance for the policymakers to frame a multi-technology Policy with a right mix of fixed-line, satellite, Wi-Fi and mobile broadband to ensure a more inclusive penetration.

The Perils of a Skewed Broadband Policy

There have been many strategies and policies undertaken by the government to create a robust digital infrastructure and connect the unconnected such as ‘Broadband Policy 2004’, ‘Digital India Programme 2015’, National

Digital Communication Policy 2018, National Broadband Mission 2019 besides the National Telecom Policy [1994, 1999, 2012 and 2014]. However, most of these policies have failed to account for the dynamics of providing connectivity in rural and remote areas from those of urban areas. The strategies, which work in urban areas, may not necessarily be suited for rural areas. The terrestrial technologies have not been able to bridge the connectivity gaps between rural and urban. This lack of connectivity cannot be attributed to a lack of spectrum allocation considering that even 4G has not been able to reach majority of Indians despite sufficient spectrum blocks sold to the operators.

The issue lies in relying on unbalanced broadband policy goals in India and subsequent allocation policy. However, the policies seem like new targets have been added to or imposed upon an old or established order.

Most of the digital and broadband policies in India acknowledge the need to connect the unconnected, however, the lack of a multi-technology approach that leans on mobile led connectivity alone does not lend itself well to create a ubiquitous connectivity infrastructure in the country and the targets and goals are being repeatedly missed.

Digital Connectivity Woes in India

The recent pandemic has demonstrated that while the urban population switched to an on-line mode of learning and supporting work requirements, the population living outside urban areas struggled to receive education and access to economic opportunities.

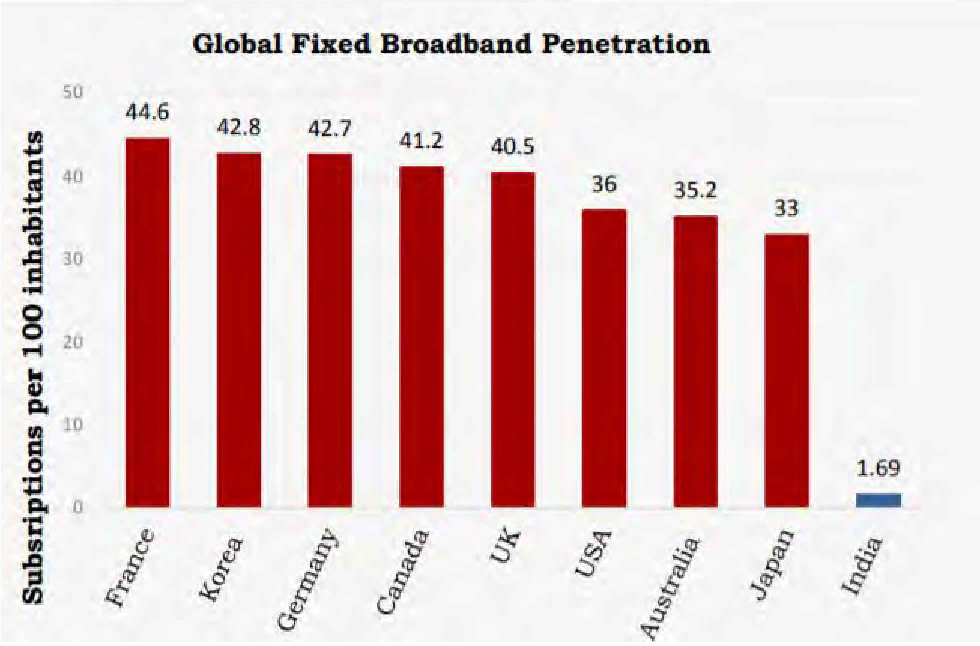
The lack of a multi-technology approach is reflected in the dismal rural digital penetration rate in the country. More than 50% of rural India is still not digitally connected. As per the Telecom Regulatory Authority of India (TRAI) report the broadband penetration is a mere 29.3% in rural India and approximately 55% in the country. Fixed broadband penetration in India is among the lowest in the world at only 1.69 per hundred inhabitants. The ability of satellite-based services to provide connectivity to these unserved and many other underserved areas is demonstrated amply, and the solutions are available now instead of alternatives with a multi-year rollout period. Thousands of such villages are in landlocked, hilly and inaccessible terrain and need to be connected with appropriate technology solutions.

The recent pandemic has demonstrated that while the urban population switched to an on-line mode of learning and supporting work requirements, the population living outside urban areas struggled to receive education and access to economic opportunities. The single biggest factor was lack of quality broadband in these areas. Surveys suggest that only 20% of students in India have access to reliable online education, with reliable internet connectivity being a significant reason for the lack of access.[7] The situation is highlighted by the drafted response of former Hon. Minister of State for communications, Shri Sanjay Dhotre for Lok Sabha on 10th Feb 2021 that *an estimated 37,439 inhabited villages in the country do not have 3G/4G mobile internet coverage.*[8]

7 See, https://www.thehindu.com/news/national/remote-education-was-inaccessible-to-most-children-says-survey/article37461115.ece.

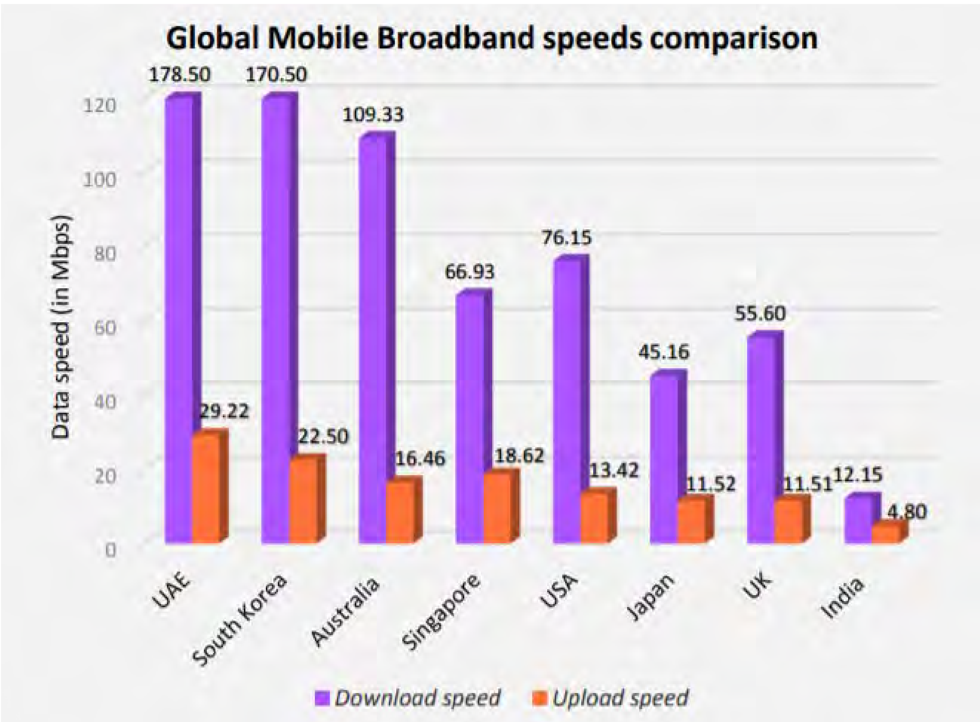
8 See http://164.100.24.220/loksabhaquestions/annex/175/AU1383.pdf

Figure 1 : Fixed Broadband Penetration in India



Source: OECD statistics for June 2020, TRAI Recommendations on Roadmap to Promote Broadband Connectivity and speed 31.08.2021

Figure 2 : Mobile Broadband Speed in India



Source: OECD statistics for June 2020, TRAI Dec2020

In terms of speed and quality too, India ranks very low at 131 out of 140 nations as of March 2021 on Global Index for mobile broadband speeds as per TRAI Recommendations report of August 2021 on 'Roadmap to Promote Broadband Connectivity and Speed'.

The importance of multiple technologies in addressing these gaps cannot be overstated as any technology alone cannot achieve the desired results. A right mix of technologies in planning and deployment is urgent and imperative. Satellite internet connections can not only provide universal connectivity but can handle high bandwidth usage, where the internet speed/quality will not be affected by lots of users or "peak use times or the geographical complexities.

Significance of Satellite Technology

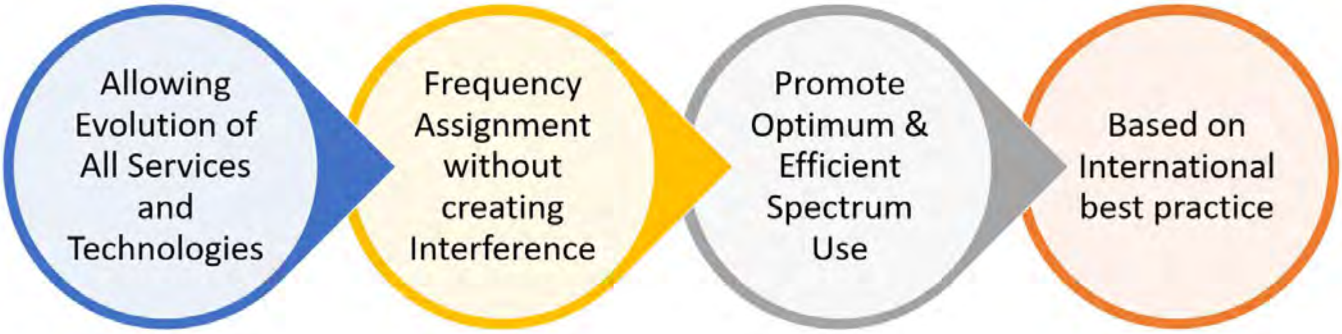
Satellite technology can make a significant contribution in achieving the PM WANI Wi-Fi hotspot targets and can provide the vital 'backhaul' or connectivity to ensure uninterrupted Wi-Fi as last mile connectivity. Recent infrastructure Total Cost of Ownership (TCO) studies confirm that satellite broadband is the most cost effective and rational method to connect Wi-Fi access points to the internet in areas unserved/underserved by terrestrial broadband.

Terrestrial technologies alone cannot achieve any significant change in the statistics. A right mix of technology policy is urgent and imperative.

The ambitious PM-WANI targets a four-fold increase in the Wi-Fi hotspots to 2 million Wi-Fi hotspots by 2022-23 from the current total of 500,000 hotspots. The BharatNet project aims to connect 250,000 gram panchayats across 650,000 villages. As per the government's assessment, 10 per cent of these villages cannot be connected through terrestrial networks. It's easier and faster (and cheaper) to connect any location with satellite broadband because setting up the terrestrial infrastructure requires extensive civil work and approvals. In comparison, satcom requires just ground stations to bring the advantage of existing satellites in space to provide connectivity.

Satellite Solutions rollout faster and have significant role to play in India's Broadband Policy and Digital India goals. In which Nations are better equipped in delivering inclusive broadband to urban, underserved and unserved populations by approaching this with a wide arsenal of wireless infrastructure solutions that includes 5G terrestrial and satellite-enabled connectivity. A balanced approach in spectrum allocation is critical to maximise the individual delivery capabilities of terrestrial and satellite network providers and there are learnings from various global studies and best practices being followed that the policy makers could take advantage of.

The policymakers in India need to pay attention to these critical elements while taking any spectrum decisions and forming encouraging policies. Allocating the required frequencies must be in a manner that facilitates entry of new technologies and competitors into the market, encouraging and promoting innovation. A Balanced Spectrum Policy Must:



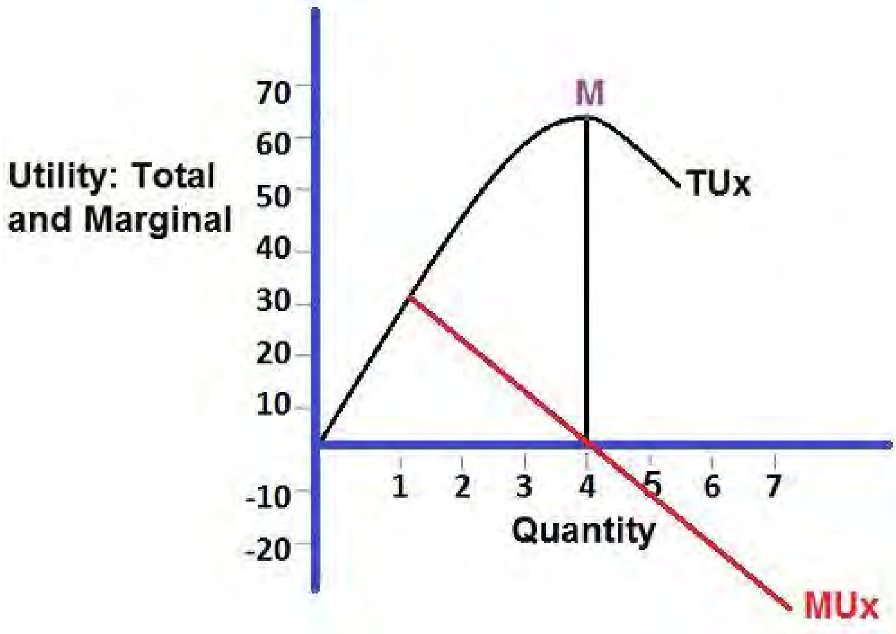
Demand and Supply Based Approach

It is important to recognise the current situation in terms of spectrum supply and demand and to adopt a more balanced approach in auctioning of the spectrum bands, taking into consideration the needs of various sectors as well as to ensure efficient take-up whilst generating a reasonable value to the Government.

Allocating too much spectrum for a given service can be as inefficient as allocating too little. If capacity supply exceeds expected traffic demand, then there is no additional benefit served and any further allocation would lead to diminishing returns and inefficient use.

Graph showing beyond optimal allocation (Point M), any additional spectrum would generate no additional benefits

Figure 3 : Excess Spectrum Allocation and Law of Diminishing Marginal Utility



The benefits of 5G IMT [TUx] or any technology would increase as a result of additional spectrum capacity add [X] while the Mux, a downward sloping curve shows that the utility diminishes with the addition of every additional unit. As TUx reaches the Optimum Utility point, there is no additional advantage beyond that leading to spectrum wastage.

Any increase in allocation after an optimal capacity has been reached would lead to smaller to negligible/marginal increase in its benefits.

India has made a lot of spectrum available for mobile services, but much of it remains unsold (including in the 700 MHz band). In other words, policymakers will have to carefully plan the next auction to match demand as per many other countries. Providing excessive spectrum for 5G poses the risks of the spectrum being unsold or, even worse, underutilised by terrestrial players at the expense of other players such as Satellite Operators. These outcomes will result in a costly regulatory failure for India through loss of substantial overall economic opportunities.

International Scenario

ITU Article 4.1 of the Radio Regulations states that "Member States shall endeavour to limit the number of frequencies and the spectrum used to the minimum essential to provide satisfactorily the necessary services. To that end, they shall endeavour to apply for the latest technical advances as soon as possible." The international best practice for rationally planning spectrum use for different applications examines alternative uses to identify the spectrum requirement for each use and which use maximises the value of that spectrum.

Evidence from the international scenario indicates that the demand for more mmWave spectrum remains uncertain. Even the South Korean MNOs, with 800 MHz of spectrum each, have struggled justify investing in mmWave 5G due to the lack of demand and applications. Three years after auction, the South Korean MNOs have deployed only 161 base stations in the mmWave as against a build-out requirement of 45,000 base stations. Policy makers should also note that the viability of 5G use cases remains uncertain. For example, In China, many 5G use cases previously showcased by the mobile industry – including remote surgery and 5G VR – are being abandoned[9] as too niche or expensive.

9 https://www.lightreading.com/asia/china-culls-unprofitable-5g-use-cases-as-it-narrows-focus/d/d-id/772855

As also rightly noted by Jessica Rosenworcel, Commissioner of the Federal Communication Commission: *"… our focus on millimetre wave spectrum is threatening to create 5G haves and have-nots in the United States. That's because while these airwaves have the substantial capacity, their signals do not travel far. As a result, commercializing them is costly—especially in rural areas. The sheer volume of antenna facilities required to make this service viable will limit deployment to the most populated urban areas. This will deepen the digital divide that already plagues too many rural communities nationwide."*[10]

The IMT industry demand for mmWave frequencies is fully met by available spectrum between 24.25-27.5 GHz (globally harmonized, COAI has sought min 400 MHz, GSMA position of 800 MHz). This will ensure availability of spectrum for the upcoming consultations on Satellite Spectrum and Spacecom Policy.

In the mid-band, the 5G/IMT industry often advocates for a minimum of 80-100 MHz in the mid-band for operations. While validating this claim, Ofcom established that MNO will be able to deliver all the primary services anticipated under 5G – including, but not limited to, connected cars, virtual reality cloud broadband, and live 4K streaming – with 40 MHz of spectrum.

There are ample examples of IMT operators in the world operating with an average of 40-80 MHz spectrum allocation, and with four operators in the country, an allocation of 300 MHz from 3300-3600 MHz barring the specific locations or districts where ISRO is using the 25 MHz (3400 MHz - 3425 MHz) of spectrum for NavIC constellation maintenance, is sufficient to allow 40 MHz for each operator and sufficient headroom for future requirements.

10 Jessica Rosenworcel (2020), Statement of Jessica Rosenworcel, Commissioner, Federal Communications Commission before the Committee on Commerce, Science, and Transportation, United States Senate "Industries of the Future", 15 January 2020. Available at https://www.commerce.senate.gov/2020/1/industries-of-the-future

Impact of Over Supply of Spectrum

The following inefficiency and loss of value risks are associated with Spectrum Oversupply to 5G.

- Risk of saturating the demand for MNOs for additional spectrum – leads to non-competitive auction and lower auction revenues
- Risk that valuable spectrum goes unsold or underutilized for an extended period
- Risk of reallocating valuable satellite spectrum to mobile operators with unproven business strategies at the expense of proven and essential existing Fixed Satellite Services (FSS).

The Spectrum is a national resource and should be carefully deployed for the technological development and welfare of the citizen. The ITU has been through an arduous task for four years in processing the member country's requirement and coming out with collective decisions by the member states including India. Offering additional spectrum resources in the upcoming 5G auction will result in Indian citizens being denied the benefits of high-demand, advanced satellite broadband services and risk lost GDP increases per annum to India's economy of up to USD 184.6 billion.[11] Similarly, the impact of the loss of C-band spectrum in the 3.6-3.67 GHz band will be felt across the entire Indian broadcasting industry.

As per international case studies it's been seen that 5G wireless is an urban phenomenon, and cannot address the rural fixed broadband gap. It would certainly improve mobile broadband and support the internet of things, also may even be suitable for fixed broadband in dense urban areas but cannot achieve an inclusive connectivity target of the government.

5G wireless is an urban phenomenon, and cannot address the rural fixed broadband gap.

11 Plum Consulting, Expanding Digital Connectivity through Satellite Broadband in the 28 GHz Band (Oct. 2021), at https://plumconsulting.co.uk/expanding-digital-connectivity-through-satellite-broadband-in-the-28-ghz-band/.

India’s Satellite Powered Economy

Space Industry Deemed a SUNRISE SECTOR

Space economy has immense potential to assist sustainable development at scale and modernize the country. They provide employment opportunities for youth, and make Indian industry more efficient and competitive.

Budget 2022

Satcom – A Sunrise Industry

The space and satellite sector in India has recently been decentralized and has allowed the private sector to take it to a new horizon. The sector is deemed a Sunrise sector with emphasis given for adopting supportive policies, light-touch regulations, facilitative actions to build domestic capacities, and promotion of research & development in the recent budget announcements.

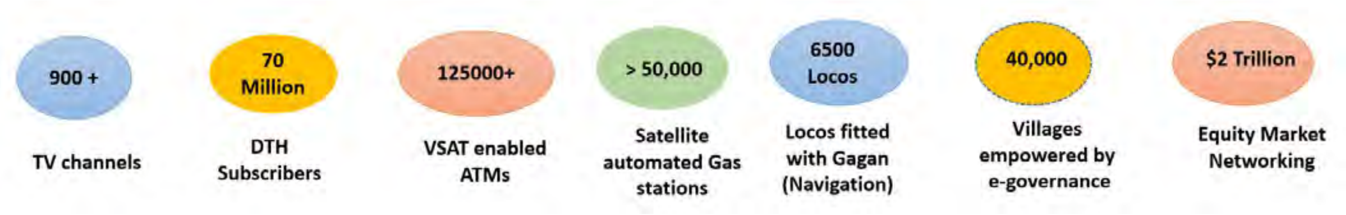
The nascent satellite communications industry is all set to propel the next big revolution in the telecom space. Apart from providing broadband, broadcast and Sat IoT services, Satcom is vital in defence, coastal security, border surveillance, disaster management, mission critical operations and strategic applications. In addition, satellite connectivity has been a key to ensuring the resiliency of terrestrial networks in times of crisis or natural disasters.

The first responder role of Satellites in natural disasters has been proven time and again from the recent volcanic eruption in Tonga to the numerous instances in the past like hurricane Katrina in USA.

Each time satellite connectivity has come to the rescue when the other modes of communications, wired and wireless were rendered unusable. In India satellite breakthrough has helped save many lives with better disaster management system. Fibre cables can be cut, and terrestrial networks are often knocked out after natural disasters. Satellites have been key to restoring communications quickly for disaster recovery and emergency telecommunications in each case.

Indian Economy Powered by Satellite

Satcom is an essential part of our economy and immense value add to the Government, Industry and Citizens. Satcom reaches over 200+ Mn HH with 900+ TV channels, nearly 50,000+ cable operators and nearly 70 million DTH subscribers. Beamed over 140+ countries, satellite in India plays an important role in video distribution value chain. Close to 5 Billion ATM transactions take place annually through 125000 VSAT enabled ATMs and help network the $2 Trillion equity market besides providing cellular backhaul, enterprise networking, rural connectivity as well as in-flight and maritime communications. Nearly 40,000 Villages are empowered by e-Governance today And more than 50,000 Gas Stations Automated through satellite technology.



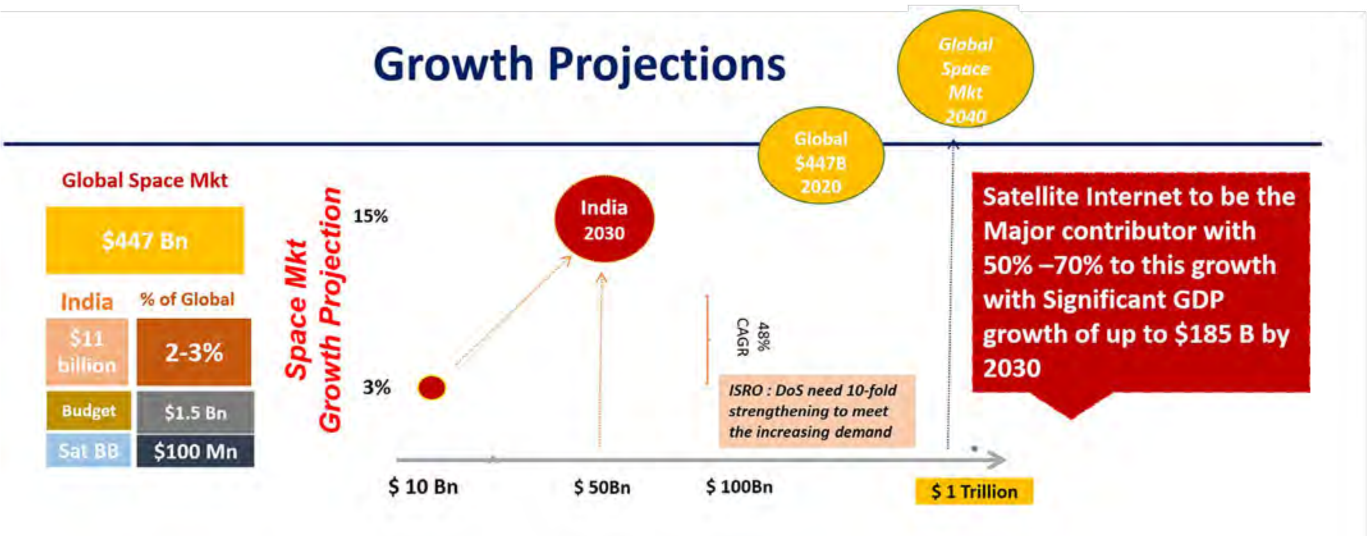
The country is at a cusp to become a potent market for increased use of satellite applications with the capacity to attract billions of dollars as FDI as stated by the Finance Minister of India in the parliament in 2020. This is further expected to boost local manufacturing, generate millions of jobs, contribute substantially to the GDP and hold a significant share in the global Space ecosystem.

Finance Minister Smt Nirmala Sitharaman Ji Speech during the Budget 2022 stated

"with the recently undertaken policy initiatives and private sector participation, the Indian space sector is expected to capture a larger share of the global space economy, which was close to USD 447 billion in 2020".

Satellite industry, which currently has a 2-3% share of $447 Bn global space economy can be a new frontier for national growth with the potential of cornering about 10% of the global pie worth approximately $50 Bn or more in 10 years' time. Major contribution to global space economy is going to be from the satellite broadband by almost 50-70%. India looks the most promising with the government's mission to take high and cutting-edge technologies to the end user, connect the 57% unconnected to the internet in rural India.

Figure 4 : Space Market- Growth Projections

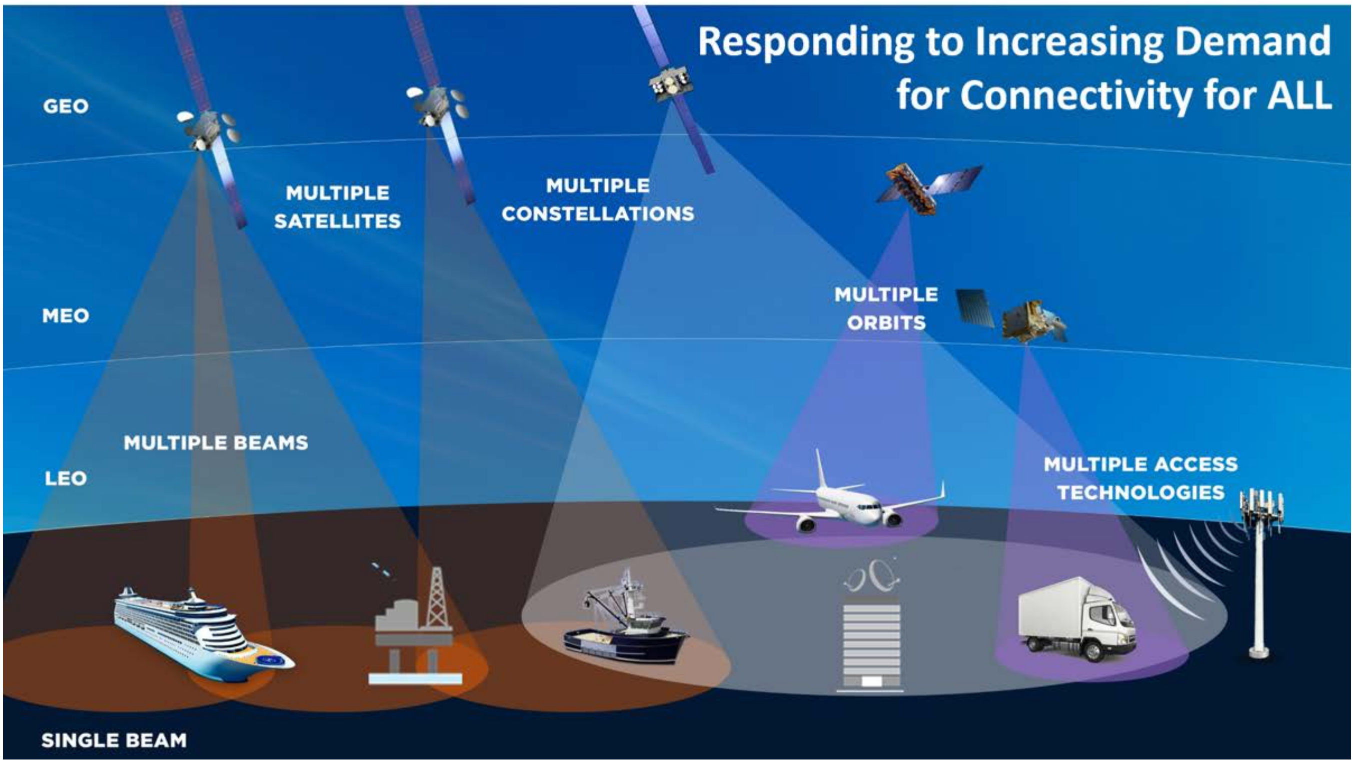


Based on the developments the estimates suggest that India's satcom user base is likely to reach up to 2 Mn by 2025, generating close to Rs 5,000-6,000 crore (800Mn USD) revenue annually. This goal would also hugely benefit Indian PM Narendra Modi's dream of a true 'Digital India' and 'Atmanirbhar Bharat' (self-reliant India).

Satellite Solutions – Faster Rollout

SatCom has a significant role to play in India's Broadband Policy and Digital India goals. There are 37,439 inhabited villages in the country that do not have 3G/ 4G mobile internet coverage. There have been persistent delays in the BharatNet programme, delayed by more than 92 months and the unreliability of the terrestrial services to provide coverage to rural and ultra-rural areas is pressing. Further, target of '2 Million Wi-Fi Hotspots' by 2021-22 is far from reach. The policymakers need to bring in satellite technology to bridge the gaps.

Figure 5 : Satellite to Provide Ubiquitous Connectivity



Space Start-ups on Rise

Several Space Tech start-ups are coming up with their innovative and disruptive plans in full swing. As many as 47 new start-ups emerged in 2021, taking the tally to 101, according to the 2022 Economic Survey Report[12]. The last three years saw a major growth in the number of new start-ups in the space sector, increasing from 11 in 2019 to 47 in 2021.

12 https://www.indiabudget.gov.in/economicsurvey/

Table 1 : Number of Start-ups in Space Sector

Year	Number of Start-ups
2012	1
2013	1
2014	1
2015	3
2016	1
2017	8
2018	7
2019	11
2020	21
2021	47
TOTAL	**101**

The Investors interest too has gone up substantially. In last two years several VC firms have invested about $90 million in India's space start-ups, only a few years ago, Indian space start-ups were struggling to raise even a million dollars.

Nearly 40 start-ups are engaged with the Government at present along with several private sector firms with billions of dollars of investments plunged in, hoping for conducive regulatory and spectrum certainty for their plans to take off.

Globally, High Throughput Satellites (HTS) are providing seamless high speed internet connection across countries and in India too it promises to bring a paradigm shift in the internet connectivity landscape. Rapid deployment of high throughput satellite [HTS] technologies in the LEO space could dramatically change the internet penetration reality in India by filling in the gaps where the terrestrial connections are challenged.

Huge Economic Impact of Satellite Broadband Proliferation in India

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It is estimated that increase in broadband adoption as a result of satellite coverage in unserved and underserved regions will contribute an additional USD72.0-184.6 billion in GDP by 2030. In addition, there are potential economic benefits from new applications and connectivity services through ESIMs in the aeronautical and maritime sectors. However, giving away satellite worthy bands would incur loss of substantial overall economic opportunities with the Indian citizens being denied the benefits of high-demand, advanced satellite broadband services.

The impact of the loss of C-band spectrum in the 3.6-3.67 GHz band alone will be felt across the entire INR 700 Bn Indian broadcasting industry carrying 900+ registered channels to 21 Cr Households in urban and rural India through ~1730+ digital platform operators and 50000+ cable operators, provides direct and indirect employment to 1.83 M people.

Figure 6 : Potential Economic Impact of Satellite Broadband Proliferation in India

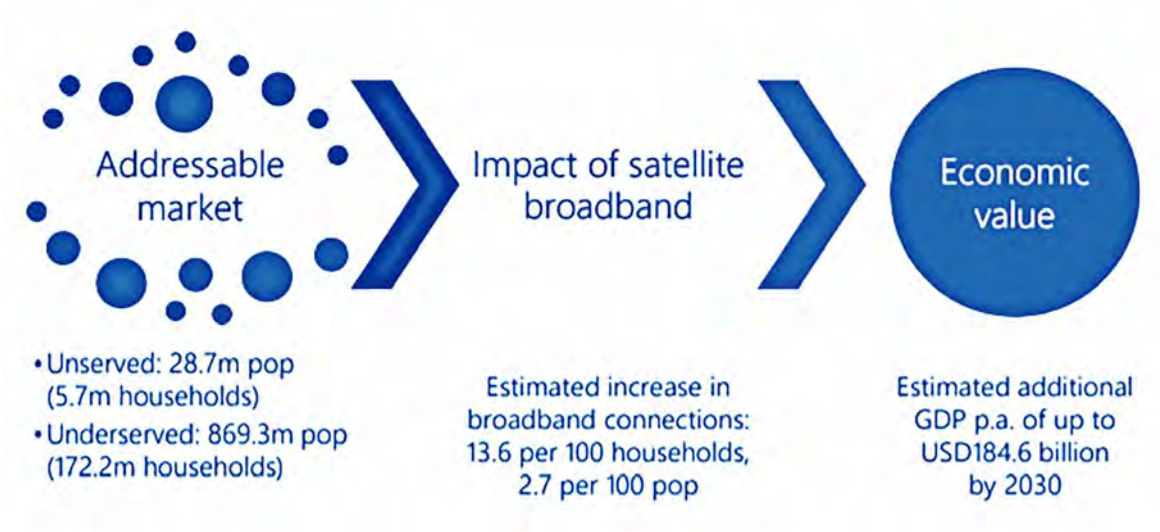
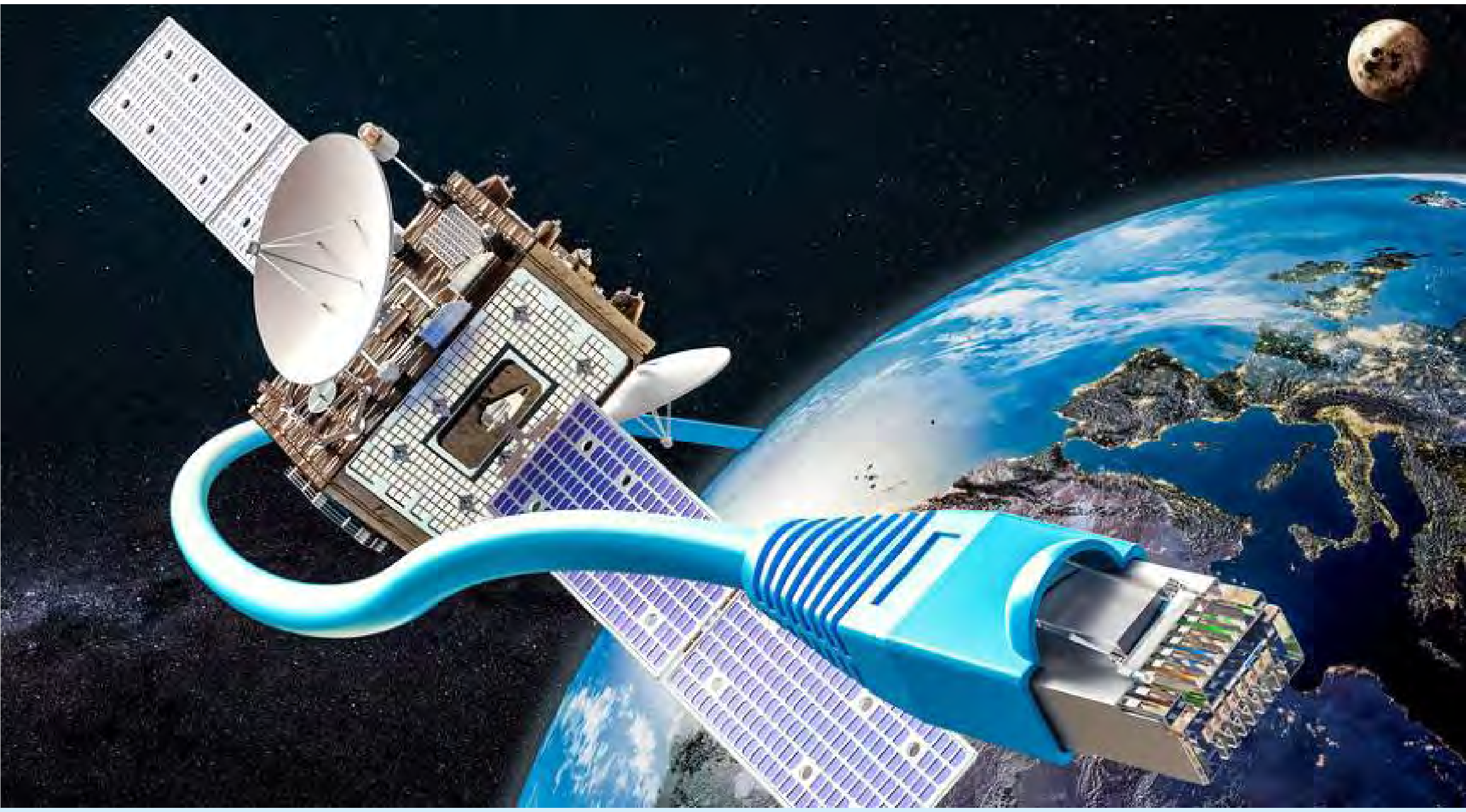


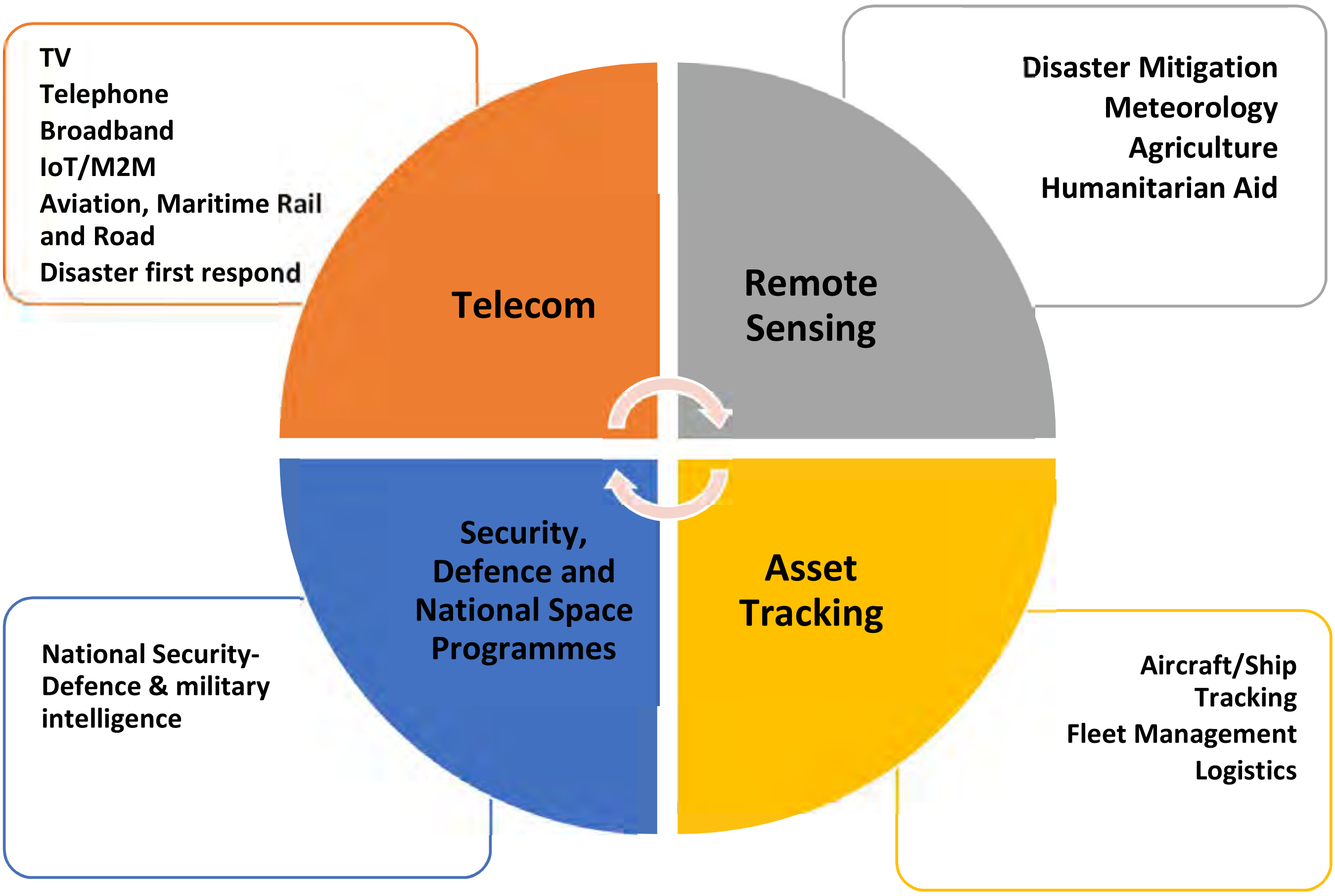
Image Source: Plum Consulting UK

Can India really afford to miss all the connectivity benefits that can arise from the satellite and space Industry and the subsequent domino effect on the economy, business, employment and society?



The Strategic Importance of India's Space Sector

The Government of India's recent decision to open the Space domain to private and foreign enterprises is a positive step and opens up several additional avenues to build strategic capacity and capability. India is demonstrated its capability to run world leading satellite programmes. Satellite technologies play a crucial role in many spheres and they are important assets for ensuring strategic autonomy in geopolitical, economic and technological shifts.



Many global companies foresee the potential in the satellite technology and are ready to invest heavily in the technology and constellations. Space industry helps in country's rapid economic development but it also has a political dimension as more and more countries are attempting to have a better hold over the space infrastructure, internet and the flow of information. Space Com is the most powerful tool for development today with all the major space faring countries as important stakeholders are ensuring that they have strong negotiating powers on the global space stage.

In India, Satellite communications sector has recently entered a period of renewed interest motivated by technological advances and nurtured through private investment and ventures.

India Space industry is close to $10 Bn dollar industry and employed more than 45,000 people. At present it includes over 500 private suppliers and other various bodies of the Department of Space in all commercial, research and arbitrary sectors. About 40 active space startups and industries are in consultation with ISRO for support related to development of satellites, launch vehicles, develop applications and provide space-based services.

In the case of major satellite missions such as the Mars Orbiter Mission (MoM), over 120 companies have contributed to manufacturing. There is a clear lack of data on the size of India's space manufacturing sector. Roughly the upstream sector that includes the manufacturing of space assets is $2.3 Bn (33%) in 2019-20.

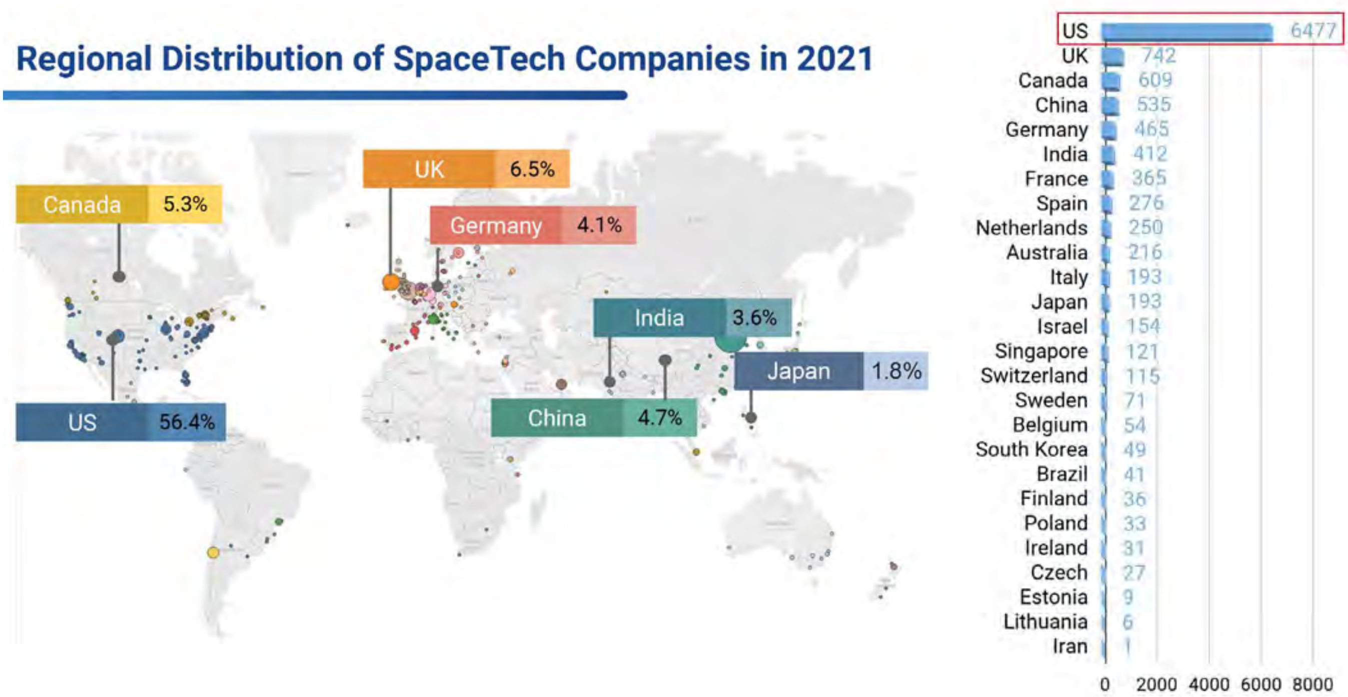
As per estimates India is going to be a $5 trillion economy by 2024-25 [As envisioned by the PM], to which Satcom sector [Direct and Indirect sectors] could contribute a larger chunk. This will be opening the floodgates for greater innovation, R&D, employment, investment and connectivity, and position India to become the next space manufacturing hub of the world.

India in APAC top 3 Countries

India, Japan and China are witnessing the emergence of internationally competitive actors, easily rivalling with their Western counterparts with aggressive expansion strategies. A large number of SMEs and MSMEs play a critical role in the value chain, with the number of newspace companies on a rise.

India holds a 3.6% share in the total number of Space Technology companies globally, including start-ups and MSMEs, after china which holds a 4.7% share.

Figure 7 : Global distribution of Space Technology Companies



Source: Spacetech Analystics/ Forbes 2021

Space Power Brings Strategic Depth in Defence Affairs

Space and satellites play a very strategic role in the Economy in mission critical operations and strategic applications. Modern air, naval and ground operations are heavily invested and reliant on space assets (primarily satellites) for terrestrial missions. As the fourth dimension of warfare the space industry provides the required C4ISR capabilities across theatres of command and operations. *"Space bestows immense force multiplication capability on the Armed Forces, and the dependence on space assets for military operation is rapidly increasing. Currently, India's space capabilities are mostly driven by civil and commercial requirements, steps for exploitation of space for military applications are being undertaken. Leveraging space power would include protection of our National space assets and exploitation of space to enable defence capabilities across the conflict spectrum."* - Extract from Joint Doctrine Indian Armed Forces

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Space as a domain will have a significant role in how terrestrial conflicts play out in the future by connecting the operational capabilities of a nation in the traditional operational theatres of land, air and sea. Active measures need to be in place to ensure the space assets are not only functional, but also well protected.

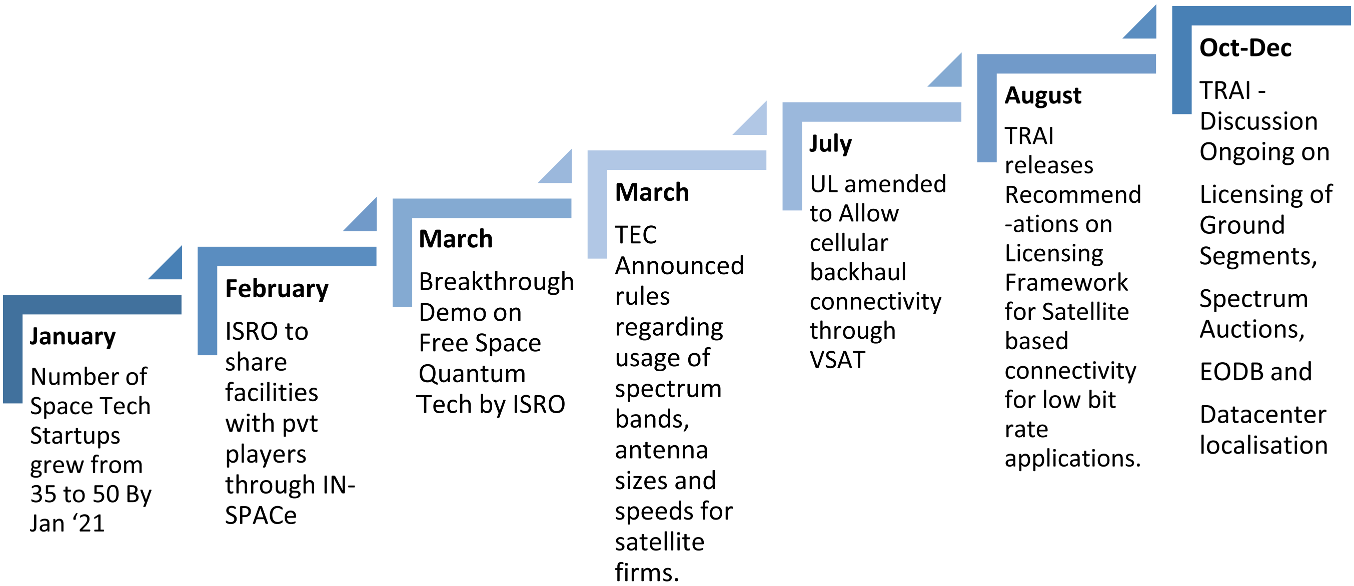
Procurement of space related capabilities will form a significant proportion of defence procurements in near future, if not immediately. The emergence of the commercial space sector and start-ups in India throws up some attractive possibilities for the country's Defence requirements.

There is an immense potential for exports that will also help the nation in helping achieve its export target of $1 Bn. This will not only allow the industry to find a place in the strategic supply chain globally but also be an enabling factor in growth of scale and maturity that is highly desirable for solutions related to defence procurement.

The Space industry is on the strategic roadmap of taking its rightful place among the established value chain internationally. There have been some very encouraging policy changes that are taking place in the sector from time to time [As seen in the Figure 8]. All these developments have a major impact on the global space arena, with significant collaborations and strategic partnerships getting formed.

These strategic partnerships between economies could meet the country's pledge to increase its share of the global space industry to $50 Billion Dollar Industry by 2030.

Figure 8 : Space Policy Reforms in 2021



Several policy reforms are taking place in the space sector, as many as 12 policy documents have come in last two years. Govt. has set a target to transform Indian industry from being a supplier of components to become end-to-end designer of space-crafts or launchers. There are massive plans to cut down on imports and boost indigenous manufacturing in the space sector. The formation of Indian National Space Promotion and Authorization Centre (IN-SPACe) to be a nodal agency to provide a level playing field for private companies through encouraging policies and a friendly regulatory environment is highly encouraging for the sector.

There is an urgent need therefore for the industry to adapt well to this transformation and for a seamless coordination between various stakeholders as the space sector activities take a full speed.

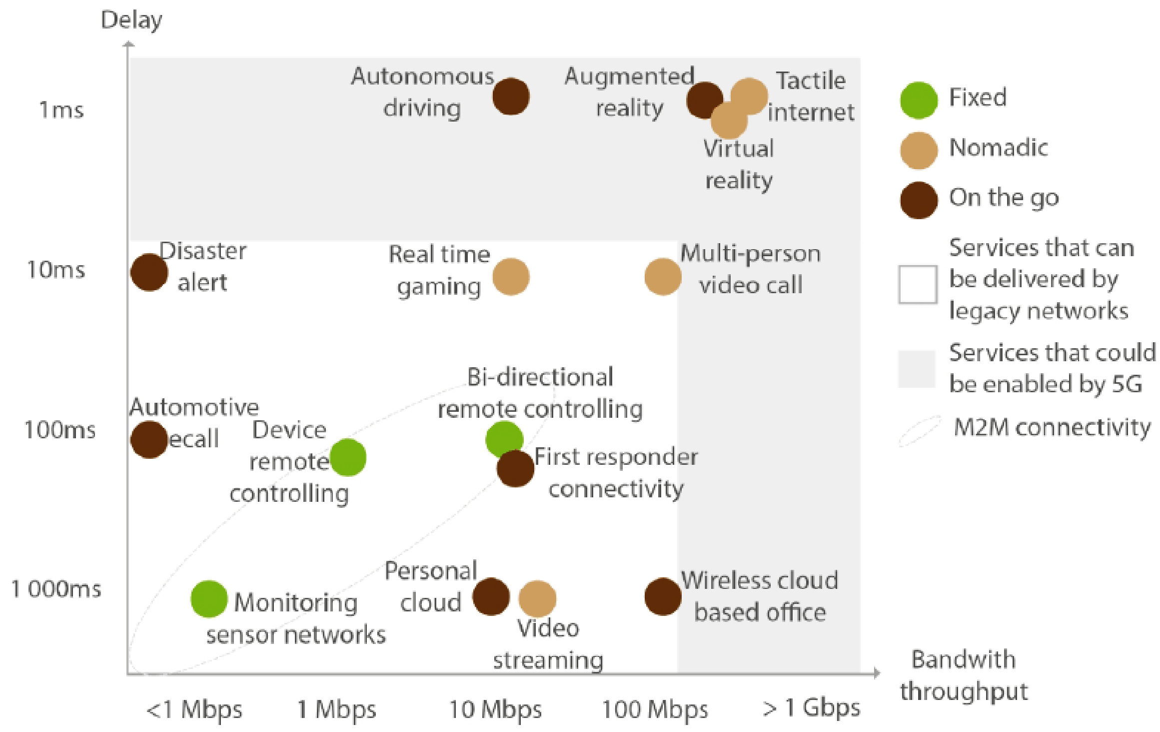
IMT, Satellite and Wi-Fi – Spectrum Expectations

While each wireless communication technology will claim certain quantum of spectrum in specific bands, an important responsibility lies with the regulators to carry out an impact assessment, along with a stakeholder consultation, in order to come to an evidence-based decision. The role played by IMT/5G, Satellite and Wi-Fi is complementary in nature towards providing this societal gain and an objective and holistic assessment of the spectrum requirements helps in the balanced approach as established towards the beginning of this paper.

Many 5G use cases are time taking

The latest generation of IMT services enable applications, some of which were not hitherto possible with existing generation of technology. Many of these applications are also, and in some cases better, served by alternate technologies like satellite and Wi-Fi. In some cases few of the applications advertised may still be at a stage of development, where an immediate allocation of spectrum may translate into welfare gains many years later, while crippling innovation in other technologies where the welfare gains are realized in a very short distance on the timeline. For all the benefits of eMBB, URLLC and mMTC that 5G can bring, if not deployed timely, efficiently and effectively, there is a risk of losing out on these benefits or not maximizing the reach of these benefits to large swaths of the population in a timely manner.

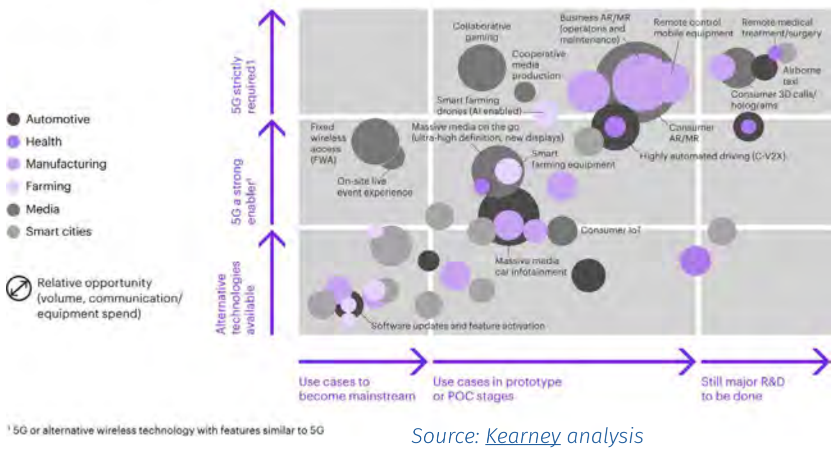
Figure 9 : Bandwidth and Latency Requirements for Generic Apps



Source: GSMA Intelligence, 2015.

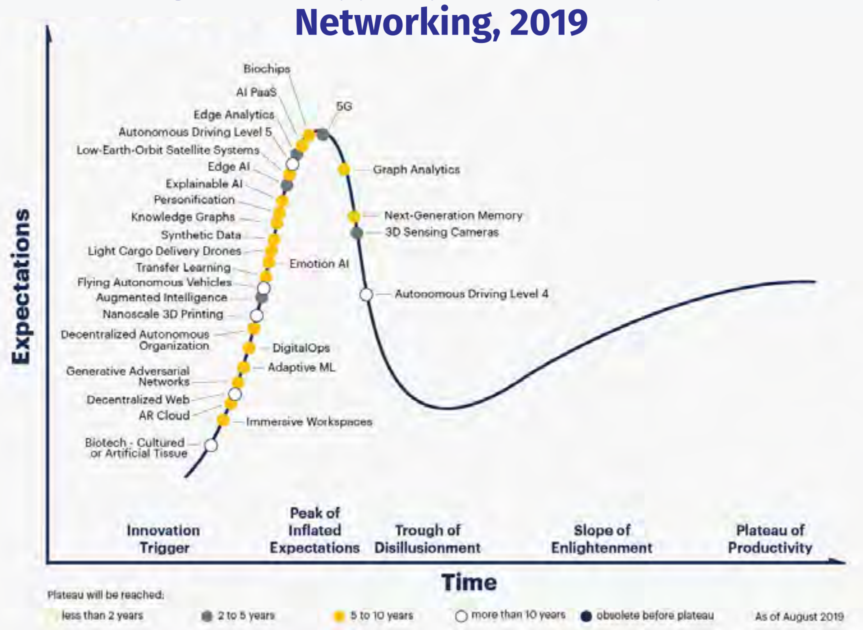
The need to quantify and assess timelines of the welfare gain from each of the advertised advantages by different technologies cannot be stressed enough, especially when the spectrum needs for these are contested between these technologies and some of the decisions may need to be taken shortly. In China, for example, many 5G use cases previously touted by the mobile industry – including remote surgery and 5G Virtual Reality – are being abandoned as too niche or expensive.[13] Indeed, one executive has admitted that the "showroom" applications "were ultimately just a promotion for 5G."[14]

Figure 10 : 5G use case



Source: Kearney analysis

Figure 11 : Hype Cycle for Enterprise Networking, 2019



Source: Garter

With the advent of IMT-2020 5G radio technologies, policy-makers and regulators are facing considerable pressure from terrestrial mobile operators to repurpose spectrum to meet new technical requirements. Without objective assessments there is a risk of industry narratives and hype, supported by their respective heft, sidelining balanced spectrum decisions.

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The discussion on 5G dominates spectrum requirement discussions. The contributions of increasing spectral efficiency and frequency reuse to overall mobile network capacity is however understated. Expanding mobile wireless capacity in an economic and effective manner requires multifaceted efforts. Thus, if the mobile industry is successful at ensuring the following actions, these individual contributions may be multiplicatively combined and their joint lift on mobile capacity matched or even exceed the forecasted traffic demand.

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13 See, https://www.lightreading.com/asia/china-culls-unprofitable-5g-use-cases-as-it-narrows-focus/d/d-id/772855.

14 Id.

a. deploying all of the spectrum allocated
b. increasing the reuse intensity of this spectrum
c. achieving all of the stated 5G/IMT efficiency gains
d. quickly migrating customers to the latest generation of technology

By utilizing the Dynamic Spectrum Sharing (DSS) and Carrier Aggregation (CA) features, the existing cellular frequency bands can also be refarmed and optimised to bring 5G service traffic to subscribers of each MNO.

mmWave – Contesting the Allocation Between Satellite and IMT

An understanding of the overall spectrum requirements for 5G services and applications is important because it helps to set the stage for why certain bands are key to the future of 5G and how the benefits they bring can be realised. The characteristics of 5G in different frequency bands is illustrated in this figure *(Image Source: SCTE-ISBE)*

5G/IMT attempts to bring about additional advantages over LTE, some of which may require larger spectrum than LTE carriers that are narrower in bandwidth, up to 20 MHz maximum that can be aggregated together to create a channel bandwidth up to 100 MHz in LTE-Advance, or up to 640 MHz in LTE-Advanced Pro. In comparison, 5G NR maximum carrier bandwidth is up to 400 MHz in frequency range 2 (FR2: 24.25 GHz to 52.6 GHz) that can be aggregated with a maximum bandwidth of 800 MHz. The need for a 400 MHz spectrum for each MNO is asserted by COAI[15] in its submission that is reflected in a report of last year only.

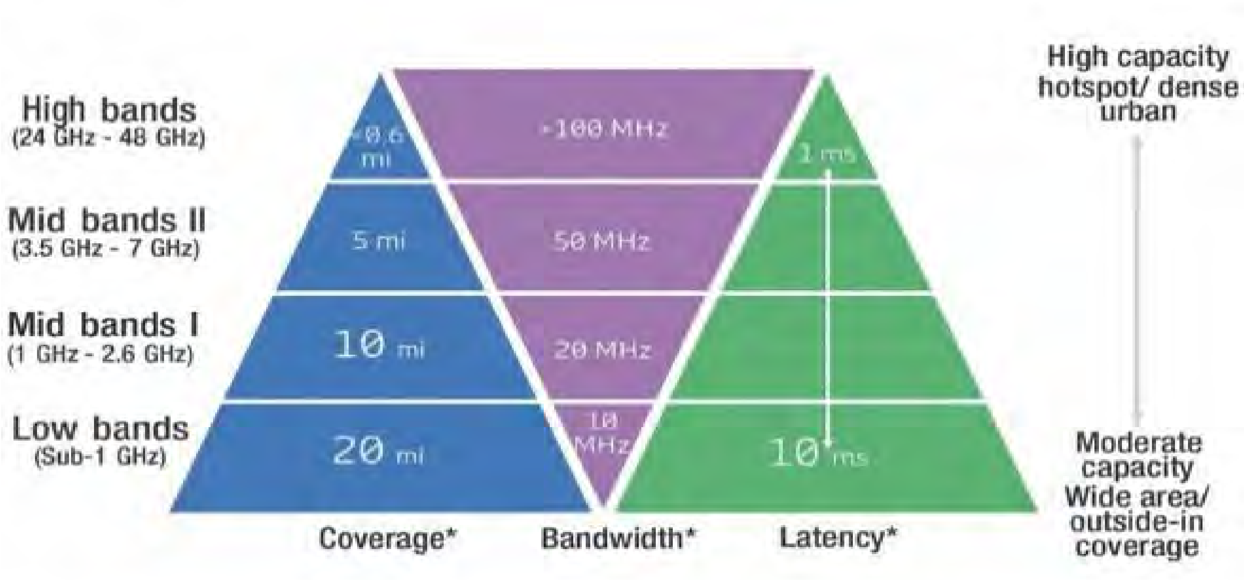
While 5G enables the aggregation of up to 800 MHz by combining two 400 MHz blocks and most base stations can utilize the wider bandwidths available in 5G, user equipment (UE) capabilities, will vary and it will be more challenging for most UEs (Mobile phones, tablets, etc.) to use the larger available bandwidths.

Frequency Band Characteristics and Benefits

There are fundamental trade-offs between capacity, coverage, latency, reliability and spectral efficiency in a wireless network. Due to these fundamental limits, if one metric is optimized for improvement by choice of frequencies, this may result in degradation of another metric. The coverage limitations of mmWave bands however bring deployment challenges beyond certain hot-spot areas. Evidence from the international scenario indicates that the demand for more mmWave spectrum remains uncertain.

15 Page 11, Para 23(b) Report on "India's Preparedness for 5G" presented by the Parliamentary "Standing Committee on Information Technology (2020-21)" to the Indian Parliament on 08 Feb. 2021

Figure 12 : Frequency Band Characteristics



Even the South Korean MNOs, with 800 MHz of spectrum each, have struggled to justify investing in mmWave 5G[16] due to the lack of demand and applications. Carriers have been reluctant to invest in mmWave 5G, considering disappointing user migration to 5G networks amid a lack of services that can take advantage of the speeds that even current 5G networks offer. Three years after auction, the South Korean MNOs have deployed only 161 base stations in the mmWave as against a build-out requirement of 45,000 base stations. It is also important to note the example of Brazil, another large economy, which recently attempted to auction mmWave spectrum for 5G. This resulted in unsold mmWave spectrum[17].

A recent TRAI consultation paper on 5G/IMT spectrum states in Sec. 2.67[18] that "*24.25–28.5 GHz (mmWave) spectrum is likely to be used for the provision of 5G use cases/applications requiring very high data rates and ultra-low latency. Therefore, the TSPs would be deploying it selectively in the areas where the demand for such use cases/applications exists. Further, the technical characteristics of the high band are such that it cannot be used for meeting coverage requirement.*"

"... the technical characteristics of the high band are such that it cannot be used for meeting coverage requirement." TRAI Consultation paper on Auction of Spectrum in frequency bands identified for IMT/5G

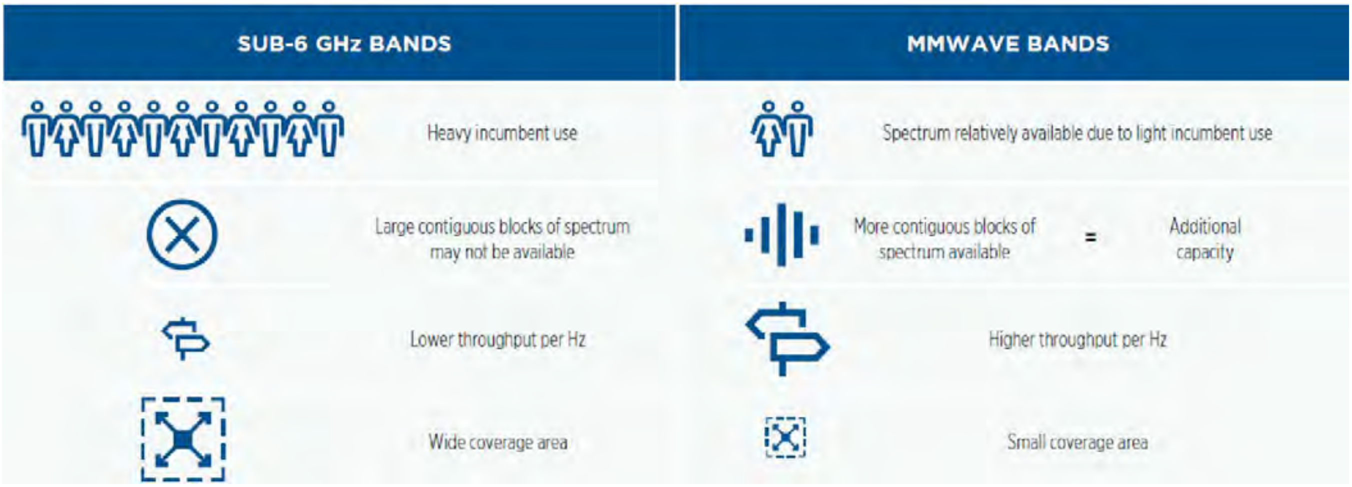
16 http://www.koreaherald.com/view.php?ud=20210910000417

17 Reuters, Brazil to reschedule auction for unsold 5G spectrum, minister says (Nov. 5, 2021), https://www.reuters.com/business/media-telecom/brazil-reschedule-auction-unsold-5g-spectrum-minister-says-2021-11-05/.

18 See sec 2.67 on page 53 https://www.trai.gov.in/sites/default/files/CP_30112021.pdf

The TRAI statement above however extends the spectrum expectations of the industry to 28.5 GHz instead of the n258 band, commonly known as the 26 GHz band, which limits from (24.25-27.5 GHz). The 26 GHz band (24.25 to 27.5 GHz) provides a substantial 3.25 GHz of spectrum for 5G networks to realize the enhanced benefits of a modern 5G network. The 3.25 GHz frequency spectrum from 24.25-27.5 GHz, as referred to time and again in the NFAP 2018[19], statement of Secretary DOT20 and other forums is more than sufficient to accommodate the needs of a minimum of 400 MHz for all 4 operating MNOs while ensuring a competitive auction.

Figure 13 : Comparison of Characteristics of Different 5G Spectrum Bands



Source: GSMA Study on Socio-Economic Benefits of 5G Services provided in mmWave Bands

The Department of Space (DoS) recognizes the critical space operations in the 28 GHz band and objected to the band being allocated to the mobile industry.[21] The allocation of the 27.5-28.5 GHz frequency range to IMT/5G will severely impair the deployment and operation of these satellites and curtail the capacity available to offer broadband services. Any requirement for FSS and IMT (mobile 5G) to share any portion of the 27.5-28.5 GHz band will constrain and, at the same time, prevent both services from reaching their full potential due to the geographical separation distances required to ensure compatibility.

Spectrum Bands Identified by ITU and other International Bodies for 5G Services

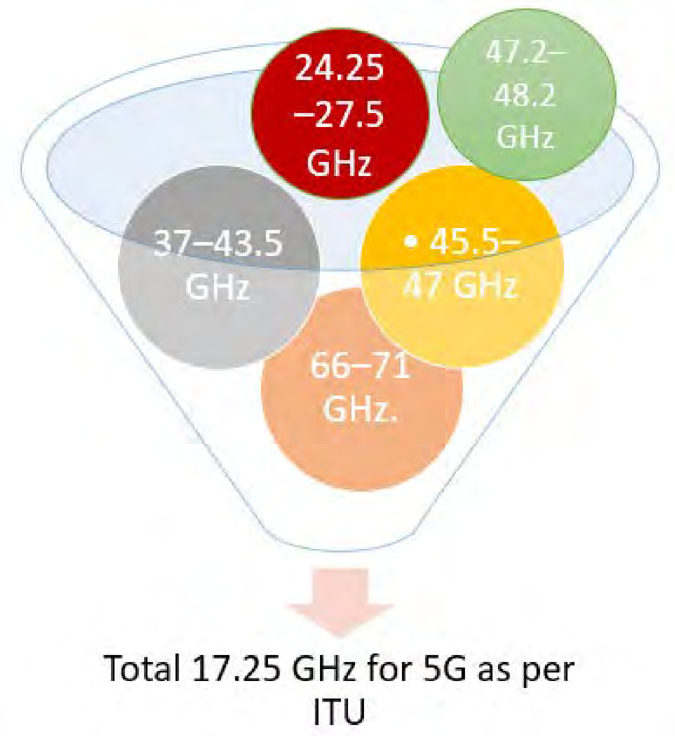
At the previous World Radio-communication Conference in 2019 (WRC-19), a total of 17.25 GHz of the spectrum was identified for IMT services to support 5G development. The majority of the new spectrum identified for IMT was in the high-band range (or mm-wave frequencies), including 24.25–27.5 GHz (3GPP n258 band), 37–43.5 GHz, 45.5–47 GHz, 47.2–48.2 GHz and 66–71 GHz. In most countries, the assignment of the mm-wave spectrum has been in the 26 GHz band, which is fully harmonised on a global basis for IMT.

19 See National Frequency Allocation Plan 2018

20 Page 10, Para 22 Report on "India's Preparedness for 5G" presented by the Parliamentary "Standing Committee on Information Technology (2020-21)" to the Indian Parliament on 08 Feb. 2021

21 See, https://economictimes.indiatimes.com/industry/telecom/telecom-news/dept-of-space-isro-refuse-to-free-up-28-ghz-band-for-5g-rollout/articleshow/68714554.cms.

Figure 14 : ITU Identification of Bands for 5G



The 5G standard allows for the resource block sizes needed for URLLC in a 50 MHz bandwidth, which has additional advantages regarding the required signal strength and therefore the service range of the site.[22] It is important to emphasize that this specialist application would be deployed at specific locations such as campus and industrial sites but not on a general network. URLLC would be better suited to unencumbered bands, free from neighbouring operators, making certain mmWave spectrum in the 26 GHz already identified for IMT far better suited for this application than 28 GHz frequencies.

Adhering to the 5G ecosystem for a globally harmonized 26 GHz band will provide emerging markets with a cost advantage in building the mmWave band 5G network. As per GSMA, in the ITU process, the 26 GHz band (24.25-27.5 GHz) and the 40 GHz band (37-43.5 GHz) have received more attention and the greatest support for IMT identification.[23] No wonder the majority of interest from terrestrial service providers globally has been exploring the 26 GHz band (31%) versus those evaluating usage of the 28 GHz band (15%). The 26 GHz band (24.25 to 27.5 GHz) is globally harmonised and as seen above, only a small number of countries have assigned (or partially assigned) or considering this band for IMT.

22 ShareTechNote.com. 5G Frame Structure. https://www.sharetechnote.com/html/5G/5G_FrameStructure.html

23 See GSMA Study on Socio-Economic Benefits of 5G Services provided in mmWave Bands https://www.gsma.com/spectrum/wp-content/uploads/2019/10/mmWave-5G-benefits.pdf

In contrast, the decisions of the Radio Spectrum Policy Group (RSPG) and the CEPT Roadmap for 5G, in which they have identified the 28 GHz frequency band as an essential band for satellite-based mobility services (ESIMs), exemplifies the importance of Ultra-High Throughput Satellites to serve the needs of end-users through services in the 28 GHz. The 28 GHz band (27.5-29.5 GHz) is part of the (17.7-21.2 and 27.5-31 GHz) which is allocated for fixed satellite services (FSS). The 28 GHz band for satellite communications has seen satellite operators' financial commitments, deployment decisions, and operational strategies, being cemented to deliver ubiquitous connectivity to end-users via satellite-enabled broadband.

Indeed, the 28 GHz spectrum enables Very High Throughput Satellites (VHTS) and Ultra-High Throughput Satellites (UHTS) capabilities for network connectivity that has a great potential for generating significant economic benefits to emerging markets by bridging the 5G broadband gap. This should be taken into account as countries make critical spectrum allocation and licensing decisions. VHTS and UHTS coming into operation are designed to support 5G deployment nationally and globally and in future to be part of the 6G architecture that India would benefit.

Any reduction in the 28 GHz spectrum allocated for providing satellite services will result in a higher cost of satellite capacity due to reduced economies of scale and the socio-economic benefits of satellite connectivity are significantly diminished. The Australian Communications and Media Authority (ACMA), an Australian government statutory authority within the communications portfolio, believed that a sufficient spectrum had already been identified in the 26 GHz band for wide-area broadband use (including 5G). Any additional allocation out of a portion of the spectrum in the 28 GHz band were not expected to maximise public benefit and thus were not considered to be an appropriate use of the band. There is currently no valid evidence that actual usage of the 26 GHz band for IMT services will not be sufficient to meet public interest needs.

In 3GPP's plenary meeting of 6-17 December 2021, various enhancements were agreed for NTN[24] work for Release 18. Specifically, an NTN-NR Work Item was approved with one objective being to look at NR-NTN deployment in above 10 GHz bands - this will start with a study using harmonized Ka-band frequencies[25] (17.7-20.2 and 27.5-30.0 GHz) as the reference, providing important recognition of satellite services that will be provided in the Ka-band.

24 Non-terrestrial networks (satellite, etc.).

25 3GPP TSG RAN Meeting #94e RP-213690.

The 28 GHz spectrum band is currently assigned to satellite services, providing connectivity to ESIM applications and users without, or with insufficient, access to terrestrial services, particularly high-speed broadband services. These users could be in urban and beyond urban areas, on ships or in the air, and without satellite services utilising 28 GHz the options for high-speed broadband are limited. Assessing the economic value of 28 GHz for 5G must take into account the loss of value associated with the removal of the arrangements for satellite services. This loss in value may have implications for national policy objectives as well as efforts to improve global trade.

Impact of Bifurcating Satellite Ka [28 GHz] Band

A 2018 study by the London School of Economics estimated that connected aircraft solutions could generate savings for the global airline industry of USD5.5-7.5 billion annually, rising to US$11.1-14.9 billion by 2035. Given the anticipated increase in demand from these use cases, the 28 GHz band will have a crucial role in meeting future satellite capacity needs including for airlines operated by Indian companies.

The 3.25 GHz spectrum available in n258 band is more than sufficient to accommodate a minimum of 400 MHz for all 4 operating MNOs while ensuring a competitive auction. The need for a minimum 400 MHz spectrum for each MNO is asserted by COAI[26] in its submission that is reflected in a report of last year only. There is no need to provide more than the 3.25 GHz available in 24.25-27.5 GHz at the expense of satellite services above 27.5 GHz.

Allocating access to 27.5 –28.5 GHz spectrum for 5G/IMT and hence making it unavailable to the satellite industry would significantly impact the existing and ongoing investments made on satellite systems and ground equipment, especially considering that the operating frequency ranges of Ka-band satellite systems cannot be changed. Subsequently, this will also reduce the benefits reaped by the end-users of satellite connectivity. 27.5-28.5 GHz is of paramount importance to modern satellite systems. Newer systems leverage on high bandwidth to revolutionise and enhance the quality of connectivity and the economics of novel applications, including backhauling of 5G networks in more remote areas. Multi-billion-dollar extensive investments have been and are being made to meet the growing demand for satellite connectivity to connect the unconnected.

The C-Band Conundrum

While the 5G/IMT industry often advocates for an immediate need of 80-100 MHz in the mid-band for operations, the UK communications regulator OFCOM, while researching the ability of mobile operators to launch 5G services found that[27] *"(...) there was no evidence that 5G could not be delivered with smaller [e.g. 40 MHz blocks] or non-contiguous carriers in other frequency bands [i.e. spectrum other than C-band]."*

26 Page 11, Para 23 Report on "India's Preparedness for 5G" presented by the Parliamentary "Standing Committee on Information Technology (2020-21)" to the Indian Parliament on 08 Feb. 2021

27 See, Ofcom, A7.39, Award of the 700 MHz and 3.6-3.8 GHz spectrum bands: Annexes (13 March 2020), available online at https://www.ofcom.org.uk/__data/assets pdf_file/0017/192410/annexes-award-700mhz-3.6-3.8ghz-spectrum.pdf.

How much Spectrum does an MNO Need

Ofcom used 3GPP document TR 22.891 as the primary source of information about potential future 5G services, which has 74 use cases. Ofcom selected a sample of the most demanding use cases listed to test technical feasibility, including 40 MHz of spectrum. A theoretical cell site throughput model[28] was developed to estimate network performance based on various assumptions on the type of antenna used, the bandwidth of the C-band carrier, and signal strength received by the user.

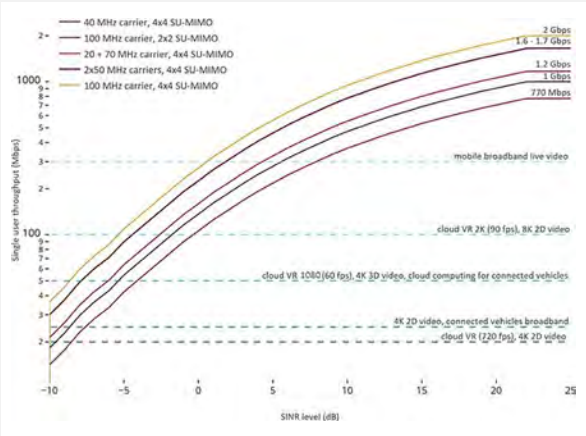


Figure 1. Downlink throughput across different signal levels in a cell compared to the minimum rate required for some 5G services[29]

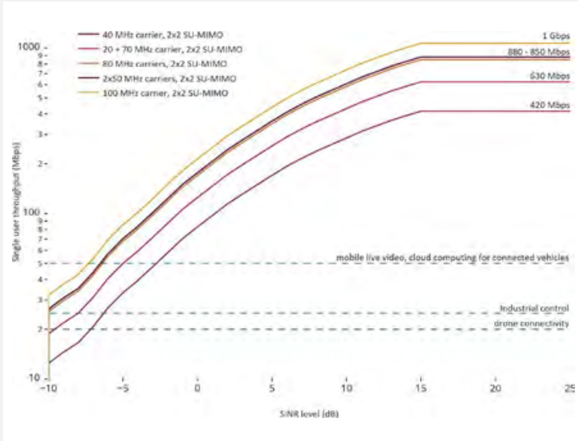


Figure 2. Uplink Throughput across different signal strengths in a cell compared with the minimum data rate requirements for some 5G services[30]

Figures 1 and 2, show that the results of Ofcom's studies clearly demonstrate that mobile operators will be able to provide all the main services provided by 5G with 40 MHz of spectrum.

UK Ofcom's analysis has demonstrated that an MNO will be able to deliver all the primary services anticipated under 5G – including, but not limited to, connected cars, virtual reality cloud broadband, and live 4K streaming – with 40 MHz of spectrum[31]. Indeed, there are ample examples of IMT operators in the world operating with an average of 40-80 MHz spectrum allocation.

Mobile operators may want an 80 to 100 MHz spectrum from the C-band for enhanced performance, but they don't need it to offer high quality to remain competitive. In other words, most benefits arising from the implementation of 5G services, both for the economy and for consumers, will be obtained through the deployment by each MNO of the first 40 MHz of the spectrum, with the deployment of any additional spectrum up to 100 MHz that they can acquire only bringing incremental benefits.

28 See 3.41 "Conclusions to further consultation on modelling and technical matters available online at https://www.ofcom.org.uk/__data/assets/pdf_file/0034/199717/statement-sut-modelling-700mhz-3.6-3.8ghz-spectrum.pdf

29 See, Ofcom, Figure A7.26, Award of the 700 MHz and 3.6-3.8 GHz spectrum bands: Annexes (13 March 2020), available online at https://www.ofcom.org.uk/__data/assets/pdf_file/0017/192410/annexes-award-700mhz-3.6-3.8ghz-spectrum.pdf.

30 See, Ofcom, Figure A7.27, Award of the 700 MHz and 3.6-3.8 GHz spectrum bands: Annexes (13 March 2020), available online at https://www.ofcom.org.uk/__data/assets/pdf_file/0017/192410/annexes-award-700mhz-3.6-3.8ghz-spectrum.pdf.

31 See, Ofcom, A7.39, Award of the 700 MHz and 3.6-3.8 GHz spectrum bands: Annexes (13 March 2020), available online at https://www.ofcom.org.uk/data/assets/pdf_file/0017/192410/annexes-award-700mhz-3.6-3.8ghz-spectrum.pdf.

This means that barring the specific locations or districts where ISRO is using the 25 MHz (3400 MHz - 3425 MHz) of spectrum for NavIC constellation maintenance, 300 MHz of spectrum in 3.3-3.6 GHz provides enough spectrum for India's mid-band 5G needs while ensuring a competitive auction. For example, India's three private MNOs with 90% of mobile subscribers could secure up to 80 MHz each (i.e. twice the minimum 40 MHz identified by Ofcom) while leaving the rest for the state-owned MNOs serving the remaining 10%. ISRO has requested for leaving 25 MHz (from 3400 MHz to 3425 MHz) untouched for NavIC constellation maintenance.

C-Band Spectrum Allocation Plan - NFAP 2018

It is pertinent to note that the National Frequency Allocation Plan 2018 (NFAP-2018[32]) limits the allocation of frequencies to IMT services within the upper limit of 3.6 GHz. DoT has sought TRAI's recommendation to allocate additional 70 MHz spectrum frequencies over and beyond the NFAP 2018 in the range of 3.6 - 3.67 GHz that has the potential to derail existing satellite services operating in the C-band (3.7-4.2 MHz).

The wide coverage of satellites in C-band enables services to be provided to sparsely populated and geographically remote areas and over large distances within India as well as between India and other countries and continents. Furthermore, due to its lower frequency compared to other alternative FSS frequency bands, in particular in regions characterized by high rain attenuation, C-band is the only realistic satellite band where FSS services can be provided with high availability.

C-Band Benefits for Satellite Communications

Due to its high resilience to rain fade and instant connectivity, C-band is heavily used for satellite communications in India as in the rest of the Asia Pacific Region using a large number of Indian and international satellites for a multitude of services including very small aperture terminal

32 National Frequency Allocation Plan 2018

(VSAT) networks (also used for disaster relief operation), internet services, backhaul for cellular networks, point-to-multipoint links, satellite news gathering, transfer of TV content between studios, TV broadcasting to satellite master antenna television (SMATV), direct-to-home (DTH) receivers and feeder links for mobile satellite services.

With C-band satellites located about every second degree along the geostationary arc, the C-band FSS frequency resources are heavily reused. It is also worth to note that most C-band satellites also are controlled through C-band signals (telemetry, tracking, command and ranging).

FSS satellites also are expected to become an integral part of the 5G infrastructure, offering several 5G applications, e.g. Internet of Things and Massive Machine Type Communications. Noting the effects of climate change with more and more intense rain in some regions and more extreme weather leading to more natural disasters, the importance of having satellite links that can combat such conditions is ever increasing.

The stakes for Indian society and the Indian economy in the smooth operation of C-band satellite distribution of broadcast signals are enormous. A huge investment has gone into the C-band satellites over the last twenty years by ISRO and foreign-owned satellites providing services for applications in India with the C-band operations also having a significant contribution to the national Indian economy including GDP, employment generation and the benefits of various services that are enabled by these C-band satellites.

Usage of C-band cannot be substituted and will impair the capability of satellite services operating in C-band, while creating risks of uncompetitive 5G auctions in the mid-band. The impact of the loss of C-band spectrum in the 3.6-3.67 GHz band will be felt across the entire Indian broadcasting industry.

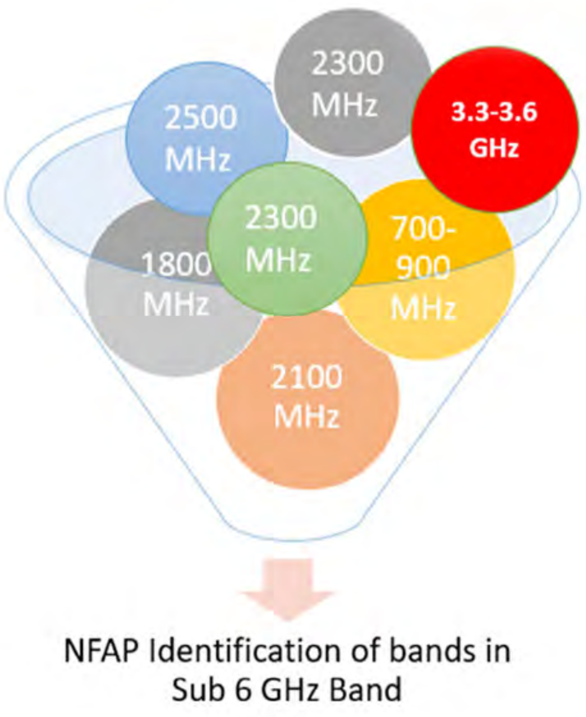
There are however ample examples of IMT operators in the world operating with an average of 40-80 MHz spectrum allocation, and with four operators in the country, an allocation of 300 MHz from 3300-3600 MHz is sufficient to allow 40 MHz for each operator and sufficient headroom for future requirements barring the specific locations or districts where ISRO is using the 25 MHz (3400 MHz - 3425 MHz) of spectrum for NavIC constellation maintenance. It should also be remembered that spectrum in the 2300 MHz and 2500 MHz can also be used to satisfy additional mid-band 5G requirements.

The Decision Success - Midbands

The report "India's preparedness for 5G" mentions the statement[33] of the Secretary, DoT, stated during evidence as "*The bandwidth of 3,300 MHz. to 3,600 MHz. is not yet used in the 2G, 3G and 4G. It is envisaged to be used for 5G, but that does not mean that 5G will not use other spectrum bands. So, 5G would also come in 700 MHz., 800 MHz., 900 MHz. bands in the time to come. 5G would also be coming in what are called the millimeter-wave bands, which are 24.25 GHz. to 27.5 GHz. Sir, that is also where the international ecosystem is coming up.*"

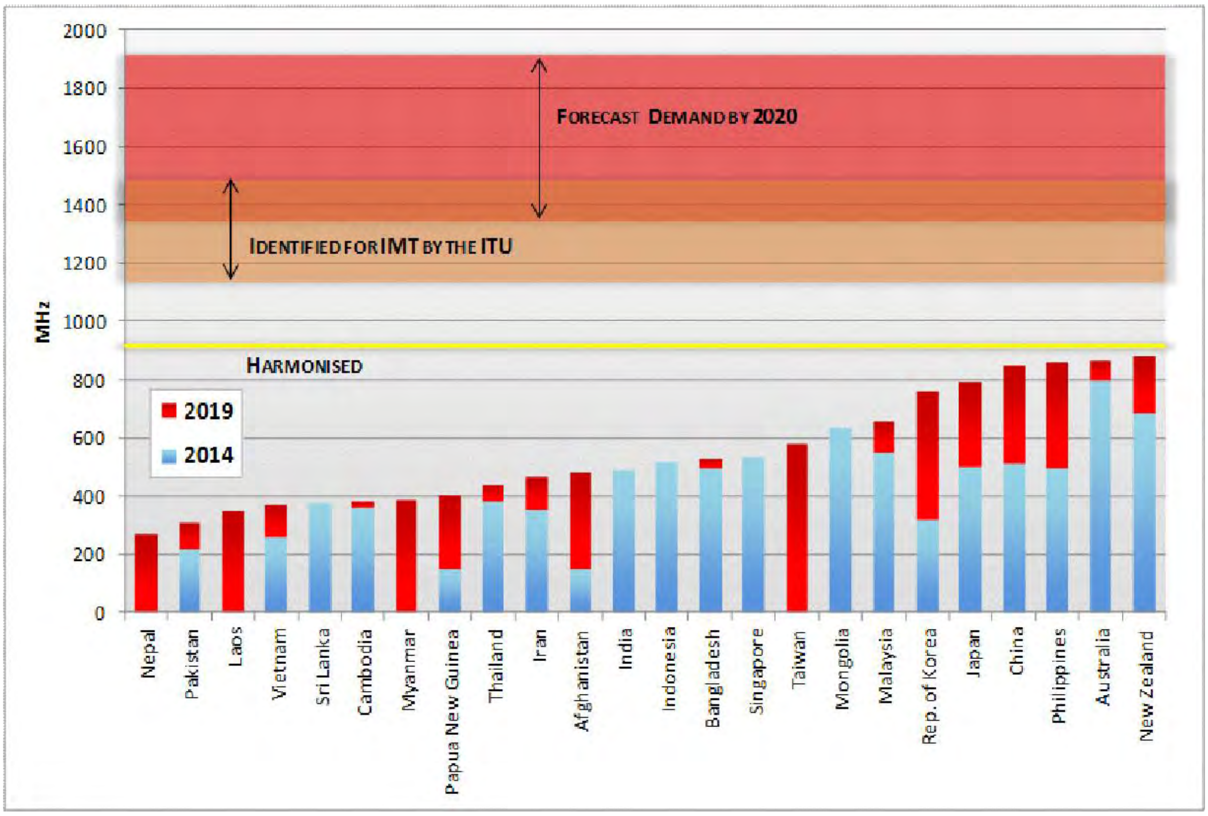
33 Page 10, Para 22 Report on "India's Preparedness for 5G" presented by the Parliamentary "Standing Committee on Information Technology (2020-21)" to the Indian Parliament on 08 Feb. 2021

Figure 15 : NAFP Identification of Bands in Sub 6 GHz Bands



The statement of the Secretary DOT to the Parliamentary "Standing Committee on Information Technology (2020-2021)" mentioning 3300-3600 MHz (and not 3300-3670 MHz) in mid-band and 24.25-27.25 GHz (and not 24.25-28.5 GHz) in mmWave band conveys the government's assertion to use these frequency bands for 5G/IMT services that also adheres to NFAP 2018 and ITU RR stipulations.

Figure 16 : Harmonized IMT Spectrum in Region 3.



Source: ITU

With four MNOs in the country, barring the specific locations or districts where ISRO is using the 25 MHz (3400 MHz - 3425 MHz) of spectrum for NavIC constellation maintenance, an allocation of 300 MHz from 3300-3600 MHz (as referred to time and again in the NFAP 2018, statement of Secretary DOT[34] and other forums) is sufficient to allow each operator to obtain at least 40 MHz while ensuring a competitive auction. It should also be remembered that mid-band spectrum in the 3.3-3.6 GHz range can be combined with frequencies in the 2300 and 2500 MHz band through spectrum aggregation, if additional mid-band spectrum is required for 5G.

Additional Spectrum Bands for 5G

This additional spectrum for 5G can be considered in bands already identified for IMT. A study conducted by LS Telcom[35] indicates that there are around 400 MHz of spectrum identified for IMT in Region 3 that have not yet been licensed and utilized in India. This ~400 MHz of spectrum, that have not yet been licensed and utilized for IMT, should be the primary candidate band without having to encroach upon spectrum being used for satellite communications. By utilizing the Dynamic Spectrum Sharing (DSS) and Carrier Aggregation (CA) features, the existing cellular frequency bands can also be re-farmed and optimised to bring 5G service traffic to subscribers of each MNO without the imminent need for wide contiguous blocks for 5G spectrum.

Table 2 : List of Harmonized IMT Spectrum in Region 3.

3GPP Band (MHz)		Uplink	Downlink (MHz)	Region 3
FDD Bands				
31	450 MHz	452.5 - 457.5	462.5 - 467.5	10
28	700 MHz	703 - 748	758 - 803	90
5	850 MHz	824 - 849	869 - 894	Up to 90
8	900 MHz	890 - 915	935 - 960	
3	1800 MHz	1710 - 1785	1805 - 1880	150
1	2100 MHz	1920 - 1980	2110 - 2170	120
7	2600 MHz	2500 - 2570	2620 - 2690	140
Sub-Total				**600**
TDD Bands				
75/76	1400 MHz	1427 - 1517		90
33	1900 MHz	1900 - 1920		20
34	2000 MHz	2010 - 2025		15
40	2300 MHz	2300 -2400		100
38	2600 MHz	2570 - 2620		50
Sub-Total				**275**
TOTAL				**875**

As an additional reference, the information in Table 1 shows the harmonized spectrum for terrestrial mobile services that is available in Region 3. A total of approximately 875 MHz could

34 Page 10, Para 22 Report on "India's Preparedness for 5G" presented by the Parliamentary "Standing Committee on Information Technology (2020-21)" to the Indian Parliament on 08 Feb. 2021

35 https://www.lstelcom.com/fileadmin/content/lst/marketing/media/2019_Study_LicensingUseofMobileSpectrum.pdf

be used for the private captive network deployments in India in a harmonized manner. The TRAI could review and identify which harmonized IMT spectrum has not yet been licensed and utilized in the country and then could make available that spectrum IMT/5G network deployments.

Ka-Band in Use by many Satellite Services

The frequency range 27.5-28.5 GHz is already used in many of the satellites that are either launched or in the build stage and will deploy to offer broadband services around the world, including to customers in India. International evidence suggests that demand for mmWave 5G is uncertain and can be met using the 3.25 GHz of spectrum in 24.25-27.5 GHz (n258 band). Whilst admitting both types of allocation (FSS/IMT) follow one type of public interest and its adequacy to each country's specific needs should be assessed, there is currently no valid evidence that actual usage of the 26 GHz band (24.25-27.5 GHz) for IMT services will not be sufficient to meet such public interest needs.

It would be prudent to deploy 5G in the 26 GHz band as with the majority of the countries to benefit from economies of scale and ensuring effective utilization of the 26 GHz. This secures a spectrum of 400 MHz allocation for each operator at the outset and a headroom to aggregate to 800 MHz in future that is in line with many other countries. SIA-India supports the continued prioritization of the FSS, including Earth Stations in Motion (ESIM), in the 27.5-31.0 GHz bands (Ka-band) so that existing and planned satellite systems in this frequency band can deploy and provide broadband services ubiquitously.

It is extremely important to carefully deal with a non-harmonized spectrum band like 28 GHz (27.5-29.5 GHz) for 5G, especially when it is already in use globally by other incumbents, as often such decisions would lead to complex problems and are irreversible due to on ground usage and future interference and logistical problems.

Considering the propagation characteristics of the 27.5-28.5 GHz frequency range for 5G/IMT, these frequencies would be best suited for 5G capacity enhancement in urban areas. However, satellite broadband systems use the 27.5-28.5 GHz for service coverage all across the country and around the world. With the high value of the 27.5-28.5 GHz band for satellite services, national allocation to 5G of the 27.5-28.5 GHz band is not the best way forward, as it would unnecessarily sterilize valuable spectrum in areas where 5G will never be deployed using these frequencies.

Additionally, the 27.5-28.5 GHz band is used by satellite systems to provide coverage to subscribers who live in unserved and underserved areas, where options for access to broadband solutions are lacking. Given a choice between using this band to provide more 5G in areas that already have 5G and using this band high-speed satellite services to connect all parts of the country that will help close the digital divide, India should choose the latter.

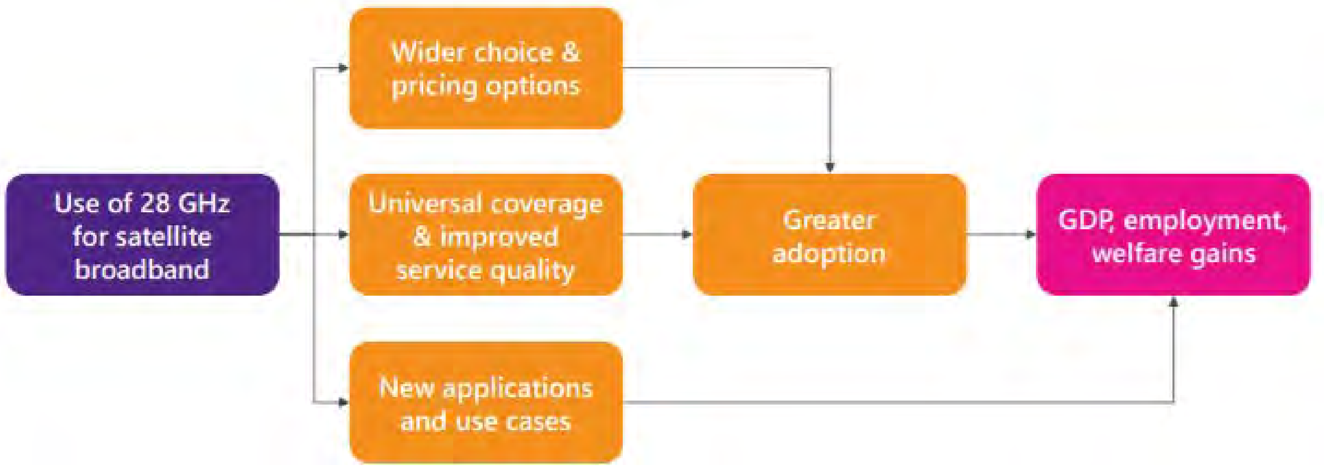
If the Government still decides that additional 27.5-28.5 GHz band will be used for 5G, stringent rollout obligations will be very important, especially given the substantial opportunity cost from the loss of satellite services in the band. Besides the efficient usage of spectrum for 5G rollout and effective use of spectrum to have a timely widespread deployment of 5G services that the authorities need to ensure, it is also essential that the Government of India reviews the feasibility of the MNO's business plans and monitors the implementation of such business plans regularly. This would include verifying the correct implementation of their systems with respect to compliance with the regulatory provisions set out to protect other services in the band and the adjacent band.

Additional spectrum, if any, should only be brought to auction when there is sufficient justification by the MNOs for the need and compliance to roll-out obligation of the initial spectrum that they may acquire through the current auction. At some stage, DOT or TRAI need to call an audit regarding the fair and sensitive treatment of incumbents versus increasing demands for spectrum from the protagonists of IMT/5G.

To minimise risks of the spectrum being hoarded, underutilised, or primarily traded, policy makers and regulators will benefit from first assessing the level of long-term demand, roll-out success, and spectrum efficiency of the use of licensed bands by 5G/IMT operators before committing any exclusive long-term use of spectrum.

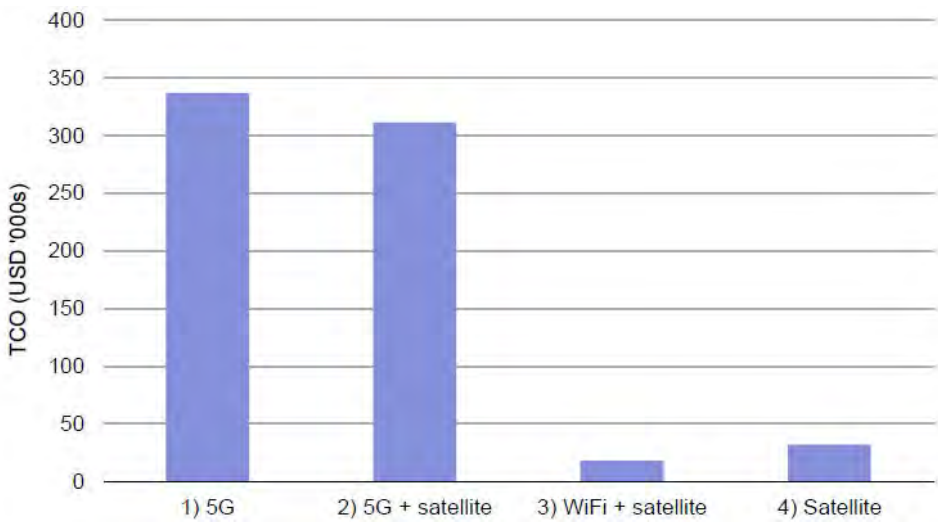
Satellite Technology in 28 GHz would be more cost effective mode to connect the unconnected

Figure 17 : Uses of 28 GHz Bands for Satellite Broadband



Infrastructure costs for India will be significantly lower if the full 28 GHz band is assigned to satellite-powered broadband while rapidly deploying connectivity using Ultra-High Throughput satellite broadband that can cover the entire territory. For example, the PM WANI initiative will be particularly well suited for expanding internet access rapidly and at lower cost. Recent infrastructure Total Cost of Ownership (TCO) studies confirm how satellite broadband is more cost effective when deployed as part of terrestrial broadband solutions and even more cost effective when combined with Wi-Fi. The following snapshot display a TCO comparison in one recent study:

Figure 18 : Satellite + Wi-Fi is Cheaper than Terrestrial 5G



The cost of satellite services is dependent on the amount of spectrum available. The model assumes that the satellite operator will have full access to the 28 GHz band. Any reduction of the amount of 28 GHz spectrum allocated for providing satellite services will result in a higher cost of satellite capacity due to reduced economies of scale, which in turn will diminish the economic benefits of using satellite in cases where other technologies are less cost effective.

The introduction of High Throughput Satellites (HTS) and increase in supply within this decade is expected to bring satellite capacity costs below USD 4 per Mbit/s per month by 2030, making satellite links more affordable over time and offsetting the cost of increasing data usage.[36] It is also anticipated that with the help of software techniques such as Network Function Virtualization, Software Defined Networking and network slicing, satellite network solutions will be able to support 5G features including multi-tenancy, re-configurability, automation, scaling, etc. Therefore, it will be easier to integrate satellite communications into end-to-end 5G system for improved service delivery and/or network operations.

SIA-India suggests that the spectrum allocation for 5G/IMT services in the mid-band is retained as per NFAP 2018 to be 3.3-3.6 GHz. In addition, adjacent band protection measures should be put in place, including a suitable guard band and out-of-band emission limits on 5G. The IMT industry demand in mmWave is fully met by available spectrum between 24.25-27.5 GHz (globally harmonized, COAI has sought min 400 MHz, GSMA position of 800 MHz). Unlike 28 GHz, assigning 26 GHz to 5G will cause no disruption to existing and emerging High-Throughput Satellite services including ESIM for which there are few, if any, alternatives. This will ensure availability of spectrum for the upcoming Consultations on Satellite Spectrum and Spacecom Policy. Moreover, the 5G operators should be mandated to ensure their emissions do not interfere with existing satellite services in the adjacent band.

36 APSCC (2020). *Are Very High-Throughput Satellite Systems New Game-Changers?*, Asia-Pacific Satellite Communication Council, December 2020. Available at https://apscc.or.kr/2020-3/#Future.

Reallocation and Interference – Crippling Satellite Investments and Innovation

International Take on Mitigation Measures

Article 4.4 of the Radio Regulations states that: "*Administrations of the Member States shall not assign to a station any frequency in derogation of either the Table of Frequency Allocations in this Chapter or the other provisions of these Regulations, except on the express condition that such a station, when using such a frequency assignment, shall not cause harmful interference*[37] *to, and shall not claim protection from harmful interference caused by, a station operating in accordance with the provisions of the Constitution, the Convention and these Regulations.*"

For purposes of clarity, Article 1.166 of the Radio Regulations defines interference as "*The effect of unwanted energy due to one or a combination of emissions, radiations, or inductions upon reception in a radio communication system, manifested by any performance degradation, misinterpretation, or loss of information which could be extracted in the absence of such unwanted energy.*"

In line with this, any new service has had to ensure the continued availability of existing services in the same or adjacent spectrum bands. The same principle needs to be applied while allocating spectrum for the new services of 5G being introduced to ensure that the 5G operations do not interfere, impact or hamper the existing operations of satellite services.

The report ITU-R BT.2337-1 on the study of Sharing and compatibility studies between digital terrestrial television broadcasting and terrestrial mobile broadband applications, including IMT, in the frequency band 470-694/698 MHz states that "*The results show that the excess of the cumulative interference from MS network over the single interferer can be up to 21 dB what causes a significant increase of required separation distance when using the same field strength threshold for cumulative interference as for single entry interference. This study shows that cumulative interference of signals from the MS base stations should be considered.*"[38]

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37 Article 1.166 of the Radio Regulations defines interference as "The effect of unwanted energy due to one or a combination of emissions, radiations, or inductions upon reception in a radio communication system, manifested by any performance degradation, misinterpretation, or loss of information which could be extracted in the absence of such unwanted energy."

38 See Results section 2.2.1.1.1.2.3 at https://www.itu.int/dms_pub/itu-r/opb/rep/R-REP-BT.2337-1-2018-PDF-E.pdf

Issues of Interference to other existing services (Satellite communication, broadcast, cable TV, Headend in the sky, cable broadband etc.) for co-existence and co-channel existence and mitigation measures required need to be seen in the light of cumulative interference of signals from the multitude of base stations and user devices that will need to be deployed for 5G network rollout in proposed bands.

Frequency Assignment Must be without creating Interference

The satellite industry is highly concerned to the possible identification of a particular spectrum in mid-band and mmWave band for IMT/5G, given that this band is currently in use at substantial investment by the Satellite sector to support a variety of applications, including video distribution businesses like Cable TV, Headend in the sky (HITS) and DTH, video broadcasting businesses, In-flight and Maritime Communications (IFMC), Disaster management, Tele-education, Tele-health, agriculture, animal husbandry etc. Each of these businesses, solutions, and application areas have invested and established under existing laws, rules, and regulations. These investments must be kept secure from disruption by any alternative or adjacent use of the spectrum bands.

In respect of interference from IMT/5G into FSS receivers, since this interference is one-way, i.e. from IMT/5G transmissions into FSS reception, individual TSPs would have no motivation or incentive to implement interference mitigation measures to protect FSS. SIA-India therefore is of the view that interference mitigation measures to be implemented by the IMT/5G operator need to be obligated in the licensing conditions for IMT/5G and cannot left for the TSPs to manage.

26 GHz and 28 GHz Band – Allocating Separate Lanes to each Service

It should be noted that the use of the 27.5-29.5 GHz band has not been identified as a key band for IMT, and there are therefore a limited number of sharing studies addressing the potential for co-channel coexistence between FSS and IMT in this band. The majority of studies address the 24.25-27.5 GHz band only. Two of such studies concluded the following:

> ***"In case a frequency band is used for ubiquitous deployment of small FSS earth stations (ESIM), sharing between IMT and the FSS is not practicable."***
>
> ***"For the case of ubiquitous deployment of small FSS earth stations, sharing between IMT [5G] and the FSS is not practicable within the same geographical areas, particularly as it is not feasible to individually coordinate large numbers of ubiquitous earth stations, nor is it even possible to determine a coordination contour around ubiquitous earth stations."***

Also, emerging FSS requirements and new demands requiring additional FSS deployment areas make using both IMT and FSS in the same band not feasible in practice. In essence, co-channel use of FSS, FSS ESIM and IMT pose regulatory challenges of managing interference risks due to incompatibility, particularly in ubiquitous applications. This indicates that deploying these different services in separate bands would better mitigate interference risks while reducing inefficient spectrum use due to geographical exclusion zones.

In the year 2018, the Government announced the Flight & Maritime Connectivity rules based on recommendations put forth by the TRAI. These rules designate the frequency band from 27.5-28.5 GHz for use by these services. Service providers have made investments to launch Flight & Maritime Connectivity services using the 27.5-28.5 GHz band, and a sudden change in the regulations will severely impact investor confidence and set a wrong precedent for the development of broadband technologies in India.

Co-Channelling uses of HTS Services and IMT in 28 GHz is Infeasible

4G/5G services need backhaul services to reach the remote areas of the country. These backhaul services are provided by satellites very effectively. The TRAI recognized this need and further recommended allowing VSAT operators to provide backhaul services via satellite.[39] However, without access to the frequency band from 27.5-28.5 GHz, the satellite capacity available to provide these backhaul services will be severely reduced.

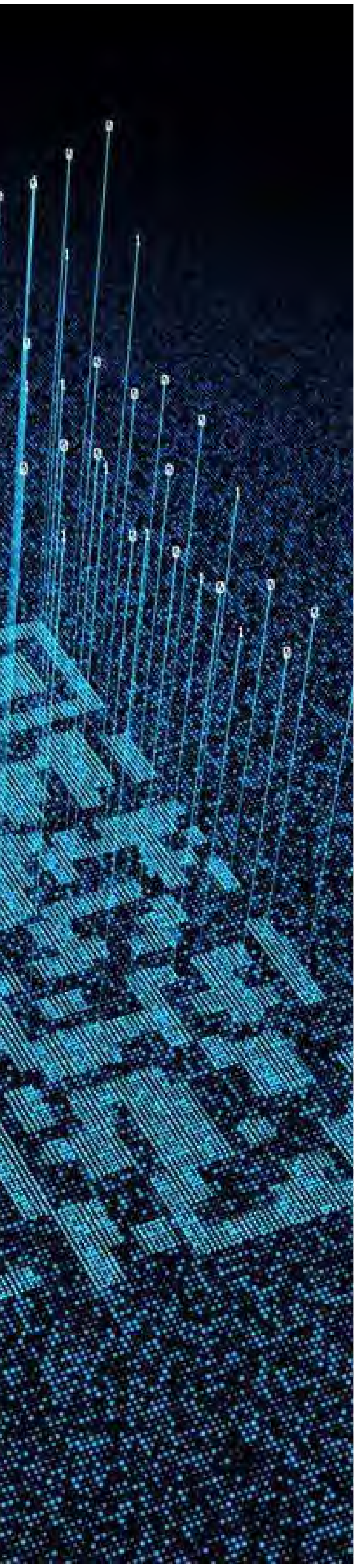
If IMT services are deployed in the 28 GHz band, in that case, potential interference between satellite earth stations and IMT receivers (base stations and terminals) is likely to occur, HTS services are expected to be deployed ubiquitously and on the move through earth stations in motion (ESIM), and in such a situation co-channel uses of HTS services and IMT in 28 GHz is not feasible. In cases of ubiquitous services provided by FSS ESIM and IMT, the services cannot coexist if operating co-channel.

In terms of in-band interference, IMT/5G systems are not being designed to be compatible with the existing and widespread satellite use of the same spectrum. As technical studies by both the terrestrial IMT/5G and the satellite industries have shown, introducing terrestrial IMT/5G services in the same bands as satellite services could constrain the continued evolution of satellite services, in violation of the principles of Resolution 238[40]. Notably, these studies may understate the incompatibility of terrestrial IMT/5G with satellite use of the 28 GHz band, because in its separate 3GPP standards process, the terrestrial IMT/5G industry is defining terrestrial IMT/5G technologies that operate at very different parameters (such as power levels and antenna pointing) than those they otherwise have identified as relevant to the ITU studies[41]

39 *See,* Recommendations on 'Provision of Cellular Backhaul Connectivity via Satellite Through VSAT Under Commercial VSAT CUG Service Authorization', 28th July 2020, available at https://trai.gov.in/sites/default/files/Recommendations_28072020_0.pdf.

40 *See* ITU-R, Resolution 238 (WRC-15).

41 *See* e.g., 3GPP TS 38.104 V15.2.0 (2018-06).



Separate and apart from incompatibility issues is the risk of aggregate IMT/5G interference from any terrestrial transmissions in the 28 GHz band into satellite receivers in space (which are designed to receive 28 GHz uplink signals from satellite user terminals and gateways). This issue has not been studied at the ITU in the context of today's broadband satellites, because, again, the ITU did not even consider designating the 28 GHz band for terrestrial IMT/5G services.

SIA-India members have supported the study and the development of reasonable operating parameters for terrestrial IMT/5G in the 26 GHz band through the ITU WRC-19 process. To this end, the policy decisions need to conform domestic deployment of terrestrial IMT/5G in the 26 GHz band to the operating parameters decided in Resolution 242 (WRC-19) as well as additional out-of-band domain and spurious domain emission limits described below. SIA emphasizes the importance of the portion of Resolution 242 (WRC-19) that requires IMT/5G base stations within the 26 GHz band with higher power operations (e.i.r.p per beam exceeding 30 dBW/200 MHz) to not point their antenna beams upward at the geostationary satellite orbit and maintain a minimum separation angle of ≥± 7.5 degrees.

Since the aggregated interference will be generated by a large number of IMT/5G transmitters associated with a large number of IMT/5G operators, possibly located in several countries, it will be impossible to identify individual IMT/5G transmitters or operators as being responsible for the interference. For this reason, in identifying the 24.25-27.5 GHz band for IMT/5G, WRC-19 in Resolution 242 include power limits to be observed by individual IMT/5G transmitters with the aim of controlling the aggregated interference.

Out-of-Band Emission Limits must be Specified

In terms of out-of-band interference, satellite operators, use the 28 GHz band and are concerned about potential out-of-band emissions from 26 GHz band IMT/5G systems into the 28 GHz band. Any departure from the spectrum use described in Resolution 242 (WRC-19) would increase out-of-band emissions in the 28 GHz band. The potential impact of increased out-of-band emissions from the 26 GHz band could adversely affect the interference environment in the 28 GHz band by impacting the ability of satellites receiving signals from earth stations. Therefore, the SIA-India respectfully requests that Telecommunication Engineering Centre (TEC) or such similar standards body specify appropriate out-of-band limitations on terrestrial IMT/5G operations using the 26 GHz band to protect satellite services in the 28 GHz band.

At a minimum, terrestrial IMT/5G stations should be required to comply with out-of-band domain and spurious domain emission limits in the frequencies above 27.5 GHz as described in Recommendations ITU-R SM. 1541-6 and ITU-R SM. 239. In the case of ITU-R SM.329, the category B limits should apply. SIA also requests that the TRAI ensures that the aggregate level of terrestrial out-of-band emissions from the 26 GHz band into the adjacent 28 GHz band does not cause interference to satellite receivers in the 28 GHz band.

To mitigate interference into IMT/5G receivers encountered when in the vicinity of transmitting earth stations, which are assumed to be individually licensed, at known locations and with known characteristics, a minimum earth station antenna sizes, e.g. 3.5 m, and minimum earth station elevation angle, e.g. 20° could be considered imposed for new earth stations.

Without clear guidelines on the interference management between IMT/5G and FSS, TSPs could cause interference to receiving satellites with little options to rectify it after the deployment and TSPs could also have false expectations in respect of deployment of new FSS earth stations.

Global Scenario on Ka-Band Allocation

The 27.5-28.5 GHz band is a part of the 27.5-31 GHz globally allocated FSS band. Several satellites also in the Asia-Pacific region, already use, amongst others, the 27.5-28.35 GHz band. Globally, there is a trend to develop and deploy "High Throughput Satellites" (HTS) offering wideband connections to end users through large numbers of small spot beams with extensive frequency re-use. This includes applications addressing maritime, aeronautical and land mobile user terminals ["ESIMs" (Earth Station in Motion)]. In Europe, the European Communications Commission (ECC) has assigned the 27.5-31 GHz band for satellite uplinks, but not 5G. Furthermore, it is notable given the importance of the band for FSS worldwide, that WRC-15 in identifying frequency bands to be studied as potential candidate bands for IMT/5G decided NOT to consider the 27.5-31 GHz band as a candidate band for IMT/5G under WRC-19 Agenda Item 1.13.

On the contrary, WRC-15 created WRC-19 Agenda Item 1.5 to study use of ESIMs operating in the 27.5-29.5 GHz uplink band (and the 17.7-19.7 GHz downlink band) to further expand the FSS applications for this band and WRC-19 consequently adopted Resolution 169 to facilitate and regulate such use of FSS satellites. FSS satellites operating in this band, both geostationary and non-geostationary will also be used to provide 5G applications to end users and are thus instrumental also in respect of the development and deployment of 5G. Also, in Europe, the European Communications Commission (ECC) has assigned the 27.5-31 GHz band for satellite uplinks, but NOT IMT/5G.

While the user terminals accessing Ka-band HTS satellites normally will transmit at frequencies above 28.5 GHz, the gateways normally will transmit within these bands, in particular starting from 27.5 GHz, but in this Region, also in the 27-27.5 GHz band. As more and more HTS satellites are deployed, one therefore will see increasing activity in these bands.

There currently is great interest in non-geostationary satellite constellations with large numbers of satellites being built and launched. Practically all of these satellites systems operate in Ka-band. In the band 28.6-29.5 GHz, unlike in most other frequency bands, the Radio Regulations prescribe a coordination process between geostationary and non-geostationary FSS systems. Due to the large number of non-geostationary FSS satellites currently being launched, geostationary FSS networks increasingly are eyeing use of gateway uplink bands below 28.6 GHz, i.e. 27.5-28.6 GHz and 27-27.5 GHz.

The 28.6-29.5 GHz band is the band where non-geostationary FSS systems do not operate on a non-interference, non-protected basis in respect of geostationary FSS networks. For this reason, these are the bands where large numbers of transmitting earth stations for user terminals of non-geostationary satellites are expected to operate, operating under a class license, without individual licensing of each earth station and without knowledge about the number, location or characteristics of individual earth stations.

Overzealous Allocation in Mid-Band Cripples C-Band Satellite Services

Conventionally, any new service has had to ensure the continued availability of existing services in the same or adjacent bands. The same principle needs to be applicable while allocating spectrum for the new services of 5G being introduced to ensure that the 5G operations do not interfere, impact or hamper the existing operations of satellite services in the C-band.

SIA-India also notes the concerns currently raised by the aviation authorities in respect of the impact of IMT/5G C-band deployment on performance of aviation altitude radars and air traffic safety. Policy makers may want to ensure that no IMT/5G deployment could put air traffic safety at risk.

It is even more critical for satellites with C-band TT&C links that are controlled from Indian Territory where careful consideration of interference is required to ensure the safe control and operation of the satellites.

As per DoT reference to TRAI, the band 3600–3670 MHz has been reallocated and identified for IMT/5G services in India. This leaves only 30 MHz of frequency separation between IMT/5G services and C-band satellite receivers that operate in 3700-4200 MHz spectrum. This decision could cause detrimental effects on the Indian economy as a whole if these valuable C-band satellite services provided in India are not well protected as IMT/5G deployment proceeds in the country.

Preserving the entire 3.6-3.7 GHz for FSS will also ensure that the bulk of satellite services in the C-band (3.7-4.2 GHz) can be maintained without the prospect of interference from 5G transmissions in the adjacent band, using a combination of a suitable guard band, power limits on 5G emitters, and the installation of filters. The disadvantage of stretching the 5G/IMT spectrum beyond 3600 MHz however, has the impact of critically impairing the C-band operations of the satellite industry being used to provide tele-education, tele-health and to support India's vibrant broadcasting industry.

Protection of existing C-Band Operations from Interference is Critical

With FSS earth stations being susceptible to interference from IMT networks, it is a matter of concern for the industry to ensure the protection of C-band operations and the impact of adjacent band compatibility between FSS and IMT. Multiple international studies, including ITU-R Report S. 2368[42] and deployment experiences worldwide, have proved the interference from 5G Services to adjacent band Satellite services wherever co-existence is attempted. Mitigation measures like band pass filters are NOT a standalone solution and are effective only when applied with a suitable guard band and emission limits on the high levels of 5G transmissions compared to the earth station receive signals.

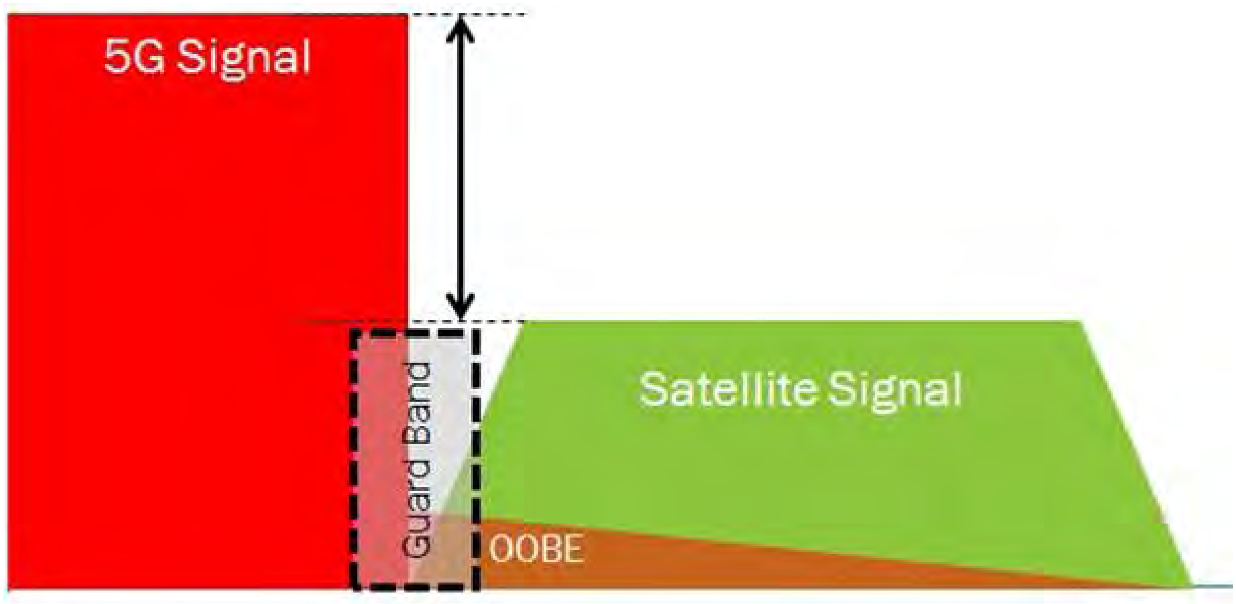
Should India decide to open up for IMT/5G beyond 3600 MHz band, leaving less than 100 MHz as guard band for satellite services in 3700-4200 MHz to operate, this would put extreme requirements on both limitations on unwanted emissions of IMT/5G transmitters and on characteristics of front-end filters for FSS receivers. In view of wider guard bands decided by other administrations, careful consideration of a realistic and reasonable guard band to allow operation with regular commercially available equipment is required. This not only impacts FSS operation but also places the requirement of stricter unwanted emission control on IMT/5G operators that are tighter than that of regular IMT/5G specifications.

Mutual interference is probable if NR (IMT) and FSS operate at the same or adjacent frequency. Hence, careful consideration should be given to adjacent band compatibility issues as indicated in Figure 17, where interference to satellite receive earth stations could happen. There are three types of possible interference into FSS caused by co-existence with NR (IMT):

42 https://www.itu.int/dms_pub/itu-r/opb/rep/R-REP-S.2368-2015-PDF-E.pdf

1. Interference from In-band NR emission
    a. Due to the long distance to the satellite and the power limitations of the satellite, the incoming FSS signal's power flux density at the earth station location is very low
    b. IMT equipment which is much closer to the earth station, can produce significantly higher power levels at the input to the FSS receiver than the desired satellite signal
2. Interference from Adjacent Band NR emission
    a. Due to the very low power level of the incoming FSS signals, unwanted emissions generated by IMT system operating in an adjacent frequency band can create interference to FSS
3. LNA / LNB Overdrive
    a. Earth station LNAs and LNBs are optimized for the reception of very low power level of the incoming satellite signal and hence should have a very high sensitivity
    b. Incoming BS NR signals at much higher power levels can severely affect the operating point of the LNA/LNB and drive it out of its dynamic range to where it exhibits a non-linear behaviour
    c. This results in the creation of intermodulation products and gains compression (within the device) that in turn result in distortion of FSS signal

Figure 19 : Representation of Adjacent Band Interference from IMT to FSS



One of the solutions is to lower the magnitude of the interfering IMT signal received that can be achieved by adding a filtering function before the LNB. The band pass filter (BPF), however, could only be adequately operated if there is frequency separation (i.e. Guard band) between the edge of the IMT/5G transmission and the FSS transmission to provide the waveguide filter with the necessary bandwidth to reject the 5G interference at the earth station.

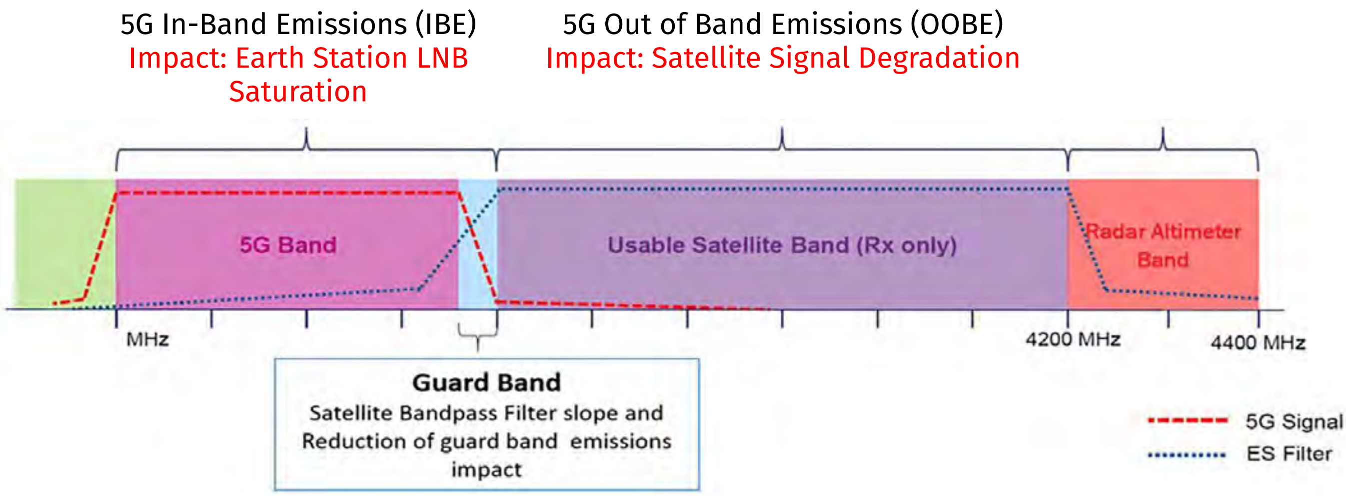
The implementation of such filters on the FSS earth station receivers, however raises specific concerns: if the guard band is smaller than 100 MHz, some tailor-made band pass filter is required, or unique technology have to be used in the filter and this will drive up the cost of the filter. In addition to the roll-off of the filter characteristics, there are other parameters that have to be carefully examined and noted, including rejection ratio in the 5G band, insertion loss in satellite receiving band. Moreover, there are also concerns on the wind loading and deformation of the receiving pattern due to the weight and size of the filter.

- Cost of filter and implementation rollout as this has to be implemented in tens of thousands of earth stations installed and planned.
- If the guard band is smaller than 100 MHz, some tailor-made bandpass filter is required, or unique technology has to be used in the filter which will drive up the cost of the filter.
- Special enhanced filters for a response with rapid attenuation increase within lower guard bands will imply elevated insertion losses that may generate the need to change the antenna to maintain the original G/T (and station operation) and avoid service interruption.
- There are also concerns about the wind loading and deformation of the receiving pattern due to the weight and size of the filter.
- The insertion of a BPF also impacts the receiver performances concerning filter insertion loss, an increase of the system noise temperature, phase and group delay).
- According to calculations made by satellite operators, it is observed that for systems employing adaptive coding and modulation, the introduction of the enhanced filter will reduce the throughput by over 30% in some cases.

Regulation on specific IMT/5G unwanted emissions limits versus frequency separation is critical in this context to limit the impact of these unwanted emissions on adjacent band operating services. The use of BPF is an additive measure that can only perform with adequate frequency separation using a guard band and not a standalone solution by itself.

It will be essential to establish adjacent band protection criteria for FSS earth stations vis a vis 5G/IMT, e.g. a guard band in the IMT portion of the band and an out-of-band PFD limit for IMT transmitters to protect FSS earth stations in the adjacent band.

Figure 20 : FSS and 5G in Adjacent Frequency Bands



International Best Practices

The issue on incompatibility in C-band downlink between FSS and various broadband terrestrial applications to individual users is not new. Extensive studies have been carried out in ITU and APT and there is also significant practical experience gained from deployment in Asia-Pacific and other parts of the world. All the studies and the practical experience lead to the same conclusion; that co-existence between FSS and IMT/5G in overlapping or adjacent frequency bands in the same geographical area is not feasible without adequate mitigation measures. It is also worth noting that prior to IMT/5G, there were broadband wireless access (BWA) networks, often referred to as WiMax, deployed in several countries in the 3400-3600 MHz band. For non-technical reasons, these networks were not successful. However, in the countries where WiMax was tried introduced, massive disruptions to FSS reception in the entire 3400-4200 MHz band was encountered, confirming the APT and ITU studies and reports.

Depending on the type of IMT deployment considered, studies have shown that separation distances required to offer adequate protection of FSS receivers in respect of co-frequency interference are in the range of tens of kilometers for IMT small-cell indoor deployment to several hundreds of kilometers for IMT macro-cell outdoor deployment.

Indian Scenario for C-Band FSS

As mentioned in the introductory paragraphs, C-band FSS is used for a multitude of applications throughout the entire India, including very small aperture terminal (VSAT) networks (also used for disaster relief operation), internet services, backhaul for cellular networks, point-to-multipoint links, satellite news gathering, transfer of TV content between studios, TV broadcasting to satellite master antenna television (SMATV), direct-to-home (DTH) receivers and feeder links for mobile satellite services. FSS satellites also are expected to become an integral part of the 5G infrastructure, offering several 5G applications, e.g. Internet of Things and Massive Machine Type Communications.

Receiving antennas for these applications are currently deployed in large numbers in every corner of India. Many of the receiving earth stations of several of these applications are not individually licensed and their numbers, locations or characteristics are not known. Other earth stations like SNG stations or disaster relief earth stations will be nomadic in nature and there location will change according to demand. Ensuring compatibility with FSS receiving earth stations receiving in the same frequency band requires that transmitters of private captive networks observe a minimum separation distance to all receiving FSS earth stations. However, since the number, location and characteristics of most receiving FSS earth stations are not known, no such separation distance can be guaranteed.

Mitigation Measures to Lower the Interference Magnitude

In effect, several of the measures below need to be adopted in unison for the adjacent band operation of IMT/5G and FSS services.

Table 3 : List of Mitigation Techniques

Mitigation techniques	Comments
Frequency separation	→ Band in which is not used by FSS or 4G LTE/5G-NR to minimise interference to FSS earth stations in the adjacent band → The frequency separation will alleviate the requirement on the transition region of the receiving FSS earth station filter.
Exclusion zone	→ Radial separation distance from location of FSS earth station within which no IMT station shall be allowed in order to adequately protect FSS earth stations, particularly TT&C stations
Coordination zone	→ Area within which coordination between FSS earth station, including TT&C stations, and 4G LTE/5G-NR is necessary to ensure co-existence. → The perimeter of the coordination zone is outside the exclusion zone, but coordination zone does not include the exclusion zone.
Block-edge mask	→ Compliance with emission limits will ensure protection of FSS earth stations in the adjacent band
Improving FSS earth station receiver performance	→ FSS earth station receiver performance can be improved with use of band pass filter.
Antenna tilt	→ Vertical down tilting of base station antenna reduces interference to radar systems and FSS → Interference reduction may be as high as 10 to 15 dB depending on the vertical antenna pattern

Mitigation techniques	Comments
Lower antenna height	→ Lower antenna heights at the base stations improve sharing, especially when surrounded by obstacles such as tall buildings → It may not be possible to lower the macro cell below a certain height, otherwise cell coverage maybe degraded
Antenna location, shielding, optimization of antenna directivity loss	→ Considering the geographic conditions, IMT-Advanced base station antennas may be located in areas where natural or man-made shielding minimizes interference from/to the radar and FSS antennas → This method is not effective if line of sight condition is configured between IMT-Advanced system and operating position of mobile radars or FSS, and if radar and FSS antenna directivity loss is insufficient. Therefore, this method should be applied together with other mitigation methods
Sector Disabling	→ The aim of this technique is to reduce, in the direction of the victim system, the transmitting output power of base stations that are located at a distance smaller than the separation distance, noting that such an area would be covered through the use of other frequency bands by IMT-Advanced systems
Antenna dynamic null steering	→ A null is steered toward the radar and FSS antenna direction to reduce the interference by adopting dynamic beam forming antenna such as dynamic adaptive array antenna → The level of interference mitigation is a function of the number of antenna elements and the propagation effects
Transmit power control	→ Interference to radars and FSS could be reduced by setting the transmission power of IMT-Advanced stations to the minimum required level especially when radar signal is detected
Forward error-correction and interleaving	→ Forward error correction coding and bit interleaving is effective in reducing the susceptibility of the IMT-Advanced receiver to interference from the radar
Improved Filter Characteristics	→ The out-of-band (OOB) and spurious emission characteristics of IMT base-station transmitters are based on the most stringent mask specified in the 3GPP technical specification series 36 (TS 36). Moreover, it is expected that commercial IMT products shall typically offer significantly better performance than 3GPP requirements

SIA-India suggests that it will be essential to establish adjacent band protection criteria for FSS earth stations vis a vis 5G/IMT (*e.g.*, a guard band in the IMT portion of the band) and an out-of-band PFD limit for IMT transmitters to protect FSS earth stations in the adjacent band.

The IMT industry has introduced very stringent limits for out-of-band and spurious emissions into other IMT services, especially those into pre-5G IMT services and co-located services. It should be required to adopt more stringent limits for such emissions into non-IMT services, where the received signal levels of those interfered non-IMT services are millions to billions of times weaker than the IMT levels. It is important that any such interference mitigation measures become an integral part of the licensing conditions for IMT/5G since the TSPs later would have no incentive or motivation to implement such measures.

In addition, SIA-India believes India also needs to protect other existing C-band primary services (e.g. FSS) in its neighbouring countries such as Bhutan, Nepal, Bangladesh, Pakistan, Sri Lanka, China, and Myanmar from harmful interference due to 5G deployment in India.

It is important for the Government to establish technical frameworks to protect C-band FSS operations from harmful interference due to 5G deployments, such as an adequate guard band between FSS and IMT/5G as well as clear unwanted emission limits for IMT/5G. It is important to have clear rules and milestones associated to the process of reporting a harmful interference situation and facilitating the start of service of new earth station installations.

This will avoid lengthy coordination and interference resolution processes that may harm the existing ecosystem of C-band solutions and could negatively impact the development of new satellite services in this frequency band. This approach can be seen in some Asia Pacific countries that have successfully deployed 5G services while protecting C-band FSS operations in the adjacent band.

There is also a need to ensuring funding to compensate the costs associated with the necessary measures to counteract any degradation in the reception of the signal (installation of filters, the replacement of antennas and the associated logistics etc.), to ensure that the quality of the transmissions that are currently being made will be maintained without imposing additional costs to satellite or earth station operators.

ITU Positions on Satellite and IMT Spectrum Issues

The need for spectrum harmonization is undisputed. This complex task has been administered globally for many years through the ITU's Radio communication Bureau, managing and updating the Radio Regulations international treaty providing binding guidelines on radio frequency spectrum allocation in different services and regions. We need a better way of harmonizing national regulations with ITU guidelines and international trends, otherwise we will end up with less spectrum, not more.

The ITU's Radio Regulations (RR), in accordance with No.31 of ITU's Constitution, is a binding international treaty document. It identifies 41 Radio Services to which the spectrum - 8.3 kHz to 275 GHz - is allocated. India uses most of these radio services for terrestrial, maritime, aeronautical and space applications. Publications, including recommendations by the ITU, focus on optimizing and providing guidelines for spectrum use by its 193 member administrations of the ITU. For example, the ITU adopted Recommendation ITU-R S. 2223 on "Technical and operational requirements for GSO FSS earth stations on mobile platforms in bands from 17.3-30 GHz" in 2011 and then updated it in 2016[43].

The RR is a binding treaty document ratified by India. India is one of the major (top 14) contributors to the ITU budget, paying 10 contributory units to the ITU each year. It is therefore in India's interest to act in coherence with its ITU work, positions and resources that have been invested globally by harmonizing spectrum use domestically with its participation at the ITU. Remaining consistent with the globally agreed RR provisions is also appropriate in the Indian National Frequency Allocation Plan (NFAP) ensuring the conditions for the use of spectrum by national stakeholders is aligned with the Radio Regulations. This is the primary method to guarantee certainty for investment and ICT development in India, including for global satellite services.

GENERAL TIMELINE FOR IDENTIFICATION OF IMT SPECTRUM (Source: GSMA Study on Socio-Economic Benefits of 5G Services provided in mmWave Bands)

43 See ITU-R Recommendation S.2223, Technical and operational requirements for GSO FSS earth stations on mobile platforms in bands from 17.3-30 GHz (2011, revised 2016), https://www.itu.int/pub/R-REP-S.2223.

mmWave Band

WRC-19 during its lengthy deliberations adopted identification of the 24.25-27.5 GHz band for 5G/IMT. The conference did NOT include the 27.5-28.5 GHz band as part of the 5G/IMT identification, as stated in the TRAI Consultation Paper[44]. It is also important to note the current ITU Radio Regulations (ITU RR) allocations in the 27.5-29.5 GHz band. The primary allocations are for the fixed, mobile and fixed satellite services. There is also a secondary allocation in the upper half of the band to Earth exploration-satellite service (EESS). Use of spectrum for 5G/IMT in the 27.5-28.5 GHz band would be inconsistent with the RRs which are internationally binding treaty obligations.

Table 4 : Service Allocations in Ka-Band Frequencies by ITU

Frequency range (GHz)	Service allocations
27.5-28.5	FIXED 5.537A FIXED-SATELLITE (Earth-to-space) 5.484A 5.516B 5.517A 5.539 MOBILE 5.538 5.540
28.5-29.1	FIXED FIXED-SATELLITE (Earth-to-space) 5.484A 5.516B 5.517A 5.523A 5.539 MOBILE Earth exploration-satellite (Earth-to-space) 5.541 5.540
29.1-29.5	FIXED FIXED-SATELLITE (Earth-to-space) 5.516B 5.517A 5.523C 5.523E 5.535A 5.539 5.541A MOBILE Earth exploration-satellite (Earth-to-space) 5.541 5.540

Primary service is indicated in caps; secondary service in lower case. The numbers refer to footnotes in the Radio Regulations.

The vast majority of Asia-Pacific is harmonising satellite broadband solutions with global markets for the purpose of securing ubiquitous fast-broadband across land, sea, and air, particularly in the full 28 GHz band. This is because the 28 GHz band is being implemented not just for residential, business and government-critical satellite broadband services across urban areas and beyond, but also this is the key band identified by the International Telecommunication Union (ITU) for use by earth stations in motion (ESIM).

On the other hand GSMA notes in its report that "In the ITU process, the 26 GHz band (24.25-27.5 GHz) and the 40 GHz band (37-43.5 GHz) have received more attention and the greatest support for IMT identification." Therefore, it follows that the similar 26 GHz (n258) band would have a higher value for 5G services than 28 GHz.

In 3GPP's plenary meeting of 6-17 December 2021, various enhancements were agreed for NTN work for Release 18. Specifically, an NTN-NR Work Item was approved with one objective being to look at NR-NTN deployment in above 10 GHz bands - this will start with a study using harmonized Ka-band frequencies (17.7-20.2 and 27.5-30.0 GHz) as the reference, providing important recognition of satellite services that will be provided in the Ka-band.

44 TRAI Consultation Paper, paragraphs 1.42 and 3.41.

The market for advanced broadband connectivity in the aviation, maritime and land transport (*e.g.*, trains, buses, public safety vehicles) sectors has been the key driver for the ITU Members States in ensuring sufficient spectrum is available for ESIM on a global basis.

A large number of countries have secured 28 GHz band for satellite services and just a few ones have made use of part of the 28 GHz band for terrestrial 5G services outside of the ITU and WRC-19 process.

Furthermore, under WRC-23 Agenda Item 1.16, ITU is currently studying ESIMs (Earth Stations In Motion – for aeronautical, maritime and land mobile operation) operating with non-geostationary FSS satellites in the 27.5-29.1 GHz band. With such ubiquitous deployment of transmitting FSS earth station antennas, it would seem difficult to employ efficient interference mitigation techniques to avoid interference into IMT/5G. For IMT/5G operation in the frequency bands not overlapping with FSS, there will be no compatibility issues and no need for special measures in respect of IMT or FSS.

The 27-27.5 GHz band is allocated to FSS in ITU-R Regions 2 and 3. This helps in the co-existence of communications links across NGSO and GSO satellites and provide essential enabling sufficient uplink gateway bandwidth for GSO and NGSO HTS networks. This is important to avoid NGSO gateways blocking access to GSO communication links.

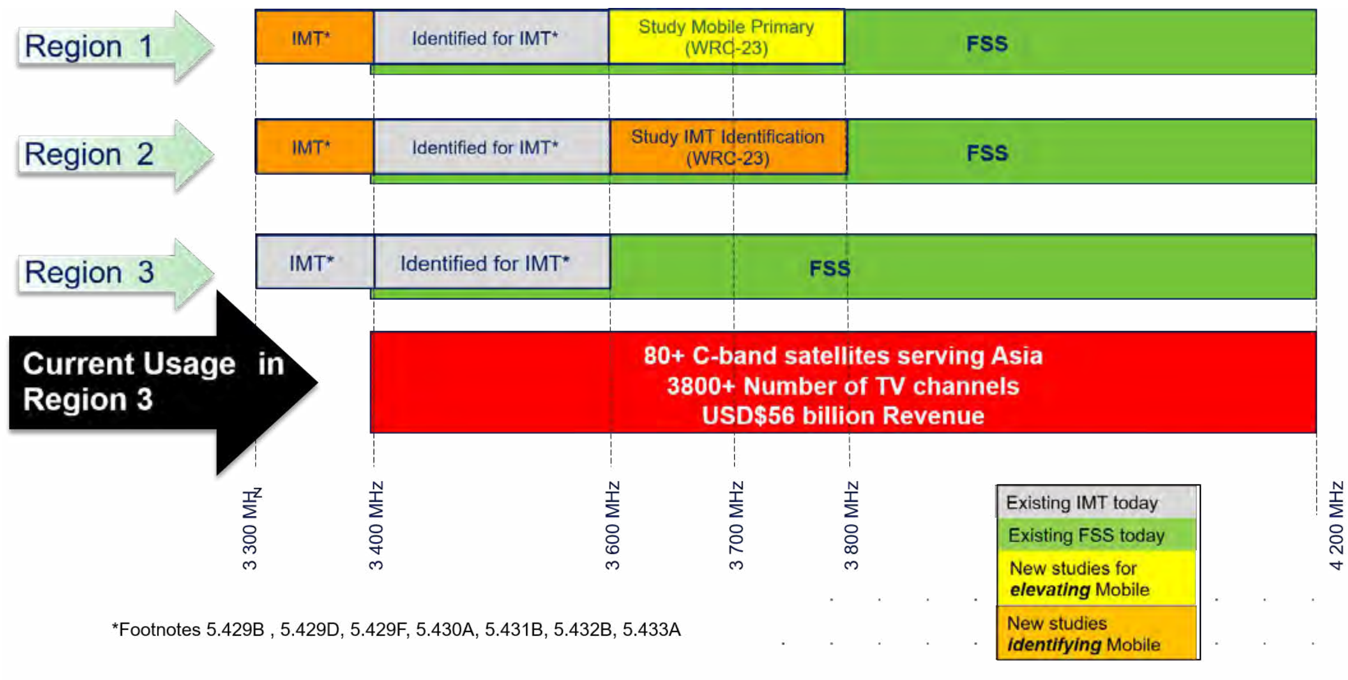
Mid Band Spectrum

At the ITU's World Radio Congress (WRC-19) 2019, member states universally upheld additional support for satellite communication. Notably, the ITU agreed to protect the existing satellite spectrum and provide access to an additional spectrum which will enable satellite service providers to maintain and expand satellite communications and provide satellite-enabled connectivity to end-users. The ITU also recognizes the critical issue of adequate spectrum access for the satellite industry to provide the necessary connectivity solutions to heterogeneous groups of end-users, by validating the use of expanded spectrum access for both fixed and mobile users.

C-Band Status Post WRC-19

It is a fact that over the next four-year ITU cycle, IMT studies will give little consideration to the 3700 to 4200 MHz band in general. An agenda item, AI 1.2, was created at the last WRC for the WRC-23 cycle to focus on possible identification of IMT in the 3600 to 3800 MHz band, specific to Region 2, with opposition from the other ITU Region 1 and Region 3 members.

Figure 21 : IMT mid-band spectrum 3.3-3.6 GHz has ITU Region 1 & 3 Support

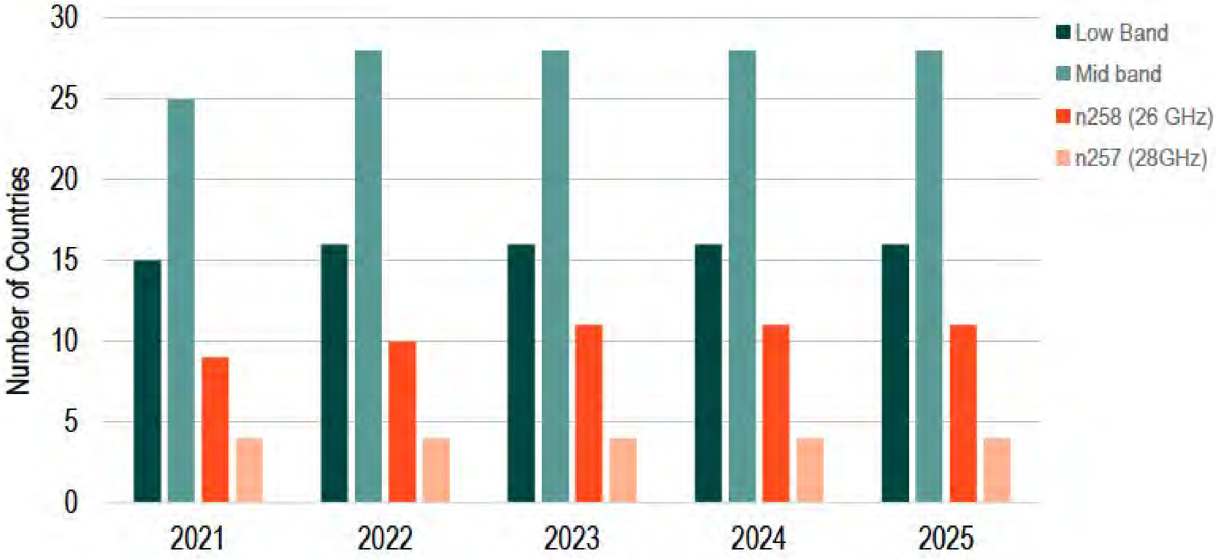


Satellite stakeholders actively participate in 5G standardisation bodies such as 3GPP and ETSI. Within 3GPP, work is ongoing to incorporate non-terrestrial networks into the 5G radio access standards. For example, 3GPP technical report 22.822 (published as part of Release 16 specifications) provides three categories of potential applications (comprising service continuity, ubiquity and scalability) for satellite access in 5G together with 12 primary use cases scenarios.

International Trends

Given the changing demand and supply of spectrum, countries need to implement a balanced strategy that requires a thorough understanding of the trends affecting spectrum. Across the globe, many countries are already leveraging emerging technologies to facilitate the adoption of new models for spectrum allocation and usage. Regulators also need to anticipate future use cases by adopting structures, processes, and tools that allow the imagination to be the limit as spectrum usage evolves in the coming years.

Figure 22 : Chart showing Current and Expected Spectrum Allocation for Terrestrial 5G in Emerging Markets, 2021-2025



Source: ABI Research

Highlighting the International Trend in 26 GHz and 28 GHz

With more than 120 countries (and rising) expressing their intention to follow the ITU decisions and preserve the 27.5-31 GHz and 17.7-21.2 GHz bands for satellite broadband services, the global consensus continues to be affirmed. Europe's "5G Roadmap" re-affirms this determination, recognizing the critical nature of this spectrum for satellite broadband, and explicitly stating its policy: "*Signal clearly that Europe has harmonised the 27.5-29.5 GHz band for broadband satellite and is supportive of the worldwide use of this band for ESIM. This band is therefore not available for 5G.*"[45]

As indicated by the ITU decisions and the European 5G Roadmap, choosing one technology over another is not an issue. A wide range of opportunities exist to accommodate 5G/IMT in other

45 See European Conference of Postal and Telecommunications Administrations (CEPT), Spectrum for wireless broadband – 5G, Section B.3 (Version 10, Revised 6 March 2020) at https://www.cept.org/Documents/ecc/57839/ecc-20-055-annex-15_cept_5g_roadmap .

spectrum bands that specifically has been identified for 5G/IMT, and that would not have any of the adverse effects the ITU considered in deciding where to accommodate the 5G/IMT spectrum needs:

(i) Changing the sharing situation regarding the satellite broadband services for which the 27.5-31 GHz and 17.7-21.2 GHz bands already are allocated;

(ii) Impairing the ability of satellite broadband

A few countries, (e.g., the U.S., South Korea, Japan etc.), have made use of part of the 28 GHz band for terrestrial 5G services outside of the ITU and WRC-19 process The global community rejected their attempts to have the WRC-15 include the 28 GHz band in Agenda Item 1.13 for consideration for terrestrial 5G. The 10 administrations that have assigned parts of the 28 GHz band for IMT represent a population of just over 600 million (under 8% of the global population). It is important to note that a common characteristic of these countries is their high availability and penetration of fibre. In cases where regulators have assigned the 28 GHz for IMT, there are usually some coexistence measures (e.g. geographic separation, restrictions) in place to manage potential interference between IMT and other uses including satellite services.

Over 120 countries and growing, including Europe[46], China, Australia, Brazil, Russia, Mexico, Nigeria, and other important economies, representing more than half the global population, have secured the full 28 GHz for ubiquitous satellite broadband to provide nationwide satellite broadband services. Accordingly, there is no justification for taking the 27.5-28.5 GHz away from productive satellite uses in order to satisfy uncertain 5G demand, especially when there is plenty of other unencumbered mmWave spectrum available.

The Roll-out Challenges in Various Countries

In the United States, 5G deployment to date has focused on mmWave bands, including 28 GHz. However, there has been an increasing awareness that this focus will worsen the digital divide. As noted by Jessica Rosenworcel, Commissioner of the Federal Communication Commission: *"... our focus on millimetre wave spectrum is threatening to create 5G haves and have-nots in the United States. That's because while these airwaves have the substantial capacity, their signals do not travel far. As a result, commercializing them is costly—especially in rural areas. The sheer volume of antenna facilities required to make this service viable will limit deployment to the most populated urban areas. This will deepen the digital divide that already plagues too many rural communities nationwide."*[47]

Implementations across the world have proven that the complete mmWave band cannot be effectively utilized. The international trends also show that the viability of 5G use cases remains uncertain. For example, in China many 5G use cases previously showcased by the mobile industry – including remote surgery and 5G VR – are being abandoned[48] as too niche or expensive.

46 https://docdb.cept.org/download/1675

47 Jessica Rosenworcel (2020), Statement of Jessica Rosenworcel, Commissioner, Federal Communications Commission before the Committee on Commerce, Science, and Transportation, United States Senate "Industries of the Future", 15 January 2020. Available at https://www.commerce.senate.gov/2020/1/industries-of-the-future

48 https://www.lightreading.com/asia/china-culls-unprofitable-5g-use-cases-as-it-narrows-focus/d/d-id/772855

Table 5 : The RollOut Challenge of mmWave IMT in countries

South Korea	South Korea licensed each of their 3 MNOs with 800 MHz of 5G spectrum in 26/28 GHz in 2018, with an obligation to build out more than 45,000 5G base stations by end of 2021. However, by end of August 2021, the three MNOs had only built out a total of 161 base stations due to a lack of demand and applications to justify the investment[49].
European Commission	Similarly, the European Commission has found a lack of demand for 26 GHz spectrum for 5G, noting that while mmWave bands were once popular, "*their popularity had now waned.*"[50]
Brazil	The minister and Anatel official Abraao Albino said the 26 GHz spectrum did not attract interest due to uncertainties in the business model. The government will consider a new auction to offer the unsold batches.[51]
Optus, Australia	While much is unknown about the possible future service made possible through mmWave application, what we can say at this early stage is that mmWave spectrum is unlikely to be used to supply wide area mobile networks; its propagation characteristics simply make this uneconomic. Rather, mmWave will be targeted to specific users and ultra-high bandwidth applications, most likely in the enterprise market."[52]
Google	A Google study from 2019 indicated it would take roughly 13 million transmitters and $400 billion to deliver 100Mbit/s to 72% of the US population using 5G in mmWave spectrum.
Financial Analysts	Most financial analysts have concluded that operators' interest in mmWave is mostly over, most mobile users in the US would remain connected to 5G on low-band and mid-band spectrum, leaving mmWave connections for an occasional trip to the airport or a football game. "The lie of millimetre wave is dead," agreed the financial analysts at New Street Research.[53]
Jessica Rosenworcel, Commissioner of the Federal Communication Commission	*"... our focus on millimetre wave spectrum is threatening to create 5G haves and have-nots in the United States. That's because while these airwaves have the substantial capacity, their signals do not travel far. As a result, commercializing them is costly—especially in rural areas. The sheer volume of antenna facilities required to make this service viable will limit deployment to the most populated urban areas. This will deepen the digital divide that already plagues too many rural communities nationwide."*[54]

49 http://www.koreaherald.com/view.php?ud=20210910000417.

50 https://5gobservatory.eu/26-ghz-holds-back-achievement-of-eu-5g-goals/

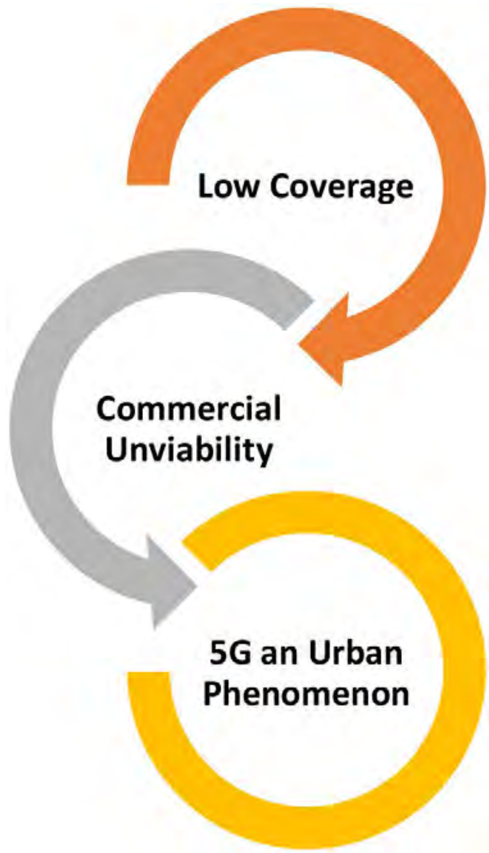
51 https://www.reuters.com/business/media-telecom/brazil-reschedule-auction-unsold-5g-spectrum-minister-says-2021-11-05/

52 Optus (2020), Spectrum allocation limits – 26 GHz band, submission in response to ACCC discussion paper, March 2020, paragraph 4. Available at https://www.accc.gov.au/system/files/Optus_31.pdf.

53 https://www.lightreading.com/5g/the-age-of-mmwave-5g-sputters-to-dusty-death/a/d-id/770838

54 Jessica Rosenworcel (2020), Statement of Jessica Rosenworcel, Commissioner, Federal Communications Commission before the Committee on Commerce, Science, and Transportation, United States Senate "Industries of the Future", 15 January 2020. Available at https://www.commerce.senate.gov/2020/1/industries-of-the-future

In other words, few if any benefits are expected beyond urban areas. This has significant implications for governments seeking to encourage economic growth beyond urban areas or to reduce the digital divide affecting unserved and underserved populations. A significant portion of the population in India is yet to benefit from the same broadband access available in urban areas.



Applicability in Indian Scenario

It is important to note that a common characteristic of the few APAC countries that have assigned 28 GHz for 5G have a much smaller geographical area that has high availability and penetration of fibre. This is not the case with India. More than 70% of the population lives outside urban areas and do not have access to broadband services.

In developing countries like India, where fibre backhaul is not ubiquitous and, in such circumstances, satellite technology is necessary to provide connectivity services. In countries such as India, even if there is interest in investing in 5G mmWave, terrestrial fibre is unlikely to be available for backhaul and therefore satellite services will be required. If the 26 GHz band is assigned to 5G while also retaining 28 GHz for satellite, then satellite backhaul remains a viable option for terrestrial mobile operators to reach subscribers where fibre or microwave backhaul is not feasible.

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Any reduction in the 28 GHz spectrum allocated for providing satellite services will diminish the economic benefits that satellite connectivity can bring. The ACMA believed that sufficient spectrum had already been identified in the 26 GHz band for wide-area broadband use (including 5G). Thus options in which such services were also allocated a portion of the spectrum in the 28 GHz band were not expected to maximise public benefit and , therefore, were not considered an appropriate use of the band.

The 27-27.5 GHz band, is allocated to FSS in ITU-R Regions 2 and 3. While this band has been identified for IMT (5G) by WRC-19, it also provides a most valuable opening for FSS gateways and other earth stations addressing HTS networks in this region (see, for example, Australia's NBN HTS satellites, which use this spectrum). As mentioned above, with the current high interest in non-geostationary systems, several of which are already deployed or in the process of being deployed, non-geostationary systems could make access difficult for geostationary satellites in the 28.6-29.5 / 18.8-19.7 GHz where. This makes use of the 27-27.5 GHz band for GSO HTS networks even more important and could prove essential in enabling sufficient uplink bandwidth for geostationary HTS networks, particularly for gateway links.

Ensuring Continuity of C-Band Satellite Services

Several countries have done some field test experiments on how to deploy IMT, including 5G while preserving satellite services in the band 3400 – 4200 MHz. Some Asia Pacific countries have performed field tests to study the coexistence between IMT and FSS and implement those field test outcomes into their 5G spectrum roadmap in their countries. The table ahead summarises those results:

Table 6 : Guard Band examples in Asia

	IMT Spectrum (MHz)	Guard Boundary (MHz)	FSS Allocation (MHz)	Guard Band (MHz)	Additional Remarks
Hong Kong[55]	3400 - 3600	3600 - 3700	3700 - 4200	100	3300-3400 MHz limited to indoor deployment Exclusion zones to protect TT&C stations
Singapore[56]	3450 - 3650	3650 - 3700	3700 - 4200	50	3600-3650 MHz and 3450-3500 MHz will be limited to indoor and underground use. Adoption of 2 exclusion zones to protect critical FSS operations and 5 precautionary zones for high density areas of C-band FSS operations.
China[57]	3300 - 3600	3600 - 3700	3700 - 4200	100	3300-3400 MHz will be limited for Indoor use. Adoption of interference coordination areas with a specific separation distance between IMT and FSS
Indonesia[58]	3400 - 3600	3600 - 3700	3700 - 4200	100	Data above is based on recently performed test experiments to study IMT-FSS coexistence in the 3400-4200 MHz band
Myanmar[59]	3400 - 3520	3520 - 3625	3625 - 4200	105	

55 OFCA decision on the reallocation of the 3.5 GHz band for IMT deployment, and applicable mitigation measures https://www.coms-auth.hk/filemanager/statement/en/upload/441/ca_statements20180328_en.pdf

56 The details on IMDA decision on the reallocation of the 3.5 GHz band for IMT deployment, including its applicable mitigation measures, could be referred to the following link https://www.imda.gov.sg/-/media/Imda/Files/Regulation-Licensing-and-Consultations/Consultations/Consultation-Papers/Second-Public-Consultation-on-5G-Mobile-Services-and-Networks/5G-Second-Consultation-Decision.pdf

57 The details on the MIIT decision on the reallocation of the 3.5 GHz band for IMT deployment, including its applicable mitigation measures, could be referred to the following link (in the Chinese language) http://www.srrc.org.cn/article22361.aspx.

58 The details of the Indonesian study and conclusions were submitted to the AWG 27 meeting of the APT https://www.apt.int/sites/default/files/2021/09/APT-AWG-REP-112_-_APT_Report_on_mitigation_measures_to_improve_sharing_and_compatibility_between_4G-LTE_and_5G-NR_systems_and_other_systems...3300_-_4200_MHz.docx

59 The details on Myanmar decisions on this band can be found at the following link: https://www.ptd.gov.mm/Uploads/Reports/Attach/122020/200471330122020_Spectrum%20Roadmap%20(2020)'%20Facilitate%20the%20sustainable%20growth%20of%20Industry%20(Draft).pdf.

As explained in above table, OFCA engaged third-party experts to perform a technical study aimed at determining what level of technical upgrades would be required, in conjunction with limits on out of the band and spurious emissions, to enable coexistence of IMT in 3.4 - 3.6 GHz band and FSS in 3.7 - 4.2 GHz band. The experts determined that an LNB upgrade alone would not provide sufficient protection and that waveguide bandpass filters would need to be retrofitted in front of the LNB.[60]

The Indonesian regulator reserves frequencies in the C, Ku and Ka-bands for satellite services.[61] While the 26 GHz is being considered for 5G deployment and 28 GHz is likely to retain satellite services in the band, no millimetre wave spectrum has been licensed to 5G as of September 2021. Initial 5G launches used spectrum in the 1.8 GHz and 2.3 GHz bands.

Conclusion

5G is a network of networks, an ecosystem, with multiple technologies supporting a global infrastructure. Satellites will play an important role in that ecosystem, and regulatory decisions must take into account the spectrum requirements of all parts of the ecosystem, not just the mobile component.

Whilst admitting both types of allocation (FSS/IMT) follow one type of public interest and its adequacy to each country's specific needs should be assessed, there is currently no valid evidence that actual usage of the 26 GHz band (24.25-27.5 GHz) for IMT services will not be sufficient to meet such public interest needs.

It would be prudent to deploy 5G in the 26 GHz band as with the majority of the countries to benefit from economies of scale and ensuring effective utilization of the 26 GHz with each operator having 400 MHz allocation at the outset and a headroom to aggregate to 800 MHz in future that is in line with many other countries. SIA-India supports the continued prioritization of the FSS, including Earth Stations in Motion (ESIM), in the 27.5-31.0 GHz bands (Ka-band) so that existing and planned satellite systems in this frequency band can deploy and provide broadband services ubiquitously.

Allocating too much spectrum for a given service can be just as inefficient as allocating too little. The following inefficiency and loss of value risks are associated with Spectrum Oversupply to 5G.

- Risk of saturating the demand for MNOs for additional spectrum – leads to non-competitive auction and lower auction revenues
- Risk that valuable spectrum goes unsold or underutilized for an extended period
- Risk of reallocating valuable satellite spectrum to mobile operators with unproven business strategies at the expense of proven and essential existing FSS services

60 Consultancy Report – Assessments on and Recommendations to Enable the Electromagnetic Compatibility between Public Mobile Services and Fixed Satellite Service Operating in the C-band, Rhode & Schwarz Hong Kong Limited https://www.ofca.gov.hk/filemanager/ofca/common/reports/consultancy/cr_201803_28_en.pdf

61 Ministry of Communications and Information Technology (2016). Indonesian Satellite Service Regulator Framework. ITU International Satellite Symposium, Bali, September 2016.
Available at https://www.itu.int/en/ITU-D/Regional- Presence/AsiaPacific/Documents/Events/2016/Sep-ISS2016/Presentation/ITU%20International%20Satellite%20Symposium%202016%20-%20Indonesia.pdf.

In other words, most benefits arising from the implementation of 5G services, both for the economy and for consumers, will be obtained through the deployment by each MNO of the first 40 MHz of the spectrum in mid-band. Additional spectrum, if any, can only bring incremental advantages. The 300 MHz spectrum from 3.3-3.6 GHz, barring the specific locations or districts where ISRO is using the 25 MHz (3400 MHz - 3425 MHz) of spectrum for NavIC constellation maintenance, can provide each of India's 4 MNOs with more than the minimum 40 MHz required for mid-band 5G applications. On similar lines, the n258 band (24.25-27.5 GHz) provides more than the minimum 400 MHz of the spectrum to each of India's MNOs[62] required for mmWave applications, for which demand remains highly uncertain.

Additional spectrum, if any, should only be brought to auction when there is sufficient justification by the MNOs for the need and compliance to roll-out obligation of the initial spectrum that they may acquire through the current auction. At some stage, DOT or TRAI need to call an audit regarding the fair and sensitive treatment of incumbents versus increasing demands for spectrum from the protagonists of IMT/5G.

Besides the efficient usage of spectrum for 5G rollout and effective use of spectrum to have a timely widespread deployment of 5G services that the authorities need to ensure, it is also essential that the Government of India reviews the feasibility of the MNO's business plans and monitors the implementation of such business plans regularly. This would include verifying the correct implementation of their systems with respect to compliance with execution concerning the regulatory provisions set out to protect other services in the band and the adjacent band.

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62 5G specifications in ITU-R M.2150 require a minimum average spectral efficiency of 7.8 bps/Hz in dense urban areas for a cell capacity of 3 Gbps per cell in a 400 MHz channel

Glimpse of the study paper released by Dr. V. K Saraswat, Honorable Member NITI Aayog.

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