Consultation Paper No. 6/2023

भारतीय दूरसंचार वनियामक प्रा धकरण

Telecom Regulatory Authority of India

Consultation Paper on

Assignment of Spectrum for Space-based Communication Services

New Delhi, India

6th April, 2023

Mahanagar Doorsanchar Bhawan, Jawahar Lal Nehru Marg, New Delhi- 110002

Written Comments on the Consultation Paper are invited from the stakeholders by 4th May 2023 and counter-comments by 18th May 2023. Comments and counter-comments will be posted on TRAI's website www.trai.gov.in.

The comments and counter-comments may be sent, preferably in electronic form, to Shri Akhilesh Kumar Trivedi, Advisor (Networks, Spectrum and Licensing), TRAI on the email ID advmn@trai.gov.in. For any clarification/ information, he may be contacted at Telephone No. +91-11-23210481.

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CHAPTER-I: INTRODUCTION

A. DoT's Reference to TRAI

1.1 The Department of Telecommunications (DoT) sent a Reference through the letter No. L-14006/01/2021-NTG dated 13.09.2021 (**Annexure-1**) on the subject- 'Seeking TRAI recommendations for the auction of spectrum in the frequency bands identified for International Mobile Telecommunications (IMT)/ 5G' to TRAI (also referred to as "the Authority"). Through the said letter, TRAI was requested to provide recommendations, *inter-alia*, on the auction of spectrum for space-based communication services. The relevant paras of the reference are reproduced below:

"6. The Department of Space had invited comments on Draft Spacecom Policy liberalizing space segment for private sector participation to provide commercial communication services in India. This includes the Low Earth Orbit (LEO) and Medium Earth Orbit (MEO) satellite constellations operational over India. In case of satellite communication, the subscriber is accessed from the satellite through "Access Spectrum" similar to "Access Spectrum" in terrestrial network and the demand for such spectrum will potentially increase in the future.

7. In view of the above, under the terms of clause 11(1) (a) of TRAI Act, 1997 as amended by TRAI Amendment Act 2000, TRAI is requested to:

…

7(c) provide recommendations on appropriate frequency bands, band plan, block size, applicable reserve price, quantum of spectrum to be auctioned and associated conditions for auction of spectrum for space-based communication services, in view of para 6 above."

1.2 In this regard, TRAI, through the letters dated 27.09.2021 and 23.11.2021, sought, *inter-alia*, the following information/ clarifications in respect of space-based communication services from DoT:

(a) Details of the frequency bands and quantum of spectrum available in each band required to be put to auction and associated information in respect of space-based communication

(b) Whether spectrum for space-based communication is being envisaged to be assigned on exclusive basis or will the same be shared among multiple service licensees?

(c) Details of spectrum assignment mechanism and methodology of charging currently being followed by DoT for space-based communication services

1.3 In response, DoT through the letter dated 27.11.2021 informed, *inter-alia*, that the information in respect of space-based communication services sought by TRAI will take some time; therefore, to avoid delay in 5G roll-out, TRAI may go ahead with consultations/ recommendations on issues excluding space-based communication services referred in DoT's reference dated 13.09.2021 and 23.09.2021. Through the said letter, DoT also mentioned that the issues related to space-based communication services may be taken up separately on receipt of information from DoT.

1.4 Thereafter, through the letter No. J-19022/01/2022-SAT dated 16.08.2022 **(Annexure-2)**, DoT provided information with respect to space-based communication services as sought by TRAI through the letters dated 27.09.2021 and 23.11.2021. While providing the said information, DoT requested TRAI to provide recommendations on certain additional issues. The relevant points of the DoT's letter dated 16.08.2022 are given below:

(a) TRAI, through consultations, may assess the demand for space-based communication services and accordingly provide recommendations on the quantum of spectrum in each band required to be put to auction.

(b) It is envisaged to auction the Space Spectrum on exclusive basis. TRAI may explore feasibility and procedure of sharing auctioned spectrum among multiple service licensees. TRAI may provide recommendations on sharing of auctioned frequency bands between satellite networks and

terrestrial networks also, the criteria for sharing and appropriate interference mitigation techniques for sharing and coexistence.

(c) In frequency bands 27.5-28.5 GHz (identified for IMT) and 28.5-29.5 GHz (being studied for Captive Non-Public Networks), TRAI may recommend mechanism for sharing of auctioned frequency bands in which both IMT/ CNPN and satellite-based services (both user terminal and Gateways) can be provided in a flexible manner.

(d) Since the service providers may require spectrum both in user link as well as in feeder link, TRAI may take inputs from the stakeholders and recommend the appropriate auction methodology so that the successful bidder gets spectrum for user link (shared with IMT in flexible) as well as feeder link.

(e) In addition, TRAI is requested to provide any other recommendations as deemed fit for the purpose of spectrum auction in these frequency bands, including the regulatory/ technical requirements as enunciated in the relevant provisions of the latest ITU-R Radio Regulations.

1.5 Through the afore-mentioned letter dated 16.08.2022, DoT provided a list of frequency bands to be considered by TRAI for providing recommendations with respect to space-based communication services, as given below:

S. No.	Frequency Band	Link	Remarks
1	10.7 – 12.75 GHz	Space to Earth	
2	12.75 – 13.25 GHz	Earth to Space	
3	13.75 – 14.5 GHz	Earth to Space	
4	17.1 – 18.6 GHz	Space to Earth	17.7–18.4 GHz is used for Earth to Space also.
5	18.8 – 19.3 GHz	Space to Earth	
6	19.3 – 19.7 GHz	Space to Earth	
7	19.7 – 21.2 GHz	Space to Earth	
8	27.5 – 29.5 GHz	Earth to Space	27.5–28.5 GHz has been identified for implementation of IMT in India.
9	29.5 – 31 GHz	Earth to Space	

Table 1.1: List of frequency bands referred by DoT

1.6 While providing the above list of frequency bands, DoT also mentioned that *"TRAI can however provide recommendations for other frequency bands also."* Besides, DoT stated that *"these frequency bands include "Planned bands" that when used by GSO systems in accordance with Appendices 30, 30A & 30B of Radio Regulations are reserved by ITU for use by National systems. Use of 'Planned Bands' by foreign GSO satellites is not permitted in India. TRAI may, inter-alia, take into account this aspect with respect to GSO systems, in the consultation process".* The information on the Planned bands, as provided by DoT, is given below:

S. No.	Plan	Frequency bands		Applicable Appendix of ITU's Radio Regulations
		Uplink	Downlink	
1	FSS Plan	12.75 - 13.25 GHz, 6.725 - 7.025 GHz	10.7 - 10.95 GHz, 11.2 - 11.45 GHz, 4.5 – 4.8 GHz	Appendix 30B
2	BSS Plan		11.7-12.2 GHz	Appendix 30
3	BSS feeder links Plan	14.5 - 14.8 GHz, 17.3 - 18.1 GHz		Appendix 30A

Table 1.2: Details of Planned Bands

1.7 Thereafter, TRAI, through the letter dated 19.10.2022 to DoT, sought further information/ clarifications, wherein DoT was requested, *inter-alia*, to clarify that for which kind of licensed services, spectrum for space-based communication has been envisaged to be granted through Auction. DoT was requested to provide information as per the table given below:

S. No.	Type of service	Whether spectrum is envisaged to be assigned through auction? (Yes/ No)	Reasons, if any
1	Access		
2	Internet		
3	NLD		
4	ILD		
5	GMPCS		
6	VSAT CUG (Commercial)		
7	Captive VSAT CUG		
8	Machine to Machine (M2M)		
9	DTH		
10	Teleport		
11	DSNG		
12	HITS		
13	Any other relevant service (please specify)		

Table 1.3: Type of services for which information was sought from DoT

1.8 In response, DoT, through the letter dated 16.12.2022, conveyed that TRAI may provide suitable recommendations for each of the space-based communication services after detailed examination. Hence, the present consultation paper requires to consider all the spectrum bands relevant for space-based communication services as indicated by DoT in the letter mentioned above.

B. The Present Consultation Paper

1.9 In this background, this consultation paper is being issued for soliciting comments of stakeholders on the issues related to assignment of spectrum for space-based communication services. This chapter provides background information. Chapter-II provides a brief description of space-based communication services. Chapter-III examines the issues related to assignment

of spectrum for space-based communication services. Chapter-IV examines the issues related to valuation of spectrum for space-based communication services. Chapter-V summarizes the issues for consultation.

CHAPTER-II: SPACE-BASED COMMUNICATION SERVICES

A. Satellite Communication

2.1 Satellite communication refers to any communication link that involves the use of an artificial satellite in its propagation path. A communications satellite relays and amplifies radio telecommunication signals via a transponder. The term "satellite transponder" refers collectively to a transmitter-receiver subsystem on board the satellite that processes, amplifies, and retransmits a range of frequencies (the transponder bandwidth) to another location/ terminal/ antenna on the earth. There are many transponders on a typical satellite, each capable of supporting one or more communication channels.[1]

2.2 Satellite-based communication systems can provide coverage to the remotest and most inaccessible areas of a geographically widespread country like India. At present, many sparsely populated areas, including areas of strategic importance and areas important from the socio-economic perspective, do not have mobile terrestrial coverage and other forms of connectivity. Communication satellites have a potential to bridge this gap by providing telecommunication and broadcasting services to even the remotest areas.

2.3 A typical satellite communication system consists of space segment, control segment and ground segment as outlined below.

(a) Space segment contains one or more satellites in space.

(b) Control segment consists of ground facilities for the control and monitoring of the satellites and for the management of the traffic and the associated resources on-board the satellites.

(c) Ground segment consists of traffic earth stations. The traffic earth stations are of three types viz. user stations, interface stations and service stations.

(i) User stations such as handsets and very small aperture terminals (VSATs) allow customer direct access to the space segment.

[1] Source: https://www.gartner.com/en/information-technology/glossary/transponder

(ii) Interface stations (also known as gateways) interconnect the space segment with the terrestrial network.

(iii) Service stations, such as hub, collect or distribute information from and to user stations via the space segment.

2.4 The following figure shows three key elements of a typical satellite communication system (viz. satellite, satellite earth station gateway and user station).

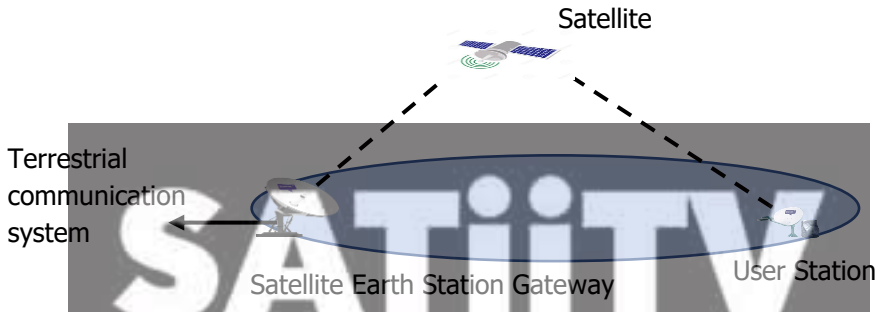


Figure 2.1: Key Elements of Satellite Communication Systems

2.5 The above figure depicts that satellite earth station gateway (hereinafter also referred to as 'gateway'), acts as a bridge (or gateway) between space-based communication network and terrestrial communication network.

2.6 The trajectory of a satellite around Earth is known as orbit. The most common orbits followed by communication satellites are Low Earth Orbit (LEO), Medium Earth Orbit (MEO), and Geostationary Satellite Orbit (GSO). MEO and LEO satellites collectively are also called Non-Geo Stationary orbit (NGSO) satellites. The satellite orbit is selected based on the requirements of the application.

2.7 GSO satellites are at about 36,000 kilometers above the Earth, a place where they appear fixed in the sky when observed from the ground. They are commonly used for communication, weather monitoring, Direct-To-Home (DTH) television broadcasting, and internet provisioning. NGSO satellites at MEO altitudes are between 8,000 and 20,000 kilometers above the Earth and

LEO altitudes are between 400 to 2,000 kilometers above the Earth. Since NGSO satellites move across the sky during their orbit around the Earth, NGSO operators deploy a fleet of satellites, generally called 'constellations', to provide continuous service from these altitudes. NGSO constellations intend to cover the globe providing high-bandwidth connectivity and processing high volumes of data with minimal delay. The following figure depicts the orbital altitudes and coverage areas of GSO and NGSO systems.

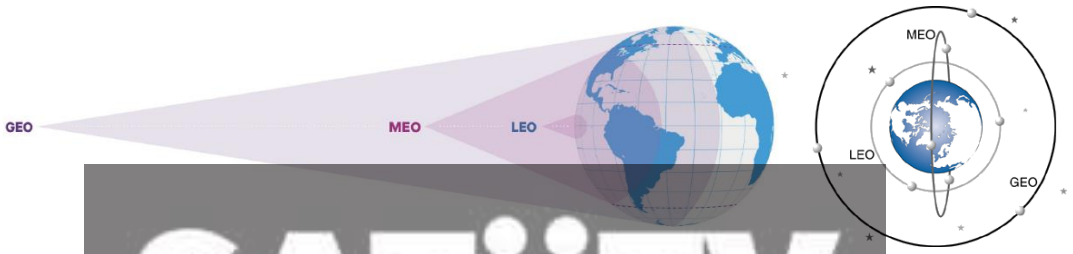


Figure 2.2: Schematic diagram of orbital altitudes and coverage areas of LEO/ MEO/ GEO satellites[2]

2.8 The International Telecommunication Union (ITU) publication titled 'The Last-mile Internet Connectivity Solutions Guide Sustainable connectivity options for unconnected sites 2020', provides a comparison of GEO, MEO and LEO characteristics as given in the following table:

[2] Source: satellitetoday.com

Satellite category	Altitude	Orbital period	Latency (round-trip)[#]	Number of satellites to span globe	Cost per satellite[$]	Effective lifetime of satellite (years)
GEO	35,786 km	24 hours	477 ms	3*	100 to 400	15 to 20
MEO	8,000 to 20,000 km	127 minutes to 24 hours	27 to 477 ms	5 to 30	80 to 100	10 to 15
LEO	400 to 2,000 km	88 minutes to 127 minute	2 to 27 ms	100s or 1000s	0.5 to 45	5 to 10

[#] Round-trip (ms), approximate

[$] In million USD, approximate

* This excludes high-latitude areas, that is, above the polar circles

Table 2.1: GEO, MEO and LEO Satellite Characteristics[3]

2.9 At present, many satellite communication systems make use of high-throughput satellites (HTSs). HTS provides significantly more throughput than a conventional satellite for the same amount of radio frequency spectrum. While a conventional satellite utilizes a broad single beam (usually in the order of thousands of kilometers) to cover wide regions or even entire continents, HTS employs - (a) frequency re-use, and (b) spot beam technology which enables frequency re-use across multiple narrowly focused spot beams (usually in the order of hundreds of kilometers), as in cellular networks. Together, these features help HTSs provide significant higher throughputs as compared to conventional satellites.

2.10 Initially, HTS systems used GSO satellites. However, the propagation delay for a round-trip transmission for a GSO satellite can exceed 500 milli-second, which is detrimental to many digital connectivity applications. As a result, the focus for HTS systems is increasingly shifting to the MEO and LEO, with altitudes as low as 400 km and delays as short as 2 milli-second.

[3] https://www.itu.int/dms_pub/itu-d/opb/tnd/D-TND-01-2020-PDF-E.pdf#page=91&zoom=100,94,109

2.11 The new-age satellite systems can be used to provide ubiquitous coverage and for providing broadband connectivity, global positioning system (GPS) and navigation, Internet of things (IoT) and machine to machine (M2M) communication, remote sensing and imaging, broadcasting, disaster management, telemedicine, etc.

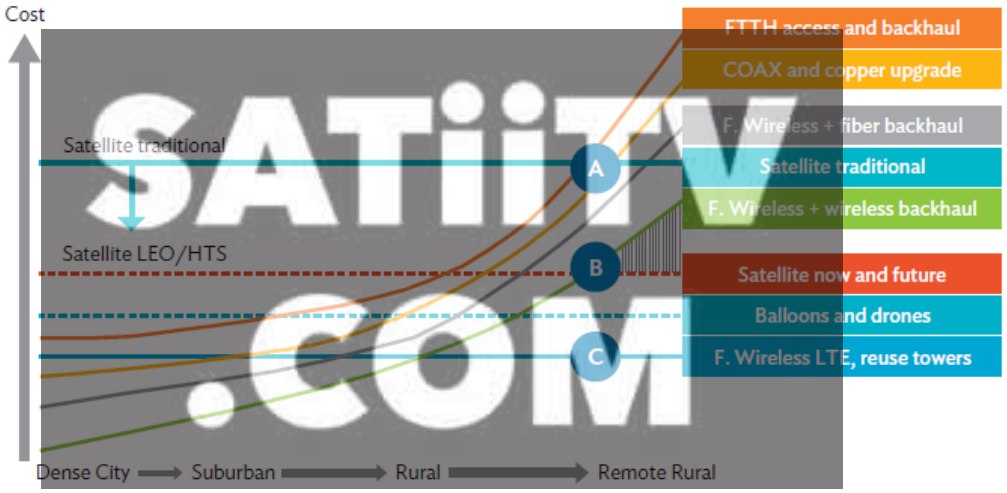
2.12 As mentioned earlier, the satellite earth station gateway provides the interface between the space-based communication network and terrestrial communication network. As GSO satellites are at geostationary location and at long distances from the Earth, the gateway requires a fixed antenna and stable communication link to maintain a constant connection with the satellite. In the case of NGSO satellites, which are non-geostationary, the gateways require precise tracking, rapid beamforming, and effective interference management.

2.13 The number of gateways required by the satellite system depends on factors such as intended application, geographic coverage, capacity, and quality of service. The conventional GSO satellites operate with a single wide beam spanning a large area (say entire Indian territory). Therefore, for conventional GSO satellites, a single gateway can provide adequate coverage for a region. On the other hand, the LEO/ MEO satellites operate through much narrower beams. For this reason, NGSO satellite systems need multiple beams to cover a geographical area as compared to a single wide beam of conventional satellites. Consequentially, there may be a need to set up multiple gateways to control a large number of beams in case of NGSO satellite systems.

2.14 Highly directional narrow beams from the NGSO satellites can provide higher data rates to a smaller geographic area. This enhances the available capacity per unit area and can support higher data rate applications such as broadband internet, cellular backhaul, and M2M communications etc. The beam span is a trade-off between capacity and coverage. Wide beams provide wide area coverage but have lower data rates. On the other hand, narrow beams provide higher data rates but have limited geographic coverage. The optimal beam span for a particular application can be determined through system design and

capacity planning, considering the specific requirements of the application and of target market.

2.15 The Asian Development Bank in its paper[4] on 'Digital Connectivity and Low Earth Orbit Satellite Constellations-Opportunities for Asia and the Pacific', has mentioned that *"satellite connectivity is only cost competitive for remote and dispersed populations where fiber deployments are challenging. The new generation of LEO and high-throughput GEO satellites are expected to lower the cost structure and make satellite connectivity more competitive*". The following graph depicts technology-wise comparison of cost and population density:



COAX = coaxial cable, FTTH = fiber to the home, HTS = high-throughput satellite, LEO = lower Earth orbit, LTE = long term evolution.

Source: Adapted from World Bank. 2019. *Innovative Business Models for Expanding Fiber-Optic Networks and Closing the Access Gaps.*

Figure 2.3: Technologies Compared by Costs and Population Density

Source: Asian Development Bank

[4] https://www.adb.org/sites/default/files/publication/696521/sdwp-076-digital-connectivity-low-earth-orbit-satellite.pdf

B. Spectrum bands for Satellite Communication Services

2.16 A variety of frequency bands can be used for providing satellite communication services. The popular frequency bands used for providing satellite communication services are outlines below:

(a) L-band: It ranges from 1 GHz to 2 GHz and is used for mobile satellite services (MSS) and global positioning system (GPS) navigation signals.

(b) S-band: It ranges from 2 GHz to 4 GHz and is used for MSS, as well as weather and air traffic control applications.

(c) C-band: It ranges from 4 GHz to 8 GHz and is commonly used for fixed satellite services (FSS) such as television and radio broadcasting, telephony, and data transmission.

(d) Ku-band: It ranges from 10 GHz to 15 GHz and is used for both FSS and mobile satellite services (MSS). It is commonly used for direct-to-home (DTH) television broadcasting and satellite internet services.

(e) Ka-band: It ranges from 17 GHz to 31 GHz and is used for FSS and MSS applications. It is commonly used for high-speed broadband.

2.17 According to European Space Agency[5], because of satellites' increased use, number and size, congestion has become a serious issue in the lower frequency bands. New technologies are being investigated so that higher bands can be used. The higher frequency bands typically give access to wider bandwidths.

C. Spectrum regulation in satellite-based communication systems

2.18 International coordination of satellite systems is crucial[6]. For the space segment, satellite operators need to obtain international recognition for the frequency and orbital resources they plan to use, by way of 'satellite-filing' in ITU. For the earth segment, operators need to obtain licenses from individual countries, unless there is an explicit exemption in place. Licenses provide national recognition for the use of certain frequencies within a country. The

[5] https://www.esa.int/Applications/Telecommunications_Integrated_Applications/Satellite_frequency_bands

[6] Publication titled 'Non- Geostationary Satellite Communication Systems' (2021) released by The Institute of Engineering and Technology

following figure[7] depicts the regulatory framework for satellite communication systems.

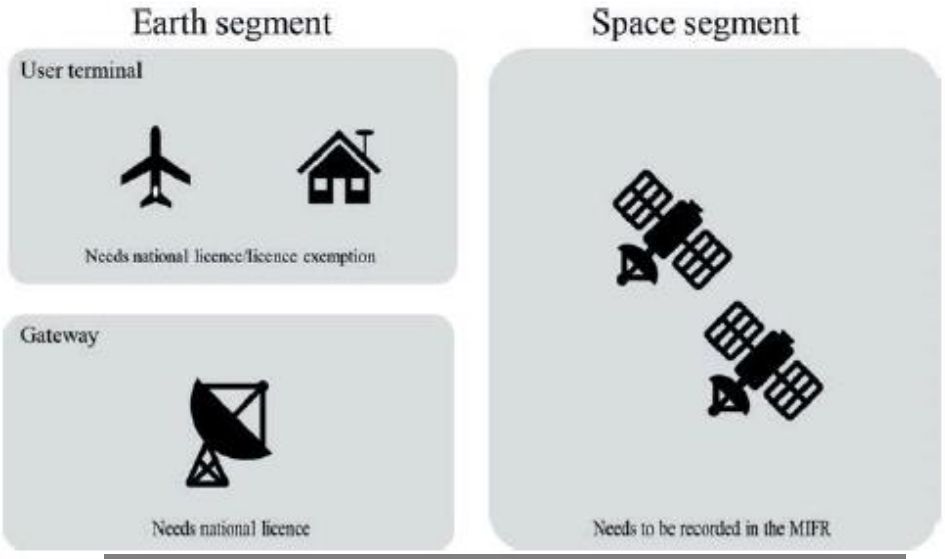


Figure 2.4: Regulatory framework for satellite communication systems

2.19 Satellite communication services do not stop at country borders. Therefore, a global agreement is needed to regulate the use of radio spectrum. The Radio Regulations (RR), which is an international treaty binding to ITU Member States, fulfils this function. RR have the following objectives:

(a) to facilitate equitable access to and rational use of the natural resources of the radio-frequency spectrum and the geostationary-satellite orbit;

(b) to ensure the availability and protection from harmful interference of the frequencies provided for distress and safety purposes;

(c) to assist in the prevention and resolution of cases of harmful interference between the radio services of different administrations;

(d) to facilitate the efficient and effective operation of all radiocommunication services; and

(e) to provide for and, where necessary, regulate new applications of radiocommunication technology.

[7] Publication titled 'Non- Geostationary Satellite Communication Systems' (2021) released by The Institute of Engineering and Technology

2.20 The Government of India has drawn up National Frequency Allocation Plan 2022 (NFAP-2022) using the Radio Regulations (Edition of 2020) as the foundational text. The central theme of NFAP-2022 is the allocation of radio-frequency spectrum to different radiocommunication services. NFAP-2022, though governing the use of spectrum in India, does not by itself provide the right to use the spectrum. Before any part of the spectrum is used in India, a license is required to be obtained from the Wireless Planning and Coordination Wing (WPC Wing), Ministry of Communications, unless such a requirement is exempted by the WPC Wing. In order that all radiocommunication services, 41 in total, have effective access to frequencies, the spectrum is divided into frequency bands and each band is allocated to one or more radiocommunication services. The principle of designating a band for the use by specified radiocommunication services is referred to as frequency allocation.

2.21 Amongst space-based communication services, Fixed-Satellite Services (FSS), Mobile-Satellite Services (MSS) and Broadcasting-Satellite Services (BSS) are the most prominent services. The definitions of these services, as provided by ITU's Radio Regulations 2020, are given below:

"1.21 fixed-satellite service: A radiocommunication service between earth stations at given positions, when one or more satellites are used; the given position may be a specified fixed point or any fixed point within specified areas; in some cases this service includes satellite-to-satellite links, which may also be operated in the inter-satellite service; the fixed-satellite service may also include feeder links for other space radiocommunication services.

…

1.25 mobile-satellite service: A radiocommunication service:

– between mobile earth stations and one or more space stations, or between space stations used by this service; or

– between mobile earth stations by means of one or more space stations.

This service may also include feeder links necessary for its operation

…

1.39 broadcasting-satellite service: A radiocommunication service in which signals transmitted or retransmitted by space stations are intended for direct reception by the general public."

2.22 In simple words, Fixed Satellite Service (FSS) supports communications from one fixed-point to another fixed-point, such as VSAT, Teleports, DSNG, etc. FSS can also be used for connectivity with mobile platforms such as aircraft, ships, and land vehicles. Such applications, however, are regulated by appropriate technical, operational, and regulatory conditions. Mobile Satellite Service (MSS) supports communications between mobile devices, such as handsets and mobile platforms. Satellite phones are important examples of MSS. In case of Broadcasting-Satellite Service (BSS), signals transmitted from satellites are intended for direct reception by the general public which can be individuals or a community, such as Direct-To-Home TV.

2.23 Besides, Article 1.22 of the ITU-RR defines Inter-Satellite Service (ISS) as "*a radiocommunication service providing links between artificial satellites*". ISS provides communication links between satellites including satellites in different orbits, such as GSO and NGSO satellites. In case of NGSO, inter-satellite communication takes place in (i) the same orbital plane, (ii) different orbital planes of the same orbital shell, and (iii) different orbital altitudes.[8]

2.24 A brief description of MSS, FSS and BSS is given below:

(1) Mobile Satellite Service

2.25 L-band and S-band are used to provide MSS on a commercial basis. Worldwide, a few global operators such as Inmarsat (GSO), Thuraya (GSO) and Iridium (NGSO) provide MSS services. In India, L-band is used by a Public Sector Undertaking (PSU) for providing Inmarsat service. The spectrum in S-Band has not been assigned for commercial purposes in India. Currently, frequency reuse is not possible in the L-band and S-band over the same geographical area.

[8] https://arxiv.org/pdf/2203.16597.pdf

Hence, each satellite needs to have its exclusive assignment to provide service over a specific area and it cannot share the same frequency with another satellite operator for providing service in the same area. Frequency ranges identified for MSS in L and S bands are given below:

S. No.	Frequency range	Link
1	1.525-1.559 GHz	Space to Earth
2	1.610-1.6605 GHz	Earth to Space
3	1.980-2.010 GHz	Earth to Space
4	2.170-2.200 GHz	Space to Earth
5	2.4835-2.520 GHz	Space to Earth
6	2.670-2.690 GHz	Earth to Space

Table 2.2: Frequency ranges identified for MSS in L and S bands

(2) FSS in non-plan bands

2.26 The C-band, Ku-band and Ka-band are the most popular bands for FSS. In these bands, FSS requires highly directive antennas producing narrow-beams which must always accurately point to a specific satellite or satellite system. This is to avoid causing interference to other adjacent satellites. The antennas on aircrafts and vessels as well as those on land mobile platforms must ensure that they always point in the specific direction in the sky to the associated satellite and stop operations within milli-seconds of a misalignment. The highly directive antennas make it possible that any frequency can be reused in the same service area by different users each one using a different satellite or satellite system. Coexistence between different satellite networks, adequately separated in the GSO arc complying with the provisions of ITU-RR, is possible in each geographical area without causing interference to one another.

2.27 To illustrate the point by an example, it is possible to make assignment of the same (or overlapping) 20 MHz spectrum (say 3.750 – 3.770 GHz) to multiple service providers/ users each one operating on a different satellite, the satellites

having their orbital slots, well separated from others in the GSO arc, for providing service over the same geographical area.

(3) BSS and Planned FSS

2.28 In the case of BSS, signals transmitted from satellites are intended for direct reception by the general public which can be individual or a community. Example of BSS is Direct-To-Home TV. BSS can be considered as a special case of FSS in which there is no reverse link. Technically, an FSS allocation can be used to provide DTH service, which, in effect, is an application of BSS. As per the Appendix 5.492 of NFAP-2022, BSS allocations may also be used for transmissions in FSS, provided that such transmissions do not cause more interference, or require more protection from interference, than BSS transmissions.

2.29 Planned bands are applicable to GSO based FSS and BSS only and serve the purpose of giving equitable access to member countries of the ITU. The planned bands have the following features and characteristics.

(a) Each country has been allotted a specific geostationary slot and associated frequencies with national coverage. The power that can be transmitted from a satellite, the service area, the antennas, etc. have been clearly defined as what is known as "the envelope of characteristics".

(b) If an administration wishes to put a satellite beyond the envelope of characteristics, it must seek agreement of other administrations whose network operations are considered affected by such modified system.

(c) In addition, any country can also put its satellite in other orbital positions but must coordinate with other administrations who have a filing before it. Such systems are called additional systems.

(d) The essential feature of planned band is that an administration can demand exclusion of its territory area from the service area of another country's satellite at any time, before as well as after the satellite is made operational.

2.30 Planned bands embody the principle of equitable access to each country, small or big, and the principle of First-Come-First-Served (FCFS) does not apply in these bands. This however is not the case for non-plan frequency bands, where FCFS applies.

2.31 BSS services operate as per Global Plans. For the Region-3 countries, the broadcast band is 11.7-12.2 GHz and the corresponding gateway link is 14.5-14.8 GHz and 17.3- 18.1 GHz. Use of these bands is governed by Appendix 30 and Appendix 30 A of the Radio Regulation.

2.32 Under ITU's BSS plan (Appendix 30), two slots at 68-degree East and 55.8-degree East have been assigned to India. The 55.8-degree slot can serve southern and eastern parts of India. The 68-degree slot could serve over North East region, Andaman and Nicobar Islands, and the North and North-West plane.

2.33 A similar Plan also exists in the FSS. A total of 800 MHz spectrum for each uplink and downlink is earmarked as FSS Planned band. The Planned C band is 4.500-4.800 GHz (downlink) and 6.725-7.025 MHz (uplink). The Planned Ku band is 10.7-10.95 GHz and 11.2-11.45 GHz for downlink and 12.75-13.25 for the uplink direction. The FSS band is governed by Appendix 30B of the Radio Regulation. For FSS, India has been allotted the 74-degree slot with a national coverage.

D. Spectrum coordination for satellite communication services

2.34 As indicated above, at the global level, ITU is responsible for management of the radio-frequency spectrum and satellite orbit resources to ensure interference free operation of space-based communication services. A key component of international frequency management is the RR, which is an international treaty that governs the use of the radio-frequency spectrum and the geostationary satellite orbits and non-geostationary satellite orbits under the aegis of ITU. RR determines how the radio frequency spectrum is shared among different services, including space services.

2.35 ITU's RR has a defined frequency coordination process. The aim of frequency coordination is for developing new orbit-spectrum assets and protecting the rights to use such resources. It is a technical and regulatory process by which radio-frequency interference between different radio systems that use the same frequency is removed or mitigated and trouble-free service to users is ensured.

2.36 ITU's coordination process includes[9]:

(a) Maintaining the Master International Frequency Register (MIFR) which records, *inter-alia*, the international rights and obligations of satellites and associated earth stations to use this resource, including international recognition and protection of that use.

(b) Coordinating the planning of new satellite networks to ensure that new satellite systems are compatible with those previously recorded in the MIFR.

(c) Ensuring that satellite systems operate in conformity with the provisions of the RR.

2.37 ITU assesses every new planned satellite system in relation to its compatibility with all the systems and stations already included in the MIFR and that could be affected by it. Beyond the initial phase, coordination needs to be an on-going effort as long as the use of the radio frequency is required by the satellite system, as an essential part in maintaining the quality and reliability of the service it provides.

2.38 In addition, ITU-R study develops recommendations and reports about the efficient orbit/ spectrum utilization, and ensure compatibility among these systems, as well as with the terrestrial systems sharing the same frequency bands. For example, previously six degrees of spatial separation between geostationary satellites using the same frequencies over the same geographic area was considered a minimum to ensure their harmonious coexistence. But

[9] https://www.itu.int/en/plenipotentiary/2014/newsroom/Documents/backgrounders/pp14-backgrounder-sharing-the-sky.pdf

due to technical advances and by coordination within the framework of the ITU-RR, the orbital separation between satellite systems is routinely two degrees.[10]

(1) Protection to GSO from NGSO[11]

2.39 The Article 22 of ITU-RR for 'space services', provides provisions for control of interference to geostationary-satellite systems as below:

'22.2 Non-geostationary-satellite systems shall not cause unacceptable interference to and, unless otherwise specified in these Regulations, shall not claim protection from geostationary-satellite networks in the fixed-satellite service and the broadcasting-satellite service operating in accordance with these Regulations.'

2.40 The two regulatory mechanisms adopted include - Equivalent Power Flux Density (EPFD) hard-limits, and coordination. The technical solution for NGSO is to avoid pointing antennas to GSO orbit or avoid operating satellite when there is insufficient separation angle between direction to NGSO satellite and closest point on GSO when viewed from NGSO earth station.

2.41 EPFD considers the aggregate of the emissions from all NGSO satellites in the direction of any GSO earth station, considering the GSO antenna directivity. EPFD considers pointing at a victim receiving antenna with respect to any source of interference.

2.42 Hard EPFD limits enable NGSO FSS systems to share frequencies with and protect GSO systems without requiring individual coordination with all the systems worldwide. NGSO FSS satellite systems shall comply with the EPFD limits contained in different tables of Article 22 of ITU's RR. Besides for coordination between NGSO and GSO system, and for coordination between

[10] https://www.itu.int/en/plenipotentiary/2014/newsroom/Documents/backgrounders/pp14-backgrounder-sharing-the-sky.pdf
[11] https://www.itu.int/en/ITU-R/space/WRS20space/27%20Non-geostationary%20satellite%20systems%20and%20networks.pdf

NGSO systems, the provisions contained in the Appendices of ITU's RR apply. The main provisions of the Appendices of ITU's RR are given below:

"9.11A for a station for which the requirement to coordinate is included in a footnote to the Table of Frequency Allocations referring to this provision, the provisions of Nos. 9.12 to 9.16 are applicable;

9.12 for a station in a satellite network using a non-geostationary-satellite orbit, for which the requirement to coordinate is included in a footnote to the Table of Frequency Allocations referring to this provision or to No. 9.11A, in respect of any other satellite network using a non-geostationary-satellite orbit, with the exception of coordination between earth stations operating in the opposite direction of transmission;

9.12A for a station in a satellite network using a non-geostationary-satellite orbit, for which the requirement to coordinate is included in a footnote to the Table of Frequency Allocations referring to this provision or to No. 9.11A, in respect of any other satellite network using the geostationary-satellite orbit, with the exception of coordination between earth stations operating in the opposite direction of transmission; (WRC-2000)

9.13 for a station in a satellite network using the geostationary-satellite orbit, for which the requirement to coordinate is included in a footnote to the Table of Frequency Allocations referring to this provision or to No. 9.11A, in respect of any other satellite network using a non-geostationary-satellite orbit, with the exception of coordination between earth stations operating in the opposite direction of transmission;

9.14 for a transmitting space station of a satellite network for which the requirement to coordinate is included in a footnote to the Table of Frequency Allocations referring to this provision or to No. 9.11A in respect of receiving stations of terrestrial services where the threshold value is exceeded;

9.15 for either a specific earth station or typical earth station of a non-geostationary satellite network for which the requirement to coordinate is included in a footnote to the Table of Frequency Allocations referring to No. 9.11A, in respect of terrestrial stations in frequency bands allocated with equal

rights to space and terrestrial services and where the coordination area of the earth station includes the territory of another country;

9.16 for a transmitting station of a terrestrial service for which the requirement to coordinate is included in a footnote to the Table of Frequency Allocations referring to No. 9.11A and which is located within the coordination area of an earth station in a non-geostationary-satellite network;"

2.43 A summary of FSS frequency bands and coordination provisions in ITU-RR are summarized in the following table.

FSS frequency bands		No hard-limits for protection of GSO	Coordination between Non-GSO	Coordination between Non-GSO and GSO	Article 22 EPFD hard limits are applicable
Earth-space	space-Earth				
	3400-4200 MHz	22.2			Yes (3700-4200)
5725-6700 MHz		22.2			Yes (5925-6700)
6700-7075 MHz		22.2	9.12		Yes (6700-6725)
7250-7750 MHz		22.2			
7900-8400 MHz		22.2			
	10.7-12.95 GHz	22.2	9.12		Yes
	11.2-11.45 GHz	22.2	9.12		Yes
	11.7-12.75 GHz	22.2	9.12		Yes
12.75-13.25 GHz		22.2	9.12		Yes
13.75-14.0 GHz		22.2	9.12		Yes
	17.8-18.6 GHz	22.2	9.12		Yes
	18.6-18.8 GHz	22.2			
	18.8-19.3 GHz		9.12	9.12A	
	19.3-19.7 GHz (MSS FL)		9.12	9.12A	
	19.3-19.7 GHz	22.2			
	19.7-20.2 GHz	22.2	9.12		Yes
	20.2-21.2 GHz	22.2			
27.5-28.6 GHz		22.2	9.12		Yes
28.6-29.1 GHz			9.12	9.12A	
29.5-30.0 GHz		22.2	9.12		Yes
V-band FSS	V-band FSS	22.2	9.12		Yes Single/Aggregate

Table 2.3: FSS frequency bands and coordination provisions, Source: ITU

E. Current Licensing Framework for Satellite Communication in India

2.44 Though the orbit-spectrum (orbital slot and frequency band) resources to be used by the satellite operators are coordinated as per the ITU procedure, as per the extant licensing regime in the country, the Government of India assigns radio frequency spectrum to the relevant service licensees for gateways links (frequency carriers used between gateway and satellite) and user links (frequency carriers between user terminal and satellite) for providing space-based communication services in India.

2.45 At present, an entity needs (a) a wireless operating license, and (b) a service license for operating satellite communication systems in the country. Through a notification dated 24.11.2014[12], DoT provided a clarification in respect of operation of satellite communication systems in the country as below:

"This is to clarify that as per the Indian regulatory provisions, for operating satellite communication systems in India, be it Broadcasting Satellite (satellite-to-earth) Service or telecommunication (satellite-to-earth and earth-to-satellite) service, all entities, including government entities, need to obtain Service license and also Wireless operating license.

For broadcasting satellite services like Direct-to-Home (DTH), TV Uplink, Digital Satellite News Gathering Service (DSNG), etc., Ministry of Information & Broadcasting (MI&B) is the licensing authority. For interactive services like VSAT Services, DoT is the licensing authority. For any hybrid service, respective service license needs to be obtained from both these authorities.

In addition to these above service licenses, the entities need to obtain wireless licenses and uplink clearances from Wireless Planning & Coordination (WPC), DoT and Network Operation & Control Centre (NOCC), DoT, respectively, for the operations of the satellite network.

Internet Service Provider (ISP)/Internet Protocol Television (IPTV) license alone is not sufficient to provide either Audio Visual or Broadband Wireless Access services through satellite.

[12] Source: https://dot.gov.in/sites/default/files/Certifcate.pdf

Even government agency engaged in Broadcasting or Telecommunication needs to obtain such service license, uplink/ downlink license, operating licenses from MI&B or DoT or both, as the case may be."

2.46 Department of Telecommunications (DoT) is the licensing authority for telecommunication services, while Ministry of Information & Broadcasting (MI&B), Government of India is the licensing authority for broadcasting services in the country. In respect of telecommunication services, DoT currently follows a regime of Unified License in terms of the provisions of Section 4 of Indian Telegraph Act, 1885[13]. DoT provides authorizations[14] for provision of telecommunications services under Unified License to eligible persons. In respect of broadcasting services, MIB grants licenses/ permissions for DTH, HITS, uplinking and downlinking of satellite TV channels/ set-up of teleports, use of Satellite News Gathering (SNG)/ Digital Satellite News Gathering (DSNG), etc.

2.47 In respect of telecommunication services, the 'Guidelines for establishing satellite-based communication network(s)' issued by DoT on 26.10.2022, provide as below:

"1.1 Satellite based communication services can be provided within the respective scope of the following licenses/ authorizations issued under Section 4 of the Indian Telegraph Act, 1885:

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[13] The Section 4 of the Indian Telegraph Act, 1885 provides as below:

"4. Exclusive privilege in respect of telegraphs, and power to grant licenses. – (1) Within India, the Central Government shall have exclusive privilege of establishing, maintaining and working telegraphs:
Provided that the Central Government may grant a license, on such conditions and in consideration of such payments as it thinks fit, to any person to establish, maintain or work a telegraph within any part of India: …"

[14] There are nine service authorizations under Unified License viz. (a) Access Service, (b) Internet Service, (c) National Long Distance (NLD) Service, (d) International Long Distance (ILD) Service, (e) Global Mobile Personal Communication by Satellite (GMPCS) Service, (f) Public Mobile Radio Trunking Service (PMRTS), (g) Very Small Aperture Terminal (VSAT) Closed User Group (CUG) Service, (h) Audio Conferencing/ Audiotex /Voicemail Service, (i) Machine to Machine (M2M) Service.

(a) Global Mobile Personal Communication by Satellite (GMPCS) Service authorization under Unified License

(b) VSAT CUG Service authorization for commercial service under Unified License

(c) In-Flight and Maritime Connectivity (IFMC) Service authorization

(d) Captive VSAT CUG license

(e) National Long Distance (NLD) Service authorization under Unified License

Besides the above, satellite-based connectivity can also be provided under other authorizations of the Unified License, viz. Access Service as per the scope of the respective license."

2.48 In respect of Broadcasting services, MIB grants license/ permission for the provision of satellite-based broadcasting services to eligible entities. The main licenses/ permissions granted by MIB are indicated below:

(a) Direct to Home (DTH) license: DTH services make use of satellites for distribution of multi-channel TV programs. DTH license is issued by MIB after clearance from different ministries/ departments. The DTH license is issued under Section 4 of the Indian Telegraph Act, 1885.

(b) Headend In The Sky (HITS) permission: The Policy guidelines for HITS operators were issued by MIB on 26.11.2009 and subsequently amended on 06.11.2020.

(c) Uplinking and downlinking of satellite TV channels/ Set-up of Teleports permission: The permission for teleports is granted by MIB under the uplinking guidelines issued by MIB for making use of satellites.

F. Process for seeking in-principle clearance and other approvals for establishing satellite based communication network by a licensee:

2.49 'Guidelines for establishing satellite-based communication network(s)' issued by DoT on 26.10.2022, provide a procedural framework for seeking in-principle

clearance and other approvals for establishing satellite based communication network by a licensee. The Chapter-II of these Guidelines provides, *inter-alia*, as below:

"1. Providing any satellite-based communication service to the public or setting up a satellite-based network is a multi-stakeholder process that requires close coordination among the Department of Space (DoS), Ministry of Information & Broadcasting (MI&B), Department of Telecommunications (DoT) Satellite Licensing division, Wireless Planning & Coordination (WPC) Wing, Network Operations & Control Center (NOCC) and seeking separate authorization/ permissions by respective entity broadly indicated below:

a) Service license or appropriate authorization from DoT under the Indian Telegraph Act …
b) Space segment assignment to render the services through DOS/NSIL or space segment provider duly authorized by DoS/IN-SPACE,
c) Frequency assignment [Decision Letter (DL), SACFA clearance, & Wireless Operating License] from WPC.
d) Carrier plan approval and up-linking permission from NOCC.
e) Security clearance (wherever applicable)

In addition, Telecommunication Engineering Center (TEC) issues/ modifies the relevant standards including the interface Requirements from time to time. NOCC is responsible for monitoring the Satellite systems & resolving interference issues.

2. To bring these entities together, an Inter-Ministerial Committee for Satellite Network Clearance (IMC-SNC), hitherto known as Apex Committee, having representatives from these units has been authorized to provide a single platform to enable the issuance of "in-principle clearance" to the proposed network. If the application is in order, on the recommendation of IMC-SNC, Satellite Licensing division of DoT issues in-principle clearance to the applicant for establishing the satellite-based network."

2.50 The Para 1 of the Chapter-I of 'Guidelines for establishing satellite-based communication network(s)' issued by DoT on 26.10.2022 outlines the licensing regime of DoT for satellite-based communication services.

2.51 The Para 5 of the Chapter-I of 'Guidelines for establishing satellite-based communication network(s)' issued by DoT on 26.10.2022 provides the following framework for spectrum allotment and use:

"5.1 Right to use of spectrum: The in-principle clearance/ letter of intent/ the License Agreement for service authorization does not confer any right to assignment and use of spectrum for which separate specific Frequency Assignment is required from WPC Wing of DoT."

2.52 The Para 6 of the Chapter-I of 'Guidelines for establishing satellite-based communication network(s)' issued by DoT on 26.10.2022 provides the following framework for use of space segment:

"6.1 The required satellite capacity (space segment) shall be obtained by the Licensee from Department of Space (DoS)/NSIL or space segment provider duly authorized by DOS/ IN-SPACe on terms and conditions as applicable.
6.2 The satellite capacity (space segment) charges will be payable to DoS/ NSIL or space segment provider as applicable."

G. 5G and Non-Terrestrial Networks (NTN)

2.53 Terrestrial networks are currently focusing on delivery of 5G services to areas already being served by existing cellular technologies. However, the unique capabilities of non-terrestrial networks can help expand the reach of 5G technology in the realization of new use cases.

2.54 New advances in 5G standards are creating opportunities to integrate Non-Terrestrial Networks (NTN) into an interoperable, standardized wireless experience across the entire globe. Satellites are one of the elements of non-terrestrial networks. Other objects that can form part of a non-terrestrial network, includes High-Altitude Platform Stations (HAPS) such as balloons, air-

to-ground networks - those transmitted from aircraft, and Unmanned Aerial Vehicles (UAV's), each operating at different altitudes and providing different types of connectivity and capabilities.

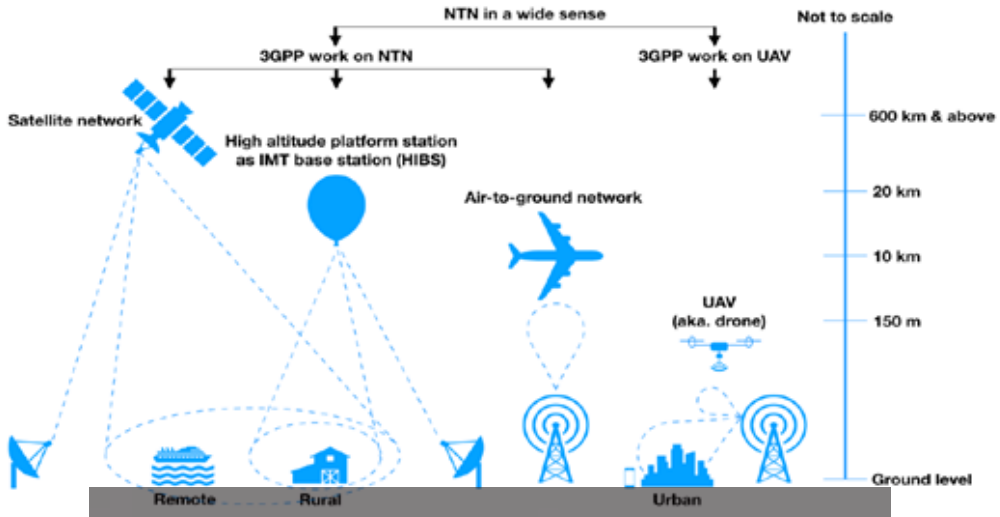


Figure 2.5: Different types of non-terrestrial networks, Source: IEEE Xplore

2.55 According to 3GPP[15], for the service continuity between NTN and Terrestrial Networks (TN), 5G system shall support service continuity between 5G terrestrial access network and 5G satellite access networks owned by the same operator or owned by two different operators having an agreement. The NTN and TN could either operate in two different frequency bands, or in same frequency bands.

[15] 3GPP TR 38.821 V16.1.0 (2021-05): Technical specification Group Radio Access Network: Solutions for NR to support non-terrestrial networks (NTN)

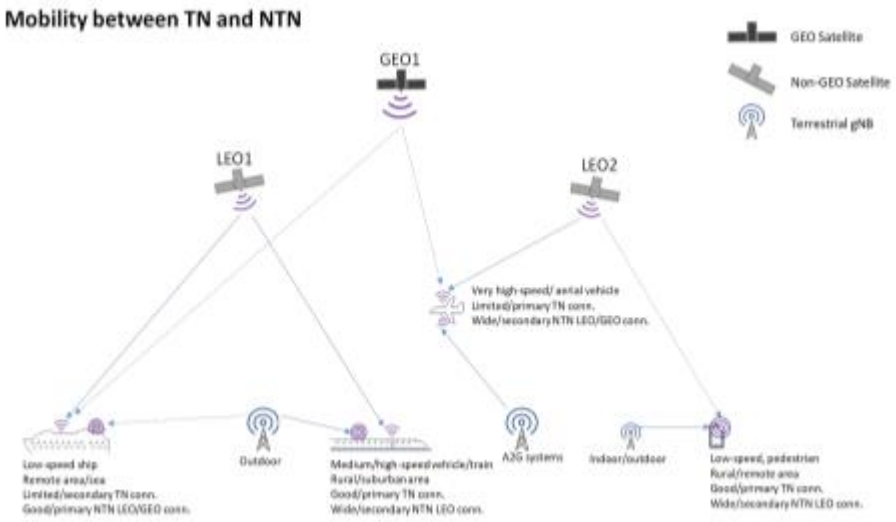


Figure 2.6: Typical example of NTN-TN interworking, Source 3GPP

2.56 As the growth of 5G wireless cellular networks continues to grow, there will be places where NTN and satellite access will potentially be needed. When NTNs can integrate with existing 5G coverage, it can extend the capabilities of 5G networks to places where cell coverage is not expected to reach.

H. Draft Spacecom Policy in India

2.57 The draft Spacecom Policy 2020 was released by the Department of Space in October 2020 with aims at meeting the growing demands of space-based communication requirements of the nation and advancements in the relevant technologies for self-sustenance in areas of commercial, secured, and societal communications. According to the draft policy, non-government private Indian entities are also proposed to be permitted to become significant players in the global space communication arena. The policy seeks a greater participation of Indian Industry to meet the demands in activities of realizing, owning, operating satellite systems for communications over India and outside, creating facilities for satellite control operations and so on. The Indian Spacecom Policy is expected to be finalized soon.

2.58 Service Providers have shown substantial interest for providing satellite broadband connectivity in India. Several players, who intend to offer satellite broadband services, are preparing to start operations in the country. DoT has

already granted Global Mobile Personal Communication by Satellite Services (GMPCS) authorization under Unified License to M/s Oneweb India Communications Private Limited and M/s Jio Satellite Communications Limited. It has been learnt that three other entities have submitted their applications for GMPCS authorization under Unified License.

2.59 The following chapter examines the issues relating to assignment of spectrum for space-based communication services.

CHAPTER-III: EXAMINATION OF ISSUES RELATED TO ASSIGNMENT OF SPECTRUM FOR SPACE-BASED COMMUNICATION SERVICES

A. Spectrum bands referred by DoT to TRAI for providing recommendations

3.1 DoT, through its reference letter dated 16.08.2022, provided a list of frequency bands that may be considered by TRAI for providing recommendations with respect to space-based communication services. These frequency bands include 'Planned bands' that when used by GSO systems in accordance with Appendices 30, 30A & 30B of Radio Regulations are reserved by ITU for use by National systems. Use of Planned Bands by foreign GSO satellites is not permitted in India. The following table enlists the frequency bands referred by DoT seeking TRAI recommendations:

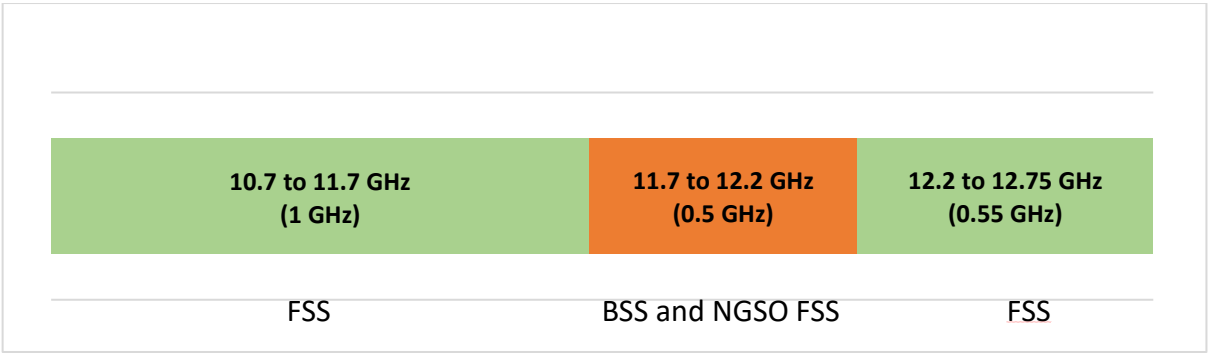
S. No.	Frequency Band	Quantum of spectrum	Link	Remarks
1	10.7 – 12.75 GHz	2.05 GHz	Space to Earth	
2	12.75 – 13.25 GHz	0.50 GHz	Earth to Space	
3	13.75 – 14.5 GHz	0.75 GHz	Earth to Space	
4	17.1 – 18.6 GHz	1.50 GHz	Space to Earth	17.7 – 18.4 GHz is used for Earth to Space also
5	18.8 – 19.3 GHz	0.50 GHz	Space to Earth	
6	19.3 – 19.7 GHz	0.40 GHz	Space to Earth	
7	19.7 – 21.2 GHz	1.50 GHz	Space to Earth	
8	27.5 – 29.5 GHz	2.00 GHz	Earth to Space	27.5 – 28.5 GHz has been identified for implementation of IMT in India.
9	29.5 – 31 GHz	1.5 GHz	Earth to Space	

Table 3.1: List of frequency bands referred by DoT

3.2 While providing the above list of frequency bands, DoT also mentioned that TRAI can however provide recommendations for other frequency bands also.

3.3 A brief description of the frequency bands specifically referred to TRAI by DoT is given below:

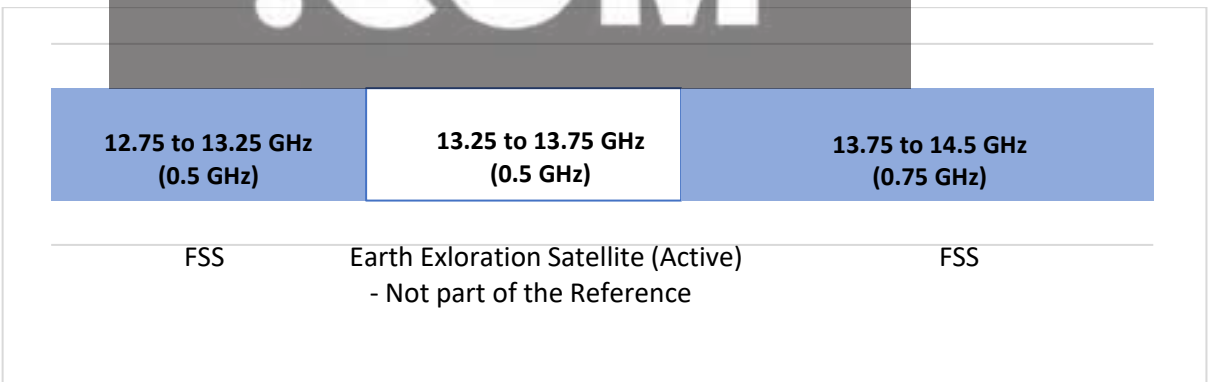
(1) 10.7-12.75 GHz (Ku Band) – Space to Earth



3.4 The band from 10.7-12.75 GHz (2.05 GHz) is downlink (Space to Earth) part of the Ku band. NFAP-2022 provides that 10.7-11.7 GHz and 12.2-12.75 GHz frequency bands can be used for FSS, whereas 11.7-12.2 can be used for BSS and NGSO FSS.

3.5 From the present frequency assignment information provided by DoT, it is observed that spectrum in 10.7-12.75 GHz band has been assigned for VSAT, IFMC, DTH, Teleport and DSNG services. It is also noted that BSS services are also operating in FSS bands.

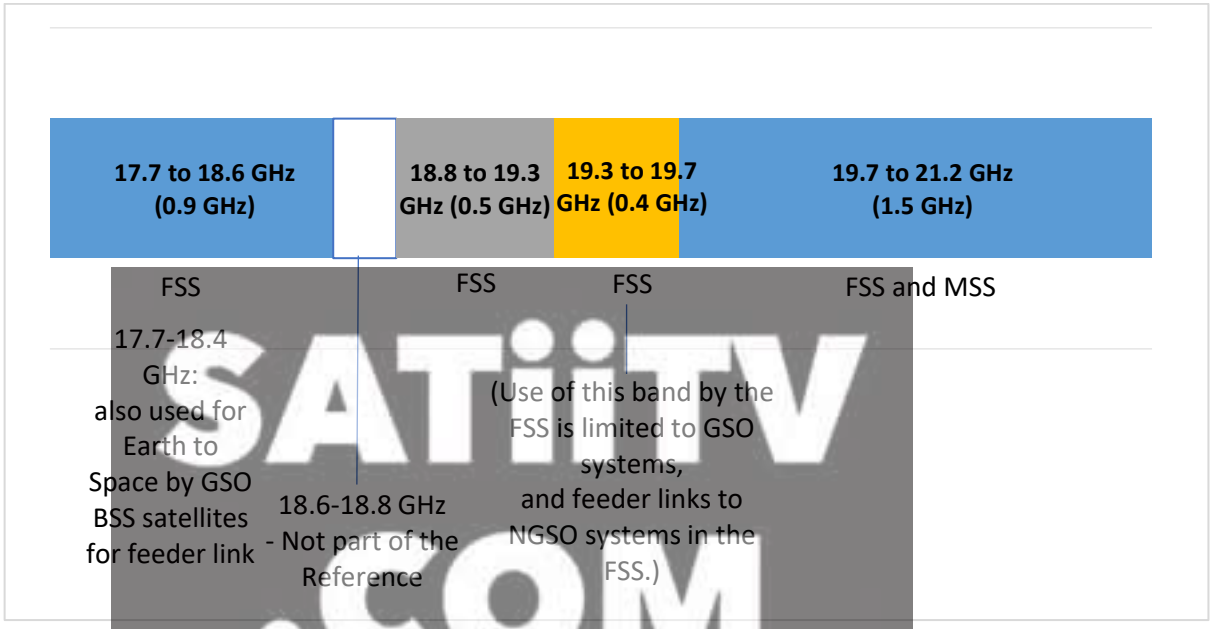
(2) 12.75-13.25 GHz and 13.75-14.5 GHz (Ku Band) – Earth to Space



3.6 The spectrum in 12.75-13.25 GHz band, and 13.75-14.5 GHz band (total 1.25 GHz) form the uplink (Earth to Space) part of the Ku band. These bands are allocated to FSS. The 13.25-13.75 GHz band is allocated to Earth Exploration Satellite (Active). The 13.25-13.75 GHz band has not been included in the Reference sent by DoT to TRAI.

3.7 From the frequency assignment information provided by DoT, it is observed that the spectrum in 12.75-13.25 GHz band, and 13.75-14.5 GHz band has been assigned for VSAT, IFMC, DTH, Teleport and DSNG services. It is also noted that BSS services are also operating in FSS bands. In the 13 GHz band, microwave access (MWA) service, which is used for cellular backhaul, coexists with FSS.

(3) 17.7-18.6 GHz and 18.8-21.2 GHz (Ka-Band) – Space to Earth



3.8 The spectrum in 17.7-18.6 GHz band and 18.8-21.2 GHz band (total 3.3 GHz) is downlink (Space to Earth) part of the Ka band for FSS services. From the frequency assignment information provided by DoT, it is observed that spectrum in these bands has been assigned for VSAT, IFMC and DTH services. Currently, MWA services coexists with FSS in 18 GHz frequency band. As per the NFAP-2022, the spectrum in 18.6-18.8 GHz band is exclusively earmarked for Earth Exploration Satellite Service (EESS-passive) in IRS Satellite system and this frequency band has not been included in the Reference sent by DoT to TRAI.

3.9 17.7-18.6 GHz band (0.9 GHz): This frequency band is to be used for FSS. DoT in its reference has mentioned that 17.7-18.4 GHz band is also used for Earth

to Space. As per ITU-Radio Regulations, this band can also be used for Earth to Space by GSO systems in FSS limited to feeder links for BSS.

3.10 18.8-19.3 GHz band (0.5 GHz): This frequency band is to be used for FSS. As per ITU-Radio Regulations, provisions relating to NGSO networks to provide protection to GSO network do not apply to this frequency band. However, it is subject to the application of the provisions of clause 9.11A of ITU-Radio Regulations with respect to the coordination requirement.

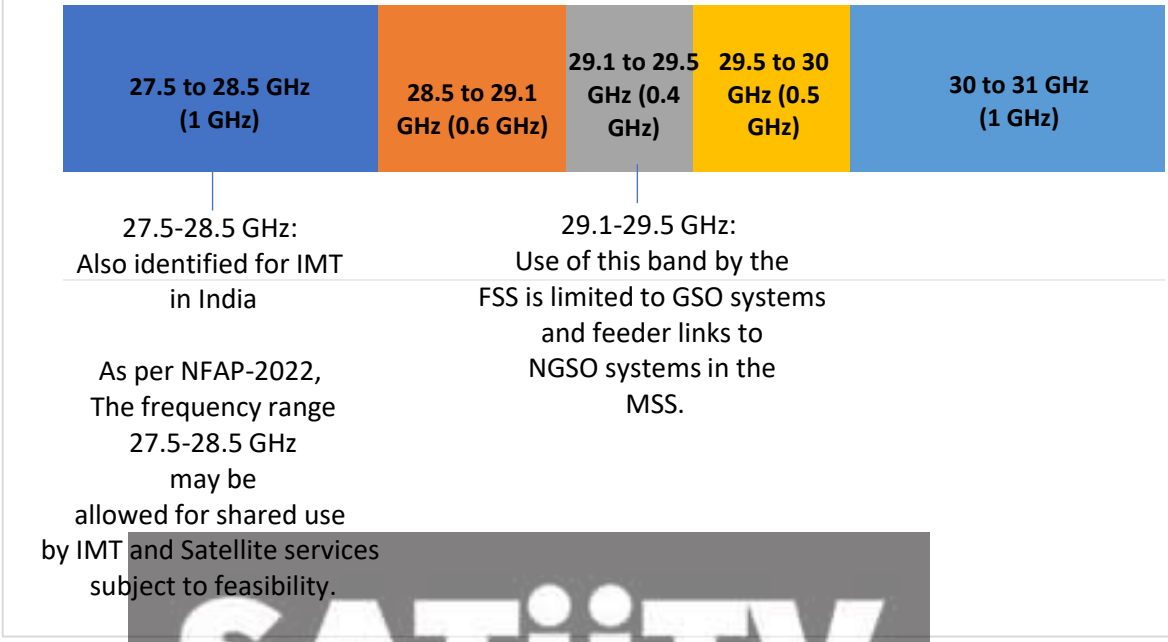
3.11 19.3-19.7 GHz band (0.4 GHz): This frequency band can be used for GSO FSS and for gateway links for NGSO FSS. Such use is subject to the application of the provisions of clause 9.11A of ITU-Radio Regulations with respect to coordination, but not subject to the provisions of clause 22.2 of ITU-Radio Regulations[16] relating to NGSO networks to protect GSO networks.

3.12 19.7-20.2 GHz band (0.5 GHz): The spectrum in 19.7-20.1 GHz band is allocated to FSS (Space to Earth) as a primary user. The spectrum in 20.1-20.2 GHz band is allocated to FSS (Space to Earth) and MSS (Space to Earth) on co-primary basis.

3.13 20.2-21.2 GHz (1 GHz): This frequency band is allocated to FSS (Space to Earth) and MSS (Space to Earth) on co-primary basis. As per the information provided by DoT, this frequency range has not been planned by any NGSO networks.

[16] The Article 22.2 of ITU RR provides that *"[n]on-geostationary-satellite systems shall not cause unacceptable interference to and, unless otherwise specified in these Regulations, shall not claim protection from geostationary satellite networks in the fixed-satellite service and the broadcasting-satellite service operating in accordance with these Regulations. …"*

(4) 27.5-31 GHz (Ka-Band) – Earth to Space



3.14 The spectrum in 27.5-31 GHz band (total 3.5 GHz) is uplink (Earth to Space) part of the Ka band for FSS. From the frequency assignment information provided by DoT, it is observed that spectrum in this band has been assigned for VSAT and IFMC services.

3.15 27.5-28.5 GHz band (1 GHz): DoT, through its letter dated 16.08.2022, has conveyed that 27.5-28.5 GHz band has been identified for implementation of International Mobile Telecommunication (IMT) in India. As per the frequency assignment information provided by DoT, the spectrum in 27.5-28.5 GHz band has been assigned only for IFMC services to one of the licensees. Since IFMC services are used for communication in the airspace or water bodies, it gets geographically separated from the terrestrial IMT services. As per the footnote IND 16 Note 7(ii) of NFAP-2022, the frequency range 27.5-28.5 GHz may be allowed for shared use by IMT and Satellite services subject to feasibility.

3.16 28.6-29.1 GHz band (0.5 MHz): The provisions of ITU-Radio Regulations relating to NGSO networks to provide protection to GSO network, do not apply to this frequency range. However, this frequency band is subject to the

application of the provisions of clause 9.11A of ITU-Radio Regulations with respect to coordination requirement.

3.17 29.1-29.5 GHz band (0.4 GHz): In this band, use by the FSS is limited to GSO systems and feeder links to NGSO systems in the MSS. Such use is subject to the application of the provisions of No. 9.11A of ITU-Radio Regulations, but not subject to the provisions of No. 22.2 of ITU-Radio Regulations.

3.18 29.5-29.9 GHz band (0.4 GHz): This frequency band is allocated to FSS (Earth to Space) on primary basis.

3.19 29.9-30 GHz band (0.1 GHz): This frequency band is allocated to FSS (Earth to Space) and MSS (Earth to Space) on co-primary basis.

3.20 30-31 GHz (1 GHz): This frequency band is allocated to FSS (Earth to Space) and MSS (Earth to Space) on co-primary basis. As per the information provided by DoT, this frequency range has not been planned by any NGSO networks.

3.21 As per the footnote IND 17 of the NFAP 2022, the bands 14-14.5 GHz (Earth to space), 28.5-30 GHz (Earth to space), 10.7-11.7 GHz (space-to-Earth), 12.5-12.75 GHz (space-to-Earth) and 18.7-20.2 GHz (space-to-Earth) may be used for earth-stations on land transportations, ships and aircrafts, as per the applicable provisions of the Radio Regulations and/ or its Resolutions.

3.22 As per the footnote IND 32 of the NFAP 2022, the frequency bands 19.7-21.2 GHz and 29.5-31.0 GHz may be considered predominantly for the use of FSS.

B. Assessment of demand for space-based communication services

3.23 DoT, through its letter dated 16.08.2022, requested, *inter-alia*, that TRAI, through consultations, may assess the demand for space-based communication services and accordingly provide recommendations on the quantum of spectrum in each band required to be put to auction.

3.24 Space-based communication services include both telecommunication services and broadcasting services. In case of satellite-based telecommunication

services, frequency spectrum requires to be assigned for forward link as well as return link. On the other hand, in case of satellite-based broadcasting services, frequency spectrum requires to be assigned only for forward link. Forward link is a communication link from gateway-to-satellite-to-user terminal. Return link is a communication link from user terminal-to-satellite-to-gateway.

3.25 Space-based telecommunication services involve frequency spectrum for establishing four types of links, viz.

(i) user link (uplink)

(ii) user link (downlink)

(iii) gateway link (uplink), and

(iv) gateway link (downlink).

The link between the satellite and user terminals is a user link. The link between satellite and satellite earth station gateway is gateway link.

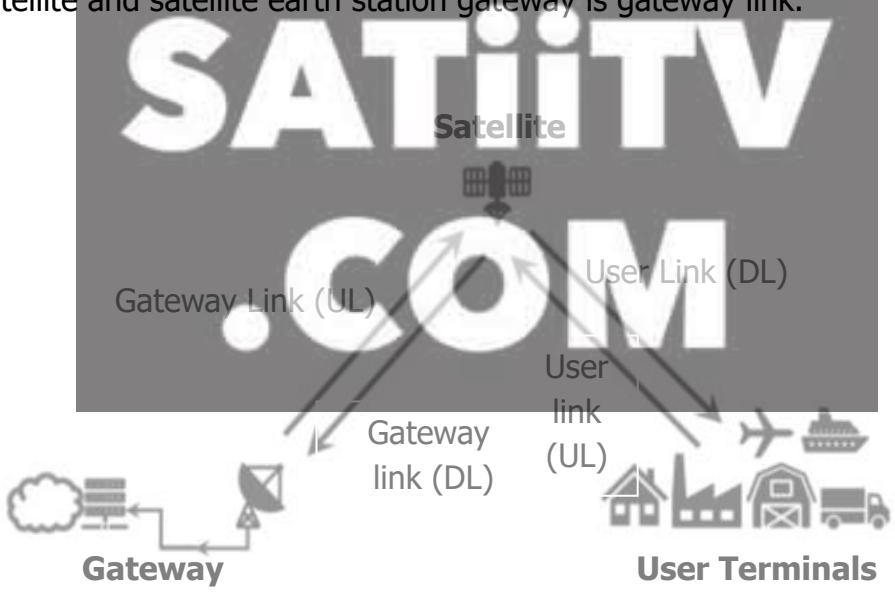


Figure 3.1: Communications links in space-based telecommunication services

3.26 On the other hand, space-based broadcasting services involve frequency spectrum for establishing two types of links, viz.

(i) gateway link (uplink)

(ii) user link (downlink)

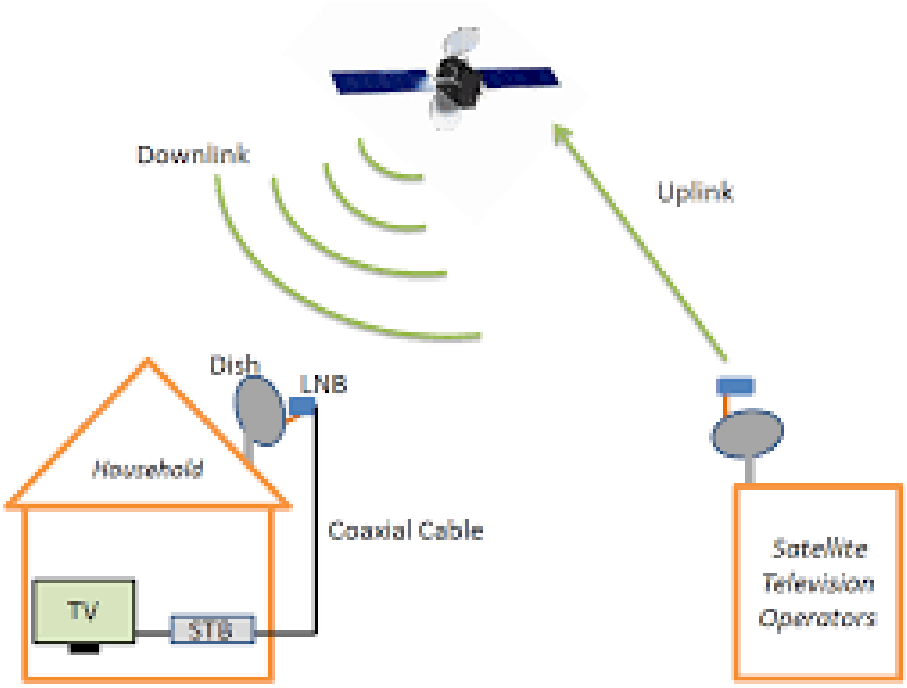


Figure 3.2: Communications links in space-based broadcasting services

3.27 Apart from Ku-band and Ka-band, space-based communication systems have been deployed in various other frequency bands, such as L-band, S-band, and C-band. Further, the new-generation satellite communication systems have plans for deployment in higher bands such as the lower part of V-band (37.5 to 52.4 GHz) for user links as well as gateway links and E-band (71-76 GHz/ 81-86 GHz) for gateway links.

3.28 Beam width of the user terminals in the lower frequency bands (viz. L-band and S-band) is much wider than that for the user terminals in the higher frequency bands (such as C-band, Ku-band, and Ka-band). Therefore, as already indicated in the Chapter-II, currently frequency reuse in L-band and S-band is not possible within the same geographical area for MSS. Hence, the frequency spectrum in these bands is assigned to service providers on exclusive basis for providing MSS. On the other hand, as the user terminals of the higher frequency bands employ highly directional beam, the same frequency spectrum in C-band, Ku-band and Ka-band can be assigned to different service providers on shared basis in the same geographical area.

3.29 In India, spectrum in L-band is being used by a public sector undertaking (PSU) under '*sui-generis*' category license for MSS. At present, there is no assignment of frequency spectrum for commercial communication services in S-band.

3.30 The spectrum in C-band has been assigned to broadcasting operators, VSAT operators, and the PSU under '*sui-generis*' category license etc. The lower part of V band is being planned by many NGSO constellations, both for user terminal link and gateway link; parts of the V-band (37-43.5 GHz, 45.4-47 GHz, 47.2-48.2 GHz and 66-71 GHz) have also been identified by ITU for IMT services. The frequency spectrum in E-band is being planned for deployment of gateway link by one of the NGSO constellations. The E-band is also being used for terrestrial cellular backhaul in India. Some parts of the C-band and Ka-band (28 GHz) are being used for IMT services in some countries. However, the C-band and Ka-band could be of critical importance for satellite communication systems, as described below.

3.31 C-band offers good propagation characteristics, utilizes a mature technology, resulting in low-cost equipment, making it the preferred option to serve remote and rural areas, particularly in large countries with severe climate conditions. Ka-band has particularly favorable qualities given the large amount of satellite spectrum allocated on a global basis, easy sharing conditions (mainly in the corresponding downlink at 18 GHz), small size terminals ideal for installation on ships and aircraft, and an advantageous regulatory deployment framework adopted in the ITU Radio Regulations for Earth Stations in Motion (ESIMs).

3.32 Technical Characteristics of higher spectrum bands for space-based communication services are depicted below:

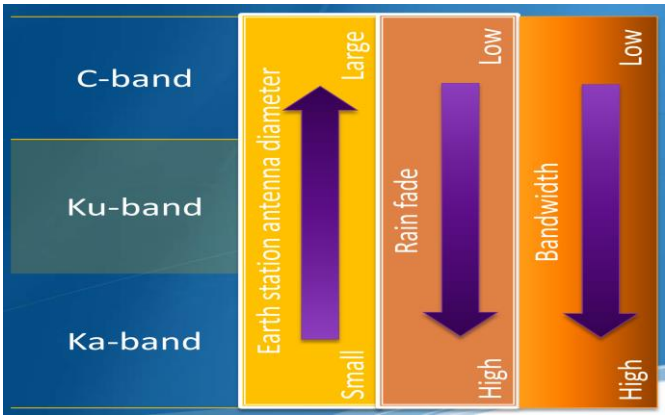


Figure 3.3: Technical Characteristics of higher spectrum bands[17]

3.33 As per the technical characteristics of frequency bands, the lower frequency bands such as C-band are less susceptible to interference from adverse weather or 'rain fade'. On the other hand, the higher frequency bands such as Ka-band is significantly prone to rain fade. However, various technologies such as Flex Adaptive Code Modulation[18] have been developed to mitigate the impact of rain fade. The technology automatically adapts the down-link signal (the signal sending data from the satellite to the user) to compensate for changing weather conditions. On the positive side, the higher frequency bands in space-based systems, represents lower capital expenditure (CAPEX). Compared to Ku-band, the Ka-band deployments have lower cost owing to smaller antenna i.e., lower manufacturing cost and lower transportation cost. Further, the materials required to fix a Ka-band antenna and the labor time needed to install the system are both lower, which also contribute to favorable expenditure with the use of Ka-band as compared to Ku-band. The following table depicts a comparison of Ku-band and Ka-band.

[17] Source: https://itso.int/wp-content/uploads/2018/04/Day-1-ITU-2-Spectrum-and-Int-Regulartoy-Framwork.pdf

[18] http://www.aidforum.org/topics/technology-data/ka-vs-ku-band-which-is-the-best-for-satellite-broadband/

	Ka-band	Ku-band
Availability	High	High
Bits per Hz (efficiency)	High	Low
Throughput (speed)	High	Comparatively low
Antenna/equipment cost	$250 - $380	$1,000 - $1,800
Power Requirement	Lower	Higher

Table 3.2: Comparison of Ku-band and Ka-band[19]

3.34 As mentioned earlier, DoT has requested that through consultations, TRAI may assess the demand for space-based communication services and provide recommendations on the quantum of spectrum in each band required to be put to auction. With respect to gateway links, DoT in its reference has mentioned that the NGSO satellite may use the entire band.

3.35 TRAI through its letter dated 19.10.2022 to DoT requested, *inter-alia*, to clarify as to for which of licensed telecommunication and broadcasting services, spectrum for space-based communication has been envisaged to be granted through Auction. In response, DoT through its letter dated 16.12.2022, mentioned that TRAI may provide suitable recommendations for each of the space-based communication services after detailed examination.

3.36 In this background, the Authority solicits comments of stakeholders on the following set of questions:

Issues for consultation

Q1. For space-based communication services, what are the appropriate frequency bands for (a) gateway links and (b) user links, that should

[19] Source: http://www.aidforum.org/topics/technology-data/ka-vs-ku-band-which-is-the-best-for-satellite-broadband/

be considered under this consultation process for different types of licensed telecommunications and broadcasting services? Kindly justify your response with relevant details.

Q2. What quantum of spectrum for (a) gateway links and (b) user links in the appropriate frequency bands is required to meet the demand of space-based communication services? Information on <u>present demand</u> and <u>likely demand after about five years</u> may kindly be provided in two separate tables as per the proforma given below:

Type of service	Name of the satellite system	Type of satellite (GSO/ LEO/ MEO)	Frequency range and quantum of spectrum required							
			User Link (Earth to space UL)		User Link (Space to Earth DL)		Gateway Link (Earth to space UL)		Gateway Link (Space to Earth DL)	
			Frequency range	Quantum (in MHz)	Frequency range	Quantum (in MHz)	Frequency range	Quantum (in MHz)	Frequency range	Quantum (in MHz)
Access										
Internet										
NLD										
ILD										
GMPCS										
VSAT CUG (Commercial)										
Captive VSAT CUG										
Machine to Machine (M2M)										
DTH										
Teleport										

DSNG										
HITS										
IFMC										
Any other relevant service (please specify)										

C. Feasibility of assignment of frequency spectrum for space-based communication services on exclusive basis

3.37 DoT, through its letter dated 16.08.2022, stated that *"[i]t is envisaged to auction the Space Spectrum on exclusive basis. TRAI may explore the feasibility and procedure of sharing auctioned spectrum among multiple service licensees. TRAI may provide recommendations on sharing of auctioned frequency bands between satellite networks and terrestrial networks also, the criteria for sharing and appropriate interference mitigation techniques for sharing and coexistence."*

3.38 As indicated above, the frequency spectrum in the lower bands (viz. L-band and S-band), which are allocated for MSS, may not be reused within the same geographical area owing to large beam width of antennas used in these bands. Therefore, the frequency spectrum in these bands may easily be assigned exclusively. On the other hand, the frequency spectrum in the higher bands (such as C-band, Ku-band and Ka-band) which are allocated mainly to FSS and BSS, may be assigned to several service providers owing to highly directional beam of antennas used in these bands.

3.39 As mentioned earlier, in India, frequency spectrum in the L-band has been assigned to a PSU under *'sui generis'* category license for providing MSS. Frequency spectrum in S-band has not yet been assigned to any commercial service provider. Frequency spectrum in C-band, Ku-band and Ka-band has

been assigned for providing GSO-FSS and GSO-BSS. The same frequency spectrum in C-band, Ku-band and Ka-band has been assigned to several service providers in the country on non-interference, non-protection basis. Within the ITU framework, multiple service providers have been using the same frequency spectrum without harmful interference. As per the information provided by DoT through the letter dated 16.08.2022, many NGSO systems have planned to use frequency spectrum in Ku-band and Ka-band. Some NGSO systems have also planned to use frequency spectrum in E band and V Band.

3.40 As per the ITU framework, NGSO systems are generally required to provide protection to GSO systems. The Article 22.2 of ITU RR provides as below:
"Non-geostationary-satellite systems shall not cause unacceptable interference to and, unless otherwise specified in these Regulations, shall not claim protection from geostationary satellite networks in the fixed-satellite service and the broadcasting-satellite service operating in accordance with these Regulations. ..."

3.41 In the frequency bands, for which Article 22.2 does not apply, NGSO networks are required to coordinate with the existing GSO networks (Article 9.11A of ITU RR). Further, for coexistence of NGSO networks, as per ITU framework, any upcoming NGSO network is required to coordinate with the existing NGSO networks.

3.42 In short, owing to angular separation, altitude separation, polarization and ITU's framework on coordination mechanism, the frequency spectrum in the higher spectrum bands such as C band, Ku-band and Ka-band can be used by multiple service providers using GSO/ NGSO satellites networks in the same geographical area.

3.43 In the case of GSO satellites, the same frequency spectrum can be used by multiple GSO satellite systems as long as they are sufficiently apart in terms of angular separation. Same frequency spectrum with different polarization can be used in case two satellites systems have insufficient angular separation between them. Thus, there would be a practical limit on the number of GSO

satellite systems that can use the same frequency spectrum in a coordinated manner.

3.44 In the case of NGSO satellite constellations, the same frequency spectrum is used by different satellite constellations by adopting coordination techniques. However, in instances such as in-line events where a satellite comes in the same line-of-sight path between the earth station and the satellite of another constellation, the satellite operators might have to split frequency spectrum among themselves as a last resort. Thus, there would be a practical limit on the number of NGSO satellite systems that can use the same frequency spectrum in a coordinated manner on an equitable basis.

3.45 In its publication[20] titled 'Spectrum Sharing Rules for Non-Geostationary Orbit, Fixed-Satellite Service Systems', Federal Communication Commission (FCC) in the USA mentions that *"[t]he Commission has adopted rules for spectrum sharing among NGSO FSS systems. NGSO FSS operators must coordinate with one another in good faith the use of commonly authorized frequencies. Absent a coordination agreement between two or more NGSO FSS satellite systems, a default spectrum-splitting procedure applies. Under the default spectrum-splitting procedure, whenever the increase in system noise temperature of an earth station receiver, or a space station receiver for a satellite with on-board processing, of either system, ΔT/T, exceeds 6 percent due to interference from emissions originating in the other system in a commonly authorized frequency band, such frequency band will be divided among the affected satellite networks in accordance with the following: (1) Each of η (number of) satellite networks involved must select 1/η of the assigned spectrum available in each of these frequency bands; (2) the affected station(s) of the respective satellite systems may operate in only the selected (1/η) spectrum associated with its satellite system while the ΔT/T of 6 percent threshold is exceeded; and (3) all*

[20] Source: https://www.federalregister.gov/documents/2022/01/24/2022-01204/spectrum-sharing-rules-for-non-geostationary-orbit-fixed-satellite-service-systems

affected station(s) may resume operations throughout the assigned frequency bands once the threshold is no longer exceeded."

3.46 DoT in its letter dated 16.08.2022 has mentioned that it is envisaged to auction the spectrum for space-based communication services on an exclusive basis. It is noted that as per the existing framework in India, the satellite-based service providers obtain transponder capacity from Department of Space (DoS). A service provider may require a specific frequency range as per the availability of transponders on satellites, and many times, the same frequency range may be required to be used by another service provider with a different satellite system. In case frequency spectrum is assigned to space-based service providers on an exclusive basis, the same frequency range cannot be assigned to other service providers. Therefore, there may be a need to explain what exclusive spectrum assignment means for satellite communication services, which cannot be similar to the way exclusive spectrum assignment is made for IMT.

3.47 For exclusive assignment of spectrum, there may be a need to prescribe the block size, minimum number of blocks per licensee and maximum number of blocks per licensee (spectrum cap), roll out obligations, etc. However, in case some spectrum cap is prescribed, the service licensees may not be able to utilize the entire capacity of the satellite system. Therefore, there may be a need to permit intra-band spectrum sharing among the licensees holding spectrum. In its reference, DoT has also envisaged to permit sharing of frequency spectrum. However, in case service providers are granted exclusive rights to use separate frequency ranges (as is being currently practiced in case of assignment of spectrum for IMT), there could be a scenario that some service providers decide not to share their frequency spectrum with other service licensees holding spectrum in a spectrum band, and in effect, cause harm to the satellite communication ecosystem. This may also result into inefficient use of frequency spectrum. To avoid such a scenario, one way could be mandating intra-band spectrum sharing among the service licensees holding spectrum in a particular spectrum band. However, there could be a scenario that the service licensees

may decide to acquire small or minimum quantum of spectrum and thereafter pool/ share frequency spectrum among themselves. In such a situation, there could be difficulty in market discovery of price for spectrum. One possible way to handle such a scenario could be to mandate intra-band spectrum sharing among licensees who have acquired spectrum upto the prescribed spectrum cap, and the spectrum shared from other licensees may not be counted for the purpose of spectrum cap. Further, for the arrangement of spectrum sharing to work efficiently, some additional conditions may have to be put in place at the time of spectrum auction. One of the possible auction design models for exclusive spectrum assignment has been discussed in the subsequent section.

3.48 In case entire spectrum in a spectrum band has been assigned/ auctioned to the service providers on exclusive basis, a question arises as to what provisions should be made applicable on any new entrant or any entity who could not acquire spectrum.

- One option could be that such entity can again take part in the next auction/ assignment cycle after expiry of the validity period of the assigned spectrum and therefore, it might be appropriate to keep the medium-term validity period. In the next spectrum auction/ assignment cycle, considering the demand of spectrum in the frequency band and other market conditions, spectrum cap can be revised.

- Another option could be that new entrant or any entity who could not acquire spectrum may be permitted to share spectrum from the service licensees holding spectrum in that band. While such an option provides an opportunity for the new entrants and the licensees who could not acquire spectrum because of exclusive assignment to provide services, it could go against the rationale of auction and may also have an adverse impact on the dynamics of spectrum auction.

- Yet another option could be that since the satellite services in higher bands (such as C-band, Ku-band, and Ka-band) are of the nature that it can practically support many satellite-based players using the same frequency

spectrum, in case an auction based on exclusive assignment is held in a spectrum band, after a certain number of years, the same spectrum can be again put to auction for the new entrants including the service licensee which could not acquire spectrum in the previous auction. One may contend that the validity period of the spectrum, which is auctioned on a later date, should be co-terminus with the validity period of the first held auction and once that period expires, all the service licensees together can take part in the next cycle of auction. With this option, a longer validity period for spectrum, can be supported.

3.49 One may also contend that for ease of doing business, a service provider holding space spectrum should be permitted to trade and/ or lease their partial or entire satellite spectrum holding to other eligible service licensees, including the licensees who do not hold any spectrum in the concerned spectrum band. However, a contrary view could be that if satellite spectrum is assigned for a medium-term validity period, there may not be a need to permit spectrum trading and leasing. Further, permitting spectrum trading and leasing could possibly disturb the dynamics of spectrum auction.

3.50 For the existing service providers, who are successful bidders in the auction process, may require to be permitted to retain the previously held frequency range to avoid any disruption of services, hardship and cost. In case such a requirement exists, issue arises as to what mechanism should be prescribed.

3.51 In this background, the Authority solicits comments of stakeholders on the following set of questions:

Issues for consultation

Q3. Whether there is any practical limit on the number of Non-Geo Stationary Orbit (NGSO) satellite systems in Low Earth Orbit (LEO) and Medium Earth Orbit (MEO), which can work in a coordinated manner on an equitable basis using the same frequency range? Kindly justify your response.

Q4. For space-based communication services, whether frequency spectrum in higher bands such as C band, Ku band and Ka band, should be assigned to licensees on an exclusive basis? Kindly justify your response. Do you foresee any challenges due to exclusive assignment? If yes, in what manner can the challenges be overcome? Kindly elaborate the challenges and the ways to overcome them.

Q5. In case it is decided to assign spectrum in higher frequency bands such as C band, Ku band and Ka band for space-based communication services to licensees on an exclusive basis,

(a) What should be the block size, minimum number of blocks for bidding and spectrum cap per bidder? Response may be provided separately for each spectrum band.

(b) Whether intra-band sharing of frequency spectrum with other satellite communication service providers holding spectrum upto the prescribed spectrum cap, needs to be mandated?

(c) Whether a framework for mandatory spectrum sharing needs to be prescribed? If yes, kindly suggest a broad framework and the elements to be included in the guidelines.

(d) Any other suggestions to ensure that that the satellite communication ecosystem is not adversely impacted due to exclusive spectrum assignment, may kindly be made with detailed justification.

Kindly justify your response.

Q6. What provisions should be made applicable on any new entrant or any entity who could not acquire spectrum in the auction process/assignment cycle?

(a) Whether such entity should take part in the next auction/ assignment cycle after expiry of the validity period of the

assigned spectrum? If yes, what should be the validity period of the auctioned/assigned spectrum?

(b) Whether spectrum acquired through auction be permitted to be shared with any entity which does not hold spectrum/ or has not been successful in auction in the said band? If yes, what measures should be taken to ensure rationale of spectrum auction and to avoid adverse impact on the dynamics of the spectrum auction?

(c) In case an auction based on exclusive assignment is held in a spectrum band, whether the same spectrum may again be put to auction after certain number of years to any new entrant including the entities which could not acquire spectrum in the previous auction? If yes,

(i) After how many years the same spectrum band should be put to auction for the potential bidders?

(ii) What should be the validity of spectrum for the first conducted auction in a band? Whether the validity period for the subsequent auctions in that band should be co-terminus with the validity period of the first held auction?

Kindly justify your response.

Q7. Whether any entity which acquired the satellite spectrum through auction/assignment should be permitted to trade and/or lease their partial or entire satellite spectrum holding to other eligible service licensees, including the licensees which do not hold any spectrum in the concerned spectrum band? If yes, what measures should be taken to ensure rationale of spectrum auction and to avoid adverse impact on the dynamics of the spectrum auction? Kindly justify your response.

Q8. For the existing service licensees providing space-based communication services, whether there is a need to create enabling provisions for assignment of the currently held spectrum frequency range by them, such that if the service licensee is successful in acquiring required quantum of spectrum through auction/ assignment cycle in the relevant band, its services are not disrupted? If yes, what mechanism should be prescribed? Kindly justify your response.

3.52 In case it emerges that despite creating the above provisions, exclusive assignment of frequency spectrum in higher frequency bands such as C-band, Ku-band and Ka-band for satellite communication services is not a practical solution, there may be a need to explore the ways in which the auction-based assignment of spectrum for its shared use could be achieved. One of the possible auction design models has been discussed in the subsequent section which envisages shared spectrum assignment.

3.53 Further, it may need to be deliberated that whether a broad framework for sharing of frequency spectrum among satellite communication service providers needs to be prescribed or it should be left to mutual coordination.

Issues for Consultation

Q9. In case you are of the opinion that the frequency spectrum in higher frequency bands such as C band, Ku band and Ka band for space-based communication services should be assigned on shared (non-exclusive) basis, -

(a) Whether a broad framework for sharing of frequency spectrum among satellite communication service providers needs to be prescribed or it should be left to mutual coordination? In case you are of the opinion that broad framework should be prescribed, kindly suggest the framework and elements to be included in such a framework.

(b) Any other suggestions may kindly be made with detailed justification.

Kindly justify your response.

D. Feasibility of Flexible use of spectrum in 27.5-28.5 GHz band and 28.5-29.5 GHz band

3.54 DoT, in its letter dated 16.08.2022, has mentioned that for spectrum in 27.5-28.5 GHz band (identified for IMT) and 28.5-29.5 GHz band (being studied for Captive Non-Public Networks), TRAI may recommend mechanism for sharing of auctioned frequency bands in which both IMT/ CNPN and satellite-based services (both user terminal and Gateways) can be provided in a flexible manner.

(a) 27.5-28.5 GHz band

3.55 As per the footnote IND 16 Note 7(ii) of NFAP 2022, the 27.5-28.5 GHz band may be allowed for shared use by IMT and satellite services subject to feasibility.

3.56 About the spectrum in 27.5-28.5 GHz band, TRAI in its recommendations on 'Auction of spectrum in frequency bands identified for IMT/5G' dated 11.04.2022, had recommended, *inter-alia*, the following:

a) *As mmWave spectrum is going to be used for capacity requirement, its deployment is not likely to be ubiquitous rather it is more likely to be kind of hotspots or urban micro cells. Therefore, IMT Stations and Satellite Earth Stations Gateway (Earth to Space) can co-exist in 27.5-28.5 GHz frequency range. The Satellite Earth Station Gateway should be permitted to be established in frequency range 27.5-28.5 GHz at uninhabited or remote locations on case-to-case basis, where there is less likelihood of 5G IMT services to come up.*

b) DoT should prescribe the exclusion zone requirement for co-existence of IMT and satellite earth stations (Earth to space) in 27.5-28.5 GHz frequency range.

c) *DoT should create a software defined automated process on a portal having database of coordinates of the IMT base stations in mmWave. The geofencing coordinates of the proposed earth station in 27.5-28.5 GHz can provide the feasibility results through the portal for establishing the earth station.*

d) *Access to 27.5-28.5 GHz should also be allowed for Earth Stations In Motion (ESIMs) for In-flight and Maritime terminals, with appropriate sharing conditions, as in such cases, the operation would be geographically separated from terrestrial IMT.*

e) *Spectrum dues for 27.5-28.5 GHz frequency range can be revised on pro-rata basis for the mobile operator holding spectrum in the LSA, in which the permission for establishing earth station is given in the same frequency range, on account of creation of exclusion zone.*

3.57 As can be seen from the above, the Authority had recommended for coexistence of IMT stations and satellite earth stations gateway (Earth to Space) in 27.5-28.5 GHz band.

3.58 It is worth noting that the term 'co-existence' in a frequency range is used to connote the use of a frequency range by multiple service providers for offering different communication services simultaneously. The co-existence of different communication services offered by different service providers in a frequency band is made possible either by prescribing power limits within which the services may operate, or by ensuring separation of the contending services in space or time domain. On the other hand, the term 'flexible use' of spectrum in a frequency range, is used to connote the use of a frequency range by the same service provider for offering more than one type of services.

3.59 DoT in its reference has envisaged flexible use of the spectrum in 27.5-28.5 GHz band. This would enable the successful bidder to deploy IMT services and satellite-based user terminals, based on the physical characteristics and business potential of a geographic area.

3.60 It is noted that USA was the one of the few early adopters of 28 GHz band for IMT. In 1996, FCC designated 850 MHz in 27.5-28.35 GHz band for Local Multipoint Distribution System (LMDS)[21] on a primary basis, along with other band segments, and permitted GSO FSS or NGSO FSS systems to provide links in that band segment on a non-interference basis to LMDS systems, but only for the purpose of providing limited Earth-to-Space gateway-type services. In 2016, while FCC[22] was planning to auction spectrum in 27.5-28.35 GHz band (850 MHz) for flexible use Upper Microwave Flexible Use Service (UMFUS[23]) licenses, FCC was disinclined to automatically grant co-primary status for all FSS operations in the 27.5-28.35 GHz band, principally because it would be inconsistent with the development of terrestrial mobile service in the band. With respect to gateways, however, FCC proposed that satellite operators could acquire terrestrial flexible use UMFUS licenses enabling them to exclude terrestrial operators that might be subject to interference from within the license area. After due examination of the comments received from the stakeholders, FCC decided to maintain the current status of FSS, create new opportunities for continued expansion of FSS earth stations on a protected basis. FCC noted that the ability of satellite earth stations and terrestrial operations to coexist in close proximity to each other has two significant ramifications. First, it should be possible for satellite and terrestrial services to share the 28 GHz band with *de minimis* impairment of each other's operations. Second, the disparity between the county-sized license areas established for 28 GHz UMFUS licensees and the extremely small areas required for FSS earth stations makes it inappropriate to rely exclusively on a market-based

[21] Local Multipoint Distribution System (LMDS) is a fixed service (point-to-point or point-to-multipoint). LMDS is a broadband wireless access technology.

[22] https://docs.fcc.gov/public/attachments/FCC-16-89A1.pdf

[23] UMFUS is the collective term the FCC uses for innovative fixed, temporary fixed, mobile and Internet of Things (IoT) terrestrial wireless services using bandwidth that is sufficient for the provision of a variety of applications, including those using voice and data (such as Internet browsing, message services, and full-motion video) content. The services provided by UMFUS licensees are limited only by the Fixed, Mobile, and co-primary Fixed Satellite Service (FSS).
Source:https://www.fcc.gov/wireless/bureau-divisions/broadband-division/upper-microwave-flexible-use-service-umfus

mechanism for assigning rights to FSS earth stations, although this option is retained as one means through which FSS operators may expand. In addition to acquiring the terrestrial license rights, it was decided to continue to authorize gateway satellite earth stations under the existing first-come, first-served basis, subject to compliance of following conditions:

a. First, no more than three locations in each county will be authorized where FSS may deploy earth stations on a protected basis.

b. Second, an FSS applicant must demonstrate in its license application that the permitted interference zone around its earth station, which will be defined as the contour within which FSS licensees generate a power flux density (PFD), at 10 meters above ground level, of no more than -77.6 dBm/m^2/MHz, together with any pre-existing earth stations located in the same county on a protected basis, will, in the aggregate, cover no more than 0.1 percent of the population of the county license area where the earth station is located.

c. Third, the applicant must show that the permitted interference zone does not infringe upon any major event venue, arterial street, interstate or U.S. highway, urban mass transit route, passenger railroad, or cruise ship port.

d. Fourth, prior to filing its application, if there is an existing 28 GHz UMFUS licensee in the county where it is proposing to locate its earth station, the earth station applicant must coordinate its operation with the existing UMFUS licensees. The purpose of the coordination is to ensure that the earth station will not interfere with existing facilities operating under the UMFUS license. It is expected that UMFUS licensees will cooperate in good faith in the coordination process and only raise objections if there is a legitimate concern about interference to existing UMFUS facilities or failure to comply with the criteria listed above.

3.61 Thus, as per FCC[24], FSS operation in the 27.5-28.35 GHz band is co-primary if the FSS licensee also holds the UMFUS license for the area where the earth station is located; otherwise, FSS is secondary to the UMFUS.

3.62 In November 2018, FCC auctioned the 850 MHz spectrum in 28 GHz band (27.5-28.35 GHz, n257 band) for UMFUS at county-level. The services provided by UMFUS licensees are limited only by the Fixed, Mobile, and co-primary Fixed Satellite Service (FSS). Construction requirements (i.e., roll out obligations) were specified as under:

"Upper Microwave Flexible Use Service licensees must make a buildout showing as part of their renewal applications. Licensees relying on mobile or point-to-multipoint service must show that they are providing reliable signal coverage and service to at least 40 percent of the population within the service area of the licensee, and that they are using facilities to provide service in that area either to customers or for internal use. Licensees relying on point-to-point service must demonstrate that they have four links operating and providing service, either to customers or for internal use, if the population within the license area is equal to or less than 268,000. If the population within the license area is greater than 268,000, a licensee relying on point-to-point service must demonstrate that it has at least one link in operation and is providing service for each 67,000 population within the license area. In order to be eligible to be counted under the point-to-point buildout standard, a point-to-point link must operate with a transmit power greater than +43 dBm.

Showings that rely on a combination of multiple types of service will be evaluated on a case-by-case basis.

If a licensee in this service is also a Fixed-Satellite Service licensee and uses the spectrum covered under its UMFUS license in connection with a satellite earth station, it can demonstrate compliance with the requirements of this section by demonstrating that the earth station in question is in service,

[24] https://www.federalregister.gov/documents/2016/01/13/2015-31852/use-of-spectrum-bands-above-24-ghz-for-mobile-radio-services

operational, and using the spectrum associated with the license. This provision can only be used to demonstrate compliance for the county in which the earth station is located.

Failure to meet this requirement will result in automatic cancellation of the license."

3.63 As envisaged by DoT, if flexible use between IMT and satellite communication services is permitted in 27.5-28.5 GHz band, this 1 GHz spectrum will have to be assigned on an exclusive basis, as IMT deployment will essentially require exclusive spectrum. In case frequency spectrum is assigned on an exclusive basis with flexible usage rights and the successful bidder(s) decides to deploy IMT services in 27.5-28.5 GHz range, the satellite gateways of other satellite providers can still use the same frequency spectrum as gateway deployment is specific to limited geographical areas, as recommended by TRAI in its recommendations dated 11.04.2022 that *"the Satellite Earth Station Gateway should be permitted to be established in frequency range 27.5-28.5 GHz at uninhabited or remote locations on case-to-case basis, where there is less likelihood of 5G IMT services to come up".* Thus, the Government should permit use of 27.5-28.5 GHz for gateway links of other satellite service licensees on case-to-case basis, provided they are located at uninhabited or remote locations. At present, the service area for assignment of spectrum for IMT services is at telecom circle/ metro level, whereas the service area for assignment of spectrum for satellite services (user links) is at national level. In such a situation, a question arises as to what should be the applicable service area in case flexible use of spectrum between IMT and satellite communication services is permitted.

3.64 As already mentioned, flexible use of spectrum in a frequency range 27.5-28.5 GHz would permit use of this frequency range by a service provider for providing IMT as well as satellite-based services (user links) in a flexible manner. For providing the satellite communication services in the country in a flexible manner, the existing Access Service licensees would require entering into partnerships with satellite operators. In case a company with Access

Service license has created a separate licensed entity for provision of satellite-based communication services, a question arises as to whether Access Service licensee or satellite communication service licensee should be made eligible for assignment of flexible use spectrum.

3.65 Further, as per the Clause 42.3 under Chapter-VII of the UL on 'Spectrum Allotment and Use', in the event of holding/ obtaining Access spectrum, no licensee or its promoter(s) directly or indirectly shall have any beneficial interest in another licensee company holding "Access Spectrum" in the same service area, where promoter means any legal entity other than Central Government, financial institutions, and scheduled banks, which hold 10% or more equity in the licensee company. In case flexible use spectrum is assigned to Access service licensee, some mechanism may have to be put in place such that another entity of the same group with relevant license could also use the same spectrum for providing satellite-based services. One may contend that the access service licensee who obtains the right to use of the flexible use spectrum may lease the said spectrum to another company of the same group having the requisite license/ authorization. To cater to such a situation, enabling provisions may have to be framed. The existing restrictions on cross-holding of equity applicable on access spectrum holders may also need to be reviewed. In light of the above, it needs to be deliberated as to what should be the associated terms and conditions including eligibility conditions for assignment of flexible use spectrum in 27.5-28.5 GHz.

3.66 Further, in case it is decided to assign the frequency range of 27.5-28.5 GHz for flexible use of terrestrial IMT services and satellite communication services, it requires to examine the possible adverse impacts on the satellite communication services and measures to mitigate such adverse impacts.

3.67 In this background, the Authority solicits comments of stakeholders on the following set of questions:

Issues for consultation

Q10. In the frequency range 27.5-28.5 GHz, whether the spectrum assignee should be permitted to utilize the frequency spectrum for IMT services as well as space-based communication services, in a flexible manner? Do you foresee any challenges arising out of such flexible use? If yes, in what manner can the challenges be overcome? Kindly elaborate the challenges and the ways to overcome them.

Q11. In case it is decided to permit flexible use in the frequency range of 27.5 - 28.5 GHz for space-based communication services and IMT services, what should be the associated terms and conditions including eligibility conditions for such assignment of spectrum? Kindly justify your response.

(b) 28.5-29.5 GHz band

3.68 About the use of 28.5-29.5 GHz band for Captive Non-Public Networks (CNPN), TRAI in its recommendations on 'Auction of spectrum in frequency bands identified for IMT/5G' dated 11.04.2022, had recommended, *inter-alia*, the following:

"Spectrum in such bands where IMT ecosystem is available but are being used for non-IMT services in India and can coexist with indoor/ within premise cellular based private captive networks on shared basis, be earmarked for private captive networks. The Authority recommends DoT may consider the possibility of earmarking spectrum for captive wireless private networks in the following bands:

a. <u>3700-3800 MHz band</u>

(i) DoT may consider the possibility of earmarking some spectrum (at least 40 MHz) in 3700-3800 MHz frequency range for low power indoor use for private captive network.

(ii) The co-existence of private captive network and satellite C-band receive stations can be made possible by creating an effective exclusion zone around the satellite C-band receive stations.

(iii) For this purpose, a digital map of all the existing satellite C-band receive stations should be created having database of their geo-coordinates with automated software system.

(iv) The location of private network proposed by an applicant to be accommodated on co-existence basis should be analyzed and permitted through the automated software system.

(v) The power limits and antenna tilt etc. for private captive network should be prescribed by the government for interference free operation and co-existence.

b. 4800-4990 MHz band

(vi) DoT may also consider identifying the frequency range 4800-4990 MHz for IMT purpose and consider the possibility of carving out some spectrum (at least 40 MHz) in this frequency range for the purpose of earmarking for private captive network.

c. 28.5-29.5 MHz band

(vii) DoT may also consider identifying some spectrum (at least 400 MHz) in the frequency range 28.5-29.5 GHz for the purpose of earmarking for private captive network, which can co-exist with satellite earth stations.

(viii) A software based transparent system should be built to permit the establishment of private networks and Satellite Earth Stations based on the geo-coordinates of the proposed location on interference free co-existence basis.

(ix) DoT should develop a digital map with geographic coordinates of all the existing and future Satellite Earth Stations as well as geographic coordinates of the premises of Private Network locations. Based on this database, permissions for establishment of new installations may be provided to the licensees.

The Authority recommends that for assessment of demand of spectrum for private networks, DoT should create a portal and open it at least for a period of 6 months, seeking demand for spectrum from companies. The following information may be asked to assess the demand:

- *Name of the company*
- *Details of their business, Net Worth, Turnover*
- *Proposed use of spectrum*
- *Requirement of spectrum*
    - *Spectrum Band*
    - *Quantum of Spectrum*
    - *Time Period for which spectrum is required*
- *Area in sq km with exact location*
- *Technology proposed to be used*

The information so collected by DoT should be accessible only to authorized person in DoT and should not be shared with any unauthorized person.

The Authority recommends that demand assessment will provide the demand factor for direct spectrum assignment from DoT for establishment of private captive network. With such empirical assessment and DoT's decision on the spectrum bands in which spectrum can be earmarked for private networks, the Authority will provide its recommendations on quantum of spectrum, block size, etc."

3.69 Regarding assignment of spectrum for CNPN, TRAI had noted in its recommendations on 'Auction of spectrum in frequency bands identified for IMT/5G' dated 11.04.2022 as below:

"4.181 The Authority has noted that the spectrum for private network will be used within specified limited geography. As it will be used for limited area, it will be used with low power and within the premises. Therefore, the same spectrum can be repeatedly used by other entities for private network at other locations on non-interference basis having different geo-coordinates of the locations. Hence, the spectrum assignment for private network will be for a

specified geographic area of its operation and the same spectrum can be reused with multiple assignment to large number of players.

…

4.183 The spectrum for private network is to be assigned for specified limited geography to a Captive Wireless Private Network permission holder/ licensee who is the occupant (either owned or on lease) of the geographical area/ property on which spectrum use is being sought. Therefore, at a particular location/ premise/ specified geography, there will be only one contender for the spectrum who will be the occupant of that premise (either owned or on lease). Generally, when there are more than one contenders for the same spectrum at the same geography, then only the question arises as to how to assign the spectrum consistent with the fundamentals of the equality clause. However, as mentioned above, in case of assignment of spectrum for private network there will be only one claimant at a specific location premise. Therefore, the Authority is of the view that the spectrum for private network can be assigned administratively to the eligible licensees on demand through a widely publicized online portal-based process in a fair and transparent manner. The assignment process will register the geo-coordinates of the specified geography for which the spectrum is to be assigned. However, DoT may ascertain that administrative assignment in such cases is legally tenable as per spectrum assignment policy of DoT, before formulating the guidelines for assignment of spectrum for captive wireless private network."

3.70 As regards flexible use of cellular-based CNPN and satellite communication services, it is felt that as CNPN would be deployed in a specific geographic area, flexible use between satellite communication services and CNPNs may not be a practical requirement. Moreover, TRAI in its recommendations on 'Auction of spectrum in frequency bands identified for IMT/5G' dated 11.04.2022 had recommended, *inter-alia*, that DoT may also consider identifying some spectrum (at least 400 MHz) in the frequency range 28.5-29.5 GHz for the purpose of earmarking for private captive network, which can co-exist with

satellite earth stations. The need for flexible use between CNPN and satellite communication services and related aspects needs deliberation.

3.71 In this background, the Authority solicits comments of stakeholders on the following set of questions:

Issues for consultation

Q12. Whether there is a requirement for permitting flexible use between CNPN and space-based communication services in the frequency range 28.5-29.5 GHz? Kindly justify your response.

Q13. Do you foresee any challenges in case the spectrum assignee is permitted to utilize the frequency spectrum in the range 28.5-29.5 GHz for cellular based CNPN as well as space-based communication services, in a flexible manner? What could be the measures to mitigate such challenges? Suggestions may kindly be made with justification.

E. Spectrum Assignment methodology for space-based communication services

3.72 As already noted, apart from Ku-band and Ka-band, space-based communication systems have been deployed in various other frequency bands, such as L-band, S-band, and C-band. Beamwidth of the user terminals in the lower frequency bands (viz. L-band and S-band) is much wider than that for the user terminals in the higher frequency bands (viz. C-band, Ku-band and Ka-band). Therefore, currently the frequency spectrum in L-band and S-band is assigned to service providers on exclusive basis for providing MSS. On the other hand, as the user terminals of the higher frequency bands employ highly directional beams, the same frequency spectrum in C-band, Ku-band and Ka-band can be assigned to different service providers on shared basis in the same geographical area.

3.73 Globally, spectrum for satellite communication services in higher bands such as C-band, Ku-band and Ka-band, is being assigned administratively except for a few exceptions, in which orbital slots alongwith spectrum have been auctioned.

3.74 Presently, India is assigning spectrum for satellite communication services provisionally on an administrative basis with formula-based charging for some services and percentage of AGR-based charging for other services. However, such spectrum assignment comes with some terms and conditions, including the following:

"ii. in the event of final decision to allot spectrum only through auction process, the provisional allotment of spectrum shall be withdrawn;

…

v. The respective wireless users would be required to give an undertaking to pay the revised spectrum charges, as finally determined through market related mechanism or otherwise as may be applicable, from the date of Letter of Intent (LoI) for provisional allotment of spectrum."

3.75 In the present reference, the Government has sought recommendations on auction of spectrum for space-based communication services. It is worth mentioning that in another reference on 'frequency assignment for data communication services between aircraft and ground stations for services provided by organizations other than the Airport Authority of India' dated 12.04.2022, DoT has requested TRAI to provide recommendations on the following:

"i. An appropriate mechanism to regulate the services provided by these organizations:

ii. The manner in which the frequency assignment should be made to these organizations, in light of the supreme Court judgment made in the 2G case in 2012 - to assign radio frequencies only through auction."

3.76 It may be noted that through the judgment dated 02.02.2012, the Hon'ble Supreme Court in the Writ Petition (Civil) No. 423 of 2010 (also referred to as "2G case") pronounced, *inter-alia*, as below:

"…In our view, a duly publicised auction conducted fairly and impartially is perhaps the best method for discharging this burden and the methods like first-come-first-served when used for alienation of natural resources/ public property are likely to be misused by unscrupulous people who are only interested in garnering maximum financial benefit and have no respect for the constitutional ethos and values.

In other words, while transferring or alienating the natural resources, the State is duty bound to adopt the method of auction by giving wide publicity so that all eligible persons can participate in the process."

3.77 Thereafter, in response to the Presidential Reference subsequent to the decision of Supreme Court in the 2G Case (referred to as "Re: Special Reference No. 1 of 2012" dated 27.09.2012), the five-Judge bench observed, *inter-alia*, that *"[t]he 2G Case does not even consider other laws and judgments that prescribe methods, other than auction, for dispensation of natural resources; something that it would have done, in case, it intended to make an assertion as wide as applying auction to all natural resources. Therefore, the observations in Paras 94 to 96 could not apply beyond the specific case of spectrum, which according to the law declared in the 2G Case, is to be alienated only by auction and no other method. Thus, 2G case does not deal with modes of allocation for natural resources, other than spectrum".*

3.78 After the pronouncement of 2G judgement, spectrum for 'mobile access spectrum' is being assigned to the telecom service providers through the process of auctions.

3.79 DoT in its letter dated 13.09.2021 mentioned that *"[t]he Department of Space had invited comments on Draft Spacecom Policy liberalizing space segment for private sector participation to provide commercial communication services in India. This includes the Low Earth Orbit (LEO) and Medium Earth Orbit (MEO)*

satellite constellations operational over India. In case of satellite communication, the subscriber is accessed from the satellite through "Access Spectrum" similar to "Access Spectrum" in terrestrial network and the demand for such spectrum will potentially increase in the future." DoT requested TRAI to provide its recommendations on appropriate frequency bands, band plan, block size, applicable reserve price, quantum of spectrum to be auctioned and associated conditions for auction of spectrum for space-based communication services.

3.80 In response to the TRAI's letters seeking details of the frequency bands and quantum of spectrum available in each band required to be put to auction and associated information in respect of space-based communication, DoT vide its letter dated 16.08.2022 provided frequency ranges (both for space to earth, and earth to space) in Ku-band and Ka-band, and mentioned that TRAI can provide recommendations for other frequency bands also.

3.81 As already mentioned in para 1.7 of this consultation paper, TRAI, through the letter dated 19.10.2022 to DoT, sought information/ clarifications, wherein DoT was requested, *inter-alia*, to clarify as to for which kind of licensed services, spectrum for space-based communication has been envisaged to be granted through Auction. DoT was requested to provide information as per the Table 1.3 given under para 1.7 of this consultation paper. In response, DoT vide its letter dated 16.12.2022 conveyed that TRAI may provide suitable recommendations for each of the space-based communication services after detailed examination.

3.82 On 21.09.2022, DoT released Draft Indian Telecommunications Bill, 2022 for public consultation to develop a modern and future-ready legal framework in telecommunication. Though the draft bill is still in its initial phases and the text/content of the bill may undergo several changes, in the draft Indian Telecommunication Bill, 2022 it has been mentioned that the Central Government may assign spectrum for telecommunication *"through administrative process for governmental functions or purposes in view of public*

interest or necessity as provided in Schedule 1". The Schedule 1 provides a list of services. The serial number 15 of the said list is reproduced below:
"15. Certain satellite-based services such as: Teleports, Direct To Home (DTH), Digital Satellite News Gathering (DSNG), Very Small Aperture Terminal (VSAT), National Long Distance (NLD), International Long Distance (ILD), Mobile Satellite Service (MSS) in L and S bands."

Note: As the draft Telecom Bill is still under consideration, it is pertinent to note that the provisions mentioned in the Bill may change subsequently, and accordingly some observations may not be applicable after changes in the draft bill.

3.83 The demand of the frequency spectrum meant for space-based communication services will be generated by operators providing distinct services such as VSAT, GMPCS, NLD, Internet, Access, IFMC, DSNG, Teleport, DTH, HITS[25] etc. Each of these services, or groups thereof, can be treated as a class, which may differ in terms of nature of service, and financial & market related parameters.

3.84 While the same frequency spectrum may be used for multiple services including telecommunication services and broadcasting services, the services are not alike. While telecommunication service is a two-way communication, broadcasting service is a one-way communication service. Further, one may contend that broadcasting service is also a public service as (i) it is used for dissemination of important information to the public; (ii) it serves as a means for education for the people living in remote areas; and (iii) it plays an important role in situations of natural disasters, etc. As regards telecommunication services, at present, satellite-based services are primarily being offered by VSAT licensees to provide closed user group (CUG) connectivity to enterprise customers, and to provide backhaul connectivity to the Access Service Providers; these services are not used directly by general public; however, a

[25] Acronyms: VSAT- Very Small Aperture Terminal, GMPCS - Global Mobile Personal Communication by Satellite, NLD - National Long Distance, IFMC - In-flight and Maritime Connectivity, DSNG - Digital Satellite News Gathering, DTH - Direct To Home, HITS - Headend In The Sky

VSAT licensee after obtaining Internet Service Provider (ISP) license is permitted to use same Hub station and VSAT (remote station) to provide Internet service directly to the subscribers, and in this case VSAT (remote station) may be used as a distribution point to provide Internet service to multiple independent subscribers. For provision of satellite-based broadband/ internet services directly to the end customers, one must possess any one of the licenses/ authorizations from amongst (a) Access Service, (b) Internet Service, or (c) GMPCS. One may contend that while satellite-based broadband/ internet service could be one class of service, the pure VSAT service (i.e. without Internet service) could be another category of service and therefore, the two categories may be treated separately.

3.85 Further, revenue and subscriber base for some of services listed in para 3.83 above are tabulated below:

S.No	Service	Annual Gross revenue (for F.Y 2021-22) Rs. in crore	Subscriber base (as on 31st March 2022 (Figures in crore)
1.	Access	2,16,933	114.20
2.	DTH	16,479 (As on March 2021)	6.69
3.	VSAT	538	0.028
4.	GMPCS	71	-
5.	NLD	30,116	-
6.	ILD	12,054	-
7.	Internet	18,431	82.49

Table 3.3: Revenue and subscriber base of a few services

Source: The above information is as reported by the licensed service providers to TRAI.

3.86 From the above description, it is quite apparent that there is a significant difference between various services in terms of technical nature of service, and market & financial parameters across different types of services. As different services will have different market conditions, in particular with respect to

demand, subscriber base and revenue potential, it may not be prudent to go for a combined auction for spectrum for different types of services. However, various types of services could be categorized under different classes of services considering their relevant market, substitutability, similarity in nature, etc.

3.87 It, therefore, gives rise to the issue as to whether spectrum should be assigned for all services through a single auction, or through a separate auction/ assignment mechanism for each class of service.

Q14. Whether space-based communication services should be categorized into different classes of services requiring different treatment for spectrum assignment? If yes, what should be the classification of services and which type of services should fall under each class of service? Kindly justify your response. Please provide the following details:

a) Service provider-wise details regarding financial and market parameters such as total revenue, total subscriber base, total capital expenditure etc. for each type of service (as mentioned in the Table 1.3 of this consultation paper) for the financial year 2018-19, 2019-20, 2020-21, 2021-22, and 2022-23 in the format given below:

Type of service: _____				
Financial Year	**Revenue (Rs. lakh)**	**Subscriber base**	**CAPEX for the year (Rs. lakh)**	**Depreciation for the year (Rs. lakh)**
2018-19				
2019-20				
2020-21				
2021-22				
2022-23				

b) Projections on revenue, subscriber base and capital expenditure for each type of service (as mentioned in the Table 1.3 of this consultation paper) for the whole industry for the next five years starting from financial year 2023-24, in the format given below:

Type of service: _____			
Financial Year	**Revenue (Rs. lakh)**	**Subscriber base**	**CAPEX for the year (Rs. lakh)**
2023-24			
2024-25			
2025-26			
2026-27			
2027-28			

3.88 In satellite communication services, the frequency spectrum for user links may be required in a ubiquitous manner to fulfil the user requirement, which may be comparable to the access spectrum in mobile services as mentioned by DoT. As already mentioned, currently the frequency spectrum in L-band and S-band is assigned to service providers on exclusive basis for providing MSS. On the other hand, as the user terminals of the higher frequency bands employ highly directional beam, the same frequency spectrum in C-band, Ku-band and Ka-band can be assigned to different service providers on shared basis in the same geographical area. Therefore, the question arises as to what should be the methodology for assignment of spectrum for user links for satellite communication services in L-band and S-band, in which the spectrum is assigned on an exclusive basis. It also needs to be deliberated as to what should be the methodology for assignment of user link spectrum for satellite communication services in higher bands such as C-band, Ku-band and Ka-band.

3.89 Further, presently the service area for assignment of spectrum for satellite services (user links) is at national level. However, considering the market

conditions and cost of spectrum, some service licensees may be interested in providing satellite communication services only in the telecom circles with tough terrains, remote locations, far-flung areas of the country, etc. Therefore, a question arises as to whether spectrum for satellite-based user links should be assigned on a national basis or telecom circle/metro level as applicable for Access services.

3.90 As per the existing licensing and policy provisions in India, satellite-based communication requires installation of Satellite Earth Station Gateway (SESG) on Indian soil and the traffic from/ to India is required to be routed through such SESG. Satellite systems may install one or more SESG, to create gateway links to connect to the satellite. The spectrum usage is specific to the geographic location of the SESG. In other words, multiple SESGs can use the same frequency spectrum if they do not interfere with one another.

3.91 The number of satellite earth station gateways required in case of NGSO satellite constellations vary depending on the altitude of the NGSO satellite constellation and the capacity requirement to meet the customer demand. In case of GSO satellites, the number of satellite earth station gateways required could vary depending on the beam size. For instance, if a GSO satellite is using a wide beam covering the entire nation, the satellite operator may decide to have one or two earth station gateways in the country. However, in case a GSO satellite is a HTS using spot beams, the number of satellite earth station gateways required to be put in place in the country may be much more.

3.92 While spectrum for SESG is to be assigned for specific geographic location where the gateway is located. *Prima facie* there appears to be no or little likelihood of two service providers competing for the same location. However, while deciding the location of the gateway, the following factors[26] play a major role, which may bring in an element of competition between service providers seeking to build gateways:

[26] https://idstch.com/space/satellite-gateway-and-hub-technology-trends/

(a) No obstructions such as buildings or mountains blocking any views to satellite;

(b) Cost of land;

(c) Ample land to install as many antennas as necessary in the future;

(d) Sufficient and good quality electrical supply;

(e) Access to optical fibre connectivity from a variety of providers;

(f) Mild temperatures with a very dry climate, minimum rain and no snow; and

(g) Absence of common natural disasters.

3.93 Since the antenna of the SESG of GSO satellites looks at a fixed angle according to the orbital slot, it is possible to establish two SESGs of GSO satellites in nearby locations without any protection zone requirement. On the other hand, NGSO satellite constellation consists of several satellites and several orbital planes. Further, NGSO satellites keep revolving around the Earth in the respective orbital planes. Therefore, the satellite earth station gateway of NGSO satellite constellation consists of an array of tracking antennas so that the satellite earth station gateway gets connected to the next arriving satellite before disconnecting with the so far connected satellite. This principle is like base transceiver station (BTS) handover in terrestrial mobile services. As the satellite earth station gateway in NGSO systems consists of tracking antenna, it should be located in an area which has clear visibility with a minimum elevation angle. Protection zone requirement may be needed for interference-free operation of the SESGs of different NGSO constellations which are using the same frequency spectrum. The protection zone requirement may also vary across spectrum bands.

3.94 In case it is decided that the frequency spectrum for space-based communication services is to be assigned through auction mechanism, the issue arises that what should be the validity period for such an assignment. Further, in case some spectrum remains unsold or more spectrum is available at a later

date, what should be the periodicity of auction i.e., after how many years, the spectrum auction should be conducted again.

3.95 There could be a scenario where a service licensee after acquiring certain frequency spectrum through auction is providing services to the consumers and after some time, it decides to shift to another satellite system because of any techno-commercial reasons. In this process, the service licensee also might have to shift to another frequency band or another block of frequency spectrum within the same band. Therefore, it needs to be deliberated as to whether there is a need to put in place a mechanism such that a service licensee could shift to another satellite operator within a frequency band or to another frequency band for the remaining validity period of the spectrum held by it.

3.96 Further, while providing additional information/ clarifications, DoT in its letter dated 16.08.2022 mentioned that "*as the service providers may require spectrum both in user link as well as in feeder link, TRAI may take inputs from the stakeholders and recommend the appropriate auction methodology so that the successful bidder gets spectrum for user link (shared with IMT in flexible) as well as feeder link".* In this regard, it is noted that use of frequency spectrum for different types of links may be different for different satellite systems. Moreover, requirement of frequency spectrum may also vary depending on the type of service. Therefore, it needs to be deliberated as to whether it would be appropriate to assign spectrum for gateway links and user links separately to give flexibility to the stakeholders or to assign spectrum for gateway links and user links in a bundled manner. Further, in case it is decided to assign frequency spectrum for user links and gateway links separately, what mechanism should be adopted such that the successful bidder gets spectrum for user links as well as gateway links, needs to be examined.

Q15. What should be the methodology for assignment of spectrum for user links for space-based communication services in L-band and S-band, such as-

(a) Auction-based

(b) Administrative

(c) Any other?

Please provide your response with detailed justification.

Q16. What should be the methodology for assignment of spectrum for user links for space-based communication services in higher spectrum bands like C-band, Ku-band and Ka-band, such as

(a) Auction-based

(b) Administrative

(c) Any other?

Please provide your response in respect of different types of services (as mentioned in Table 1.3 of this consultation paper). Please support your response with detailed justification.

Q17. Whether spectrum for user links should be assigned at the national level, or telecom circle/ metro-wise? Kindly justify your response.

Q18. In case it is decided to auction user link frequency spectrum for different types of services, should separate auctions be conducted for each type of services? Kindly justify your response with detailed methodology.

Q19. What should be the methodology for assignment of spectrum for gateway links for space-based communication services, such as

(a) Auction-based

(b) Administrative

(c) Any other?

Please provide your response in respect of different types of services. Please support your response with detailed justification.

Q20. In case it is decided to auction gateway link frequency spectrum for different types of services, should separate auctions be conducted for

each type of services? Kindly justify your response with detailed methodology.

Q21. In case it is decided to assign frequency spectrum for space-based communication services through auction,

(a) What should be the validity period of the auctioned spectrum?

(b) What should be the periodicity of the auction for any unsold/ available spectrum?

(c) Whether some mechanism needs to be put in place to permit the service licensee to shift to another satellite system and to change the frequency spectrum within a frequency band (such as Ka-band, Ku-band, etc.) or across frequency bands for the remaining validity period of the spectrum held by it? If yes, what process should be adopted and whether some fee should be charged for this purpose?

Kindly justify your response.

Q22. Considering that (a) space-based communication services require spectrum in both user link as well as gateway link, (b) use of frequency spectrum for different types of links may be different for different satellite systems, and (c) requirement of frequency spectrum may also vary depending on the services being envisaged to be provided, which of the following would be appropriate:

(i) to assign spectrum for gateway links and user links separately to give flexibility to the stakeholders? In case your response is in the affirmative, what mechanism should be adopted such that the successful bidder gets spectrum for user links as well as gateway links.

or

(ii) to assign spectrum for gateway links and user links in a bundled manner, such that the successful bidder gets spectrum for user link as well as gateway link? In case your

response is in the affirmative, kindly suggest appropriate assignment methodology, including auction so that the successful bidder gets spectrum for user links as well as gateway links.

Q23. Whether any protection distance would be required around the satellite earth station gateway to avoid interference from other satellite earth station gateways for GSO/ NGSO satellites using the same frequency band? If yes, what would be the protection distance (radius) for the protection zone for GSO/ NGSO satellites?

F. Eligibility conditions and other terms and conditions for assignment of spectrum for space-based communication services

3.97 With regard to the eligibility for participating in auction process, in the Notice Inviting Application (NIA) for Auction of Spectrum in 600 MHz, 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz, 2500 MHz, 3300 MHz, and 26 GHz Bands dated 15.06.2022[27] for IMT access services, the eligibility criteria to participate in the auction included:

(i) Any licensee that holds a UASL/ UL with authorization for Access Services for that LSA; or

(ii) Any licensee that fulfils the eligibility criteria for obtaining a Unified License with authorization for Access Services, and gives an undertaking to obtain a Unified License with authorization for Access Services; or

(iii) Any entity that gives an undertaking to obtain a Unified License with authorization for Access Services through a New Entrant Nominee as per the DoT guidelines/ license conditions, can bid for the Spectrum in 600 MHz, 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz, 2500 MHz, 3300 MHz & 26 GHz Bands subject to other provisions of the Notice.

[27] https://dot.gov.in/sites/default/files/NIA_Version_Dated_15_06_2022.pdf

3.98 Further, the Notice Inviting Application (NIA) for Auction of Spectrum in 600 MHz, 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz, 2500 MHz, 3300 MHz, and 26 GHz Bands dated 15.06.2022 for IMT access services, had Associated Eligibility Conditions including 'Net Worth requirements'. An extract of the 'Net Worth requirements' under Associated Eligibility Conditions of the NIA 2022 is given below:

"(vii) A Bidder is required to show a net worth of Rs.100 Crore per License Service Area (Rs. 50 Crore each for Jammu and Kashmir and North East Service Areas), in which the bidder wants to submit bids. …"

3.99 Thus, any entity, which holds Unified Access Service License (UASL)/ Unified License (UL) with authorization for Access Services or submits an undertaking to obtain Unified License with authorization for Access Services, subject to other provisions, is eligible to participate in the auction process for mobile access spectrum. However, auction of spectrum for satellite-based services is being considered for the first time in the country. Besides, the process of getting Unified License with appropriate authorization has been simplified. Therefore, it needs to be deliberated as to whether it should be a precondition for the bidder to hold the requisite service license/ authorization under Unified License prior to taking part in the auction process. Further, it may be prudent to impose some other eligibility conditions such as minimum net worth requirement, requirement of existing agreement with satellite operator(s), etc. on the bidders in the auction of spectrum for space-based communication services to ensure that only earnest entities may take part in the auction.

3.100 The Clause 42.3 under Chapter-VII of the UL on 'Spectrum Allotment and Use' provides as under:

"42.3 In the event of holding/ obtaining Access spectrum, no licensee or its promoter(s) directly or indirectly shall have any beneficial interest in another licensee company holding "Access Spectrum" in the same service area.

For the purpose of this clause:

(a) Promoter shall mean legal entity other than Central Government, financial institutions and scheduled banks, which hold 10% or more equity in the licensee company.

(b) Beneficial interest shall mean holding of any equity directly or indirectly including through chain of companies in the licensee company.

(c) Any arrangement contrary to above shall be made consistent with the above stipulations within a period of one year from the date of grant of UL.

(d) Exception granted in para 1.4 of UAS licensee in respect of basic and CMTS licenses existing on 11.11.2003 shall end on the expiry of CMTS/UAS/Basic Service license held by such licensee. They shall comply with the above stipulation within a period of one year from the date of migration to UL."

3.101 DoT in its reference dated 13.09.2021 had mentioned, inter-alia, that *"in case of satellite communication, the subscriber is accessed from the satellite through 'Access Spectrum' similar to 'Access Spectrum' in terrestrial network and the demand for such spectrum will potentially increase in the future"*. Therefore, it needs to be deliberated as to whether the provisions of the UL related to restriction on crossholding should also be made applicable for satellite-based service licensees. If so, whether these provisions should be made applicable for each class of service separately.

3.102 In this background, the Authority solicits comments of stakeholders on the following set of questions:

Issues for Consultation

Q24. What should be the eligibility conditions for assignment of spectrum for each type of space-based communication service (as mentioned in the Table 1.3 of this Consultation Paper)? Among other things, please provide your inputs with respect to the following eligibility conditions:

(a) Minimum Net Worth

(b) Requirement of existing agreement with satellite operator(s)

(c) Requirement of holding license/ authorization under Unified License prior to taking part in the auction process.

Kindly justify your response

Q25. What should be the terms and conditions for assignment of frequency spectrum for both user links as well as gateway links for each type of space-based communication service? Among other things, please provide your detailed inputs with respect to roll-out obligations on space-based communication service providers. Kindly provide response for both scenarios viz. exclusive assignment and non-exclusive (shared) assignment with justification.

Q26. Whether the provisions contained in the Chapter-VII (Spectrum Allotment and Use) of Unified License relating to restriction on crossholding of equity should also be made applicable for satellite-based service licensees? If yes, whether these provisions should be made applicable for each type of service separately? Kindly justify your response.

G. Interference Mitigation - Sharing of frequency bands between satellite networks and terrestrial networks

3.103 DoT, through its letter dated 16.08.2022, stated, *inter-alia*, that *"TRAI may provide recommendations on sharing of auctioned frequency bands between satellite networks and terrestrial networks also, the criteria for sharing and appropriate interference mitigation techniques for sharing and coexistence."*

3.104 As already mentioned, in the 13 GHz band (12.75-13.25 GHz) and 18 GHz band (17.7-19.7 GHz), microwave access (MWA) service, which is used for cellular backhaul, coexists with FSS. In this regard, TRAI vide its letter dated 19.10.2022 requested DoT to provide following information:

"Whether DoT has issued any guidelines or standard operating procedure for mitigation of interference in case of:

i. Usage of the same satellite frequency spectrum by different licensees; and

ii. Usage of the same frequency spectrum for space-based communication and for microwave links (MWA/ MWB)?

If yes, a copy of the same may kindly be shared."

3.105 In response, DoT, through its letter dated 16.12.2022, informed, *inter-alia*, as below:

"Satellite networks are coordinated and registered in the ITU to ensure interference-free operation with respect to networks of other countries. Coexistence of satellite networks or satellite-based communication within the country is ensured through various provisions in RR, ITU recommendations, WRC Resolutions, NFAP and License conditions for the satellite and MW services. In some case standards for Interface Requirements (IR) and Generic Requirements (GR) have also been issued by TEC, DoT. Moreover, as per the current practice to assign spectrum administratively, all frequency assignments/ operations are issued on non-interference/ non-protection basis."

3.106 To control interference, ITU provides elaborate framework including the following[28]:

(a) Allocation: Frequency separation of stations of different services (Article 5)

(b) Coordination: between Administrations to ensure interference-free operations conditions (Article 9)

(c) Power Limits: (Articles 5, 21 & 22)

(i) Power Flux Density (PFD) to protect terrestrial services

(ii) Equivalent isotropically radiated power (EIRP) to protect space services

(iii) Equivalent Power Flux Density (EPFD) to protect GSO from NGSO

[28] Source: https://www.itu.int/en/ITU-R/space/WRS16space/PFD%20External.pdf

(d) Regulatory Protection: Not to cause harmful interference or claim protection (Article 5 and 22)

3.107 In this regard, it is noteworthy that the Article 21 of ITU-RR deals with the aspects of terrestrial and space services sharing frequency bands above 1 GHz. The Section I of Article 21 deals with the choice of sites and frequencies. It provides as below:

"21.1 Sites and frequencies for terrestrial stations and earth stations, operating in frequency bands shared with equal rights between terrestrial radiocommunication and space radiocommunication services, shall be selected having regard to the relevant ITU-R Recommendations with respect to geographical separation between earth stations and terrestrial stations.

21.2 As far as practicable, sites for transmitting stations, in the fixed or mobile service, employing maximum values of equivalent isotropically radiated power (e.i.r.p.) exceeding the values given in Table 21-1 in the frequency bands indicated, should be selected so that the direction of maximum radiation of any antenna will be separated from the geostationary-satellite orbit by at least the angle in degrees shown in the Table, taking into account the effect of atmospheric refraction.

TABLE **21-1**

Frequency band (GHz)	e.i.r.p. value (dBW) (see also Nos. 21.2 and 21.4)	Minimum separation angle with respect to geostationary-satellite orbit (degrees)
1-10	+35	2
10-15	+45	1.5
25.25-27.5	+24 (in any 1 MHz band)	1.5
Other bands above 15 GHz	+55	No limit[3]

21.2.1 For their own protection receiving stations in the fixed or mobile service operating in frequency bands shared with space radiocommunication services (space-to-Earth) should also avoid directing their antennas towards the geostationary-satellite orbit if their sensitivity is sufficiently high that interference from space station transmissions may be significant. In particular, in the frequency bands 13.4-13.65 GHz and 21.4-22 GHz, it is recommended to

maintain a minimum separation angle of 1.5 degree with respect to the direction of the geostationary-satellite orbit."

3.108 The Section II of Article 21 of ITU' RR deals with power limits for terrestrial stations. It provides, *inter-alia*, as below:

"21.3 The maximum equivalent isotropically radiated power (e.i.r.p.) of a station in the fixed or mobile service shall not exceed +55 dBW."

3.109 The Section-III of Article 21 of ITU's RR provides power limits for earth stations. The Section-IV provides minimum angle of elevation of earth stations. The Section-V provides limits of power flux density from space stations.

3.110 In this background, the Authority solicits comments of stakeholders on the following question:

Issues for Consultation

Q27. Keeping in view the provisions of ITU's Radio Regulations on coexistence of terrestrial services and space-based communication services for sharing of same frequency range, do you foresee any challenges in ensuring interference-free operation of space-based communication network and terrestrial networks (i.e., microwave access (MWA) and microwave backbone (MWB) point to point links) using the same frequency range in the same geographical area? What could be the measures to mitigate such challenges? Suggestions may kindly be made with justification.

H. Spectrum re-use through polarization

3.111 A frequency can be reused by using the principle of orthogonal polarization. Suppose a satellite system uses a bandwidth of B Hz centred on the frequency f_U for the uplink, and B Hz on the frequency f_D for the downlink. Using the

concept of orthogonal polarization, the bandwidth B can be used twice as illustrated in the following figure.

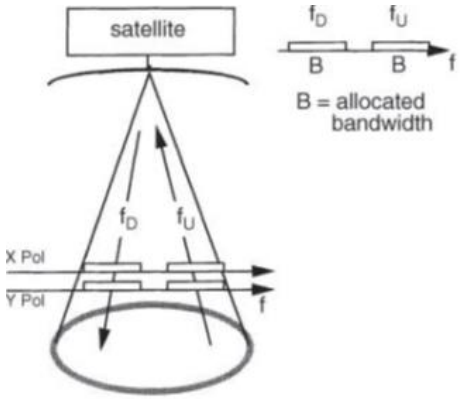


Figure: Frequency reuse using orthogonal polarization[29]

3.112 Similarly, the use of Left- or Right-Hand Circular Polarization (LHCP or RHCP) allows frequency reuse to the same satellite, since a LHCP and RHCP antenna reject each other's signals. So, for a single frequency allocation, two simultaneous radio frequency (RF) links may be used with two different rotational sense antennas.

3.113 It has been observed that, DoT has assigned the same frequency spectrum with different polarization for use with the same or different satellite(s).

3.114 In this background, the Authority solicits comments of stakeholders on the following question:

Issue for Consultation

Q28. In what manner should the practice of assignment of a frequency range in two polarizations should be taken into account in the present exercise for assignment and valuation of spectrum? Kindly justify your response.

[29] Source: Satellite Communications Systems Systems, Techniques and Technology, John Wiley & Sons Ltd.

I. Auction design models

3.115 Through the reference dated 13.09.2021, DoT has requested TRAI to provide recommendations for auction of spectrum for space-based communication services. Further, through the letter dated 16.08.2022, DoT has mentioned that *"[i]t is envisaged to auction the Space Spectrum on exclusive basis. TRAI may explore the feasibility and procedure of sharing of auctioned spectrum among multiple service licensees. TRAI may provide recommendations on sharing of auctioned frequency bands between satellite networks and terrestrial networks also, the criteria for sharing and appropriate interference mitigation techniques for sharing and coexistence."* Further, through the letter dated 16.08.2022, DoT has stated that *"[s]ince the service providers may require spectrum both in user link as well as feeder link, TRAI may take inputs from the stakeholders and recommend the appropriate auction methodology so that the successful bidder gets spectrum for user link (shared with IMT in flexible) as well as feeder link."*

3.116 Presently, for auction and assignment of frequency spectrum bands for mobile access services in the country, Simultaneous Multiple Rounds Ascending Auction (SMRA) method is being followed. The detailed methodology of SMRA has been explained in the Notice Inviting Application (NIA) for *Auction of Spectrum in 600 MHz, 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz, 2500 MHz, 3300 MHz, and 26 GHz Bands* dated 15.06.2022[30]. Apart from SMRA, there are some other prevalent auction methodologies for auctioning resources such as[31]:

(a) Non-continuous Auctions: First price sealed bid auction and Vickrey auction i.e., the second best price sealed bid auction, unlike SMRA, these auctions are non-continuous and generally have one round and are hence considered to be less competitive than continuous or ascending auctions

30 https://dot.gov.in/sites/default/files/NIA_Version_Dated_15_06_2022.pdf
31 Source: The Economics of Special Markets: Auctions by Leslie R. Fine, Econlib

because none of the bidders know the prices their competitors are offering until the winner is selected.

(b) Continuous Auctions:

- Dutch auction, i.e., the reverse auction
- English Auction, i.e., the ascending auctions
- Penny auction[32] in which the time and number of bids in an auction are limited
- Combinatorial auction[33] in which participants can place bids on combinations of discrete heterogeneous items, or "packages", rather than individual items or continuous quantities.

3.117 It may also be mentioned that presently the auction process for mobile access spectrum grants exclusive rights to use of frequency spectrum to the allotees of spectrum. In case the satellite spectrum is to be assigned on an exclusive basis, the auction and assignment methodology will be similar to that of the mobile access spectrum being followed currently.

3.118 Before discussing the sharing of satellite spectrum, the four different types of goods defined in economics[34] are categorized based on excludability and rivalry. The same are illustrated in the figure below:

Figure : Type of goods in Economics

32 The 6 Different Types Of Online Auctions, by Joshua Kodner, January,2020
33 Combinatorial Auctions, Peter Cramton, MIT Press
34 The Continua of Excludability and Rivalry by Bryan Caplan

3.119 As per the "*Economic Theory of Clubs*" by James Buchanan (1965)[35], the club goods are economic goods that are excludable and have limited rivalry. It follows then that if the satellite systems are designed to operate on shared spectrum with low or no rivalry in consumption, the spectrum for satellite-based communications acquires characteristics of a "club good".

3.120 Regarding exploring the feasibility and procedure for sharing auctioned spectrum amongst multiple service licensees, the spectrum sharing could be achieved by following: -

(a) either through an exclusive assignment through auction followed by mandatory sharing of spectrum with other service providers,
or

(b) by devising appropriate mechanism to ensure that all the successful bidders get spectrum on a shared basis. In such a scenario, design of the spectrum auction process will need to suitably reflect the requirement of sharing of spectrum amongst successful bidders of spectrum. Such an auction must also take care of the fact that, in case of sharing of spectrum, the competitiveness in the bidding process may not be adversely impacted. Therefore, in such a case, it is important to ensure that suitable incentives are provided to the bidders to bring competitiveness in the auction process. Possible ways to achieve the above could be limiting the number of successful bidders, prescribing the periodicity of the spectrum auction, incentives to the winners like price discounts etc. At the same time, it is necessary to analyze their merits/ demerits prior to inclusion in the auction process.

3.121 As already discussed, spectrum for user links will be required for ubiquitous use but spectrum for gateway links is required for a specific geography and therefore, same frequency spectrum can be reused by satellite gateways as long as they do not cause interference to one another.

[35] Buchanan Clubs: Page 265-284 (2013), Springer

3.122 On examination of the international experience on auction of spectrum for space-based communication services, it has been observed that a few countries, such as USA, Brazil and Saudi Arabia, have conducted auctions for frequency spectrum in the past. USA and Brazil conducted auction of satellite spectrum along with orbital slots. However, both the countries have reverted to administrative assignment. Saudi Arabia recently conducted auction of spectrum in S-band. Since the technical characteristics of S-band are such that it is assigned on exclusive basis for MSS, auction can be conducted in a manner similar to the spectrum auction for terrestrial mobile services. Therefore, it can be inferred that internationally, there is no design model available for auction of the frequency spectrum in higher frequency bands such as C-band, Ku band, and Ka band, which are sharable among multiple service providers.

3.123 In view of the above, there may be a need to look for new methods to assign frequency spectrum for space-based communication services. The Authority is undertaking the exercise for assignment of spectrum for space-based communication services through a market mechanism for the first time and there is no international experience in auction of space spectrum on the matter except few cases where orbital slots along with spectrum have been auctioned.

3.124 Prior to discussing the auction models, it is worth reiterating certain basics of an auction such as the Reserve Price (RP), Auction Determined Price (ADP) and the possible relation between ADP and RP. Since the reserve price acts as a bare minimum price at which the auction starts, the auction determined price can never be less than the reserve price, thereby ruling out the possibility of ADP < RP. It is safe to list out, the following possible outcomes of an auction:

a) ADP = RP

b) ADP> RP

ADP – RP = β, where β ≥0; β is stochastic (i.e. it cannot be determined beforehand)

3.125 It is worth mentioning that the outcome of an auction, i.e., whether ADP is equal to or greater than RP cannot be predicted beforehand (ex-ante) as the same depends upon the bidder's behaviour and competitiveness of the auction. Moreover, the value of β is stochastic i.e., it is non-deterministic, beforehand. However every auction process must be fair[36], i.e. rules of the auction shall be transparently, fully and accurately described and it must be efficient in ensuring price discovery through competitive bidding.

3.126 Based on the discussions held with stakeholders, details available in public domain, and the existing spectrum auction method used by the DoT, a few design models are being put forward for soliciting comments of stakeholders on the suggested models. However, stakeholders are requested to suggest other suitable models, for each type of services, which may be considered by the Authority.

Suggested design models for auction of spectrum for User links in higher bands such as C band, Ku band and Ka band

(1) Auction design model # 1: SMRA[37] auction design with exclusive spectrum assignment

3.127 One of the possible auction design model could involve spectrum assignment on exclusive basis, wherein satellite spectrum bands, excluding the spectrum range which will be decided to be permitted with flexible use, can be split into a number of blocks basis total bandwidth available and bandwidth requirement for each class of services. Spectrum cap can be defined in terms of number of blocks. Satellite spectrum may be auctioned in blocks in a manner similar to the auction of IMT spectrum with spectrum cap.

3.128 Suppose 2 GHz of spectrum is available in a frequency band. This spectrum may be divided into 40 blocks of 50 MHz each. For illustration, a cap of 500 MHz may be fixed in such an assignment i.e., no bidder may obtain more than

[36] Law of Auctions : Stimmel Law

[37] SMRA is an acronym of Simultaneous Multiple Round Ascending. At present, the Government follows SMRA model for auction of spectrum for terrestrial access spectrum.

500 MHz spectrum in this frequency band. Market price will be determined if there are more than four bidders, who bid upto the spectrum cap.

3.129 However, in order to make this model work without disturbing the satellite communication ecosystem, some additional conditions may have to be put in place, as described below:

a) ITU framework permits sharing of frequency spectrum among multiple satellite systems and any reduction in frequency spectrum for a satellite system may reduce its serving capacity. Therefore, intra-band spectrum sharing may be mandated among licensees who have acquired spectrum upto the prescribed spectrum cap. The additional (shared) spectrum will not be counted for the purpose of spectrum cap.

b) In case entire frequency spectrum in a frequency band is sold in an auction process, and subsequently a new entrant intends to provide space-based communication services in the country, some provisions could be created, which have already been discussed in the para 3.48.

c) In case there is some unsold / available spectrum in a frequency band and a new entrant intends to provide space-based communication services, then the new entrant will have to take part in the periodical auction to become eligible to share spectrum with existing players.

d) In case (i) entire spectrum in a band could not be sold in an auction, (ii) the successful bidders were not permitted to acquire more spectrum because of spectrum cap, but (iii) they need to use the entire frequency band to make optimal use of the satellite capacity, such successful bidders will be permitted to use the unsold spectrum at a price = (Auction Determined Price per MHz of the frequency band * Quantum of the unsold spectrum)/ N, where N is the number of bidders interested in using unsold spectrum on shared basis.

(2) Auction design Model # 2: Auction design model based on non-exclusive spectrum assignment for higher bands (such as C band, Ku band and Ka band) to limited bidders

3.130 In the existing technological scenario, the major distinction between satellite spectrum in higher frequency bands and IMT spectrum is that the satellite spectrum usage is non-rivalrous in nature, thus this spectrum can be shared amongst multiple users.

3.131 Although spectrum, such as access spectrum as a resource has a composite demand since various sectors of the economy attach high utility/ value to it, thus making spectrum an essential scarce natural resource.

3.132 However, satellite spectrum due to its characteristics of being amenable to non-rivalrous usage makes it relatively abundant in nature and due to this abundance, auction may not reflect its true value.

3.133 This has been supported by the "Paradox of value" also known as the Diamond–Water Paradox introduced by economist Adam Smith[38]. The paradox lies in the fact that water which is essential to life and has high utility is priced lower compared to non-essential commodity such as diamonds.The economics behind the paradox can be explained vide the concepts of marginal utility and scarcity as done by economist William Stanley Jevons[39].

3.134 There tends to be an inverse relationship between marginal utility and supply. i.e. goods that are scarce in supply tend to have a higher additional utility and vice-versa for abundant goods.

3.135 Thus, in order to reflect true value of satellite spectrum, the auction design/model should create some sort of scarcity in case where supply is non-rivalrous and shareable, this can be achieved by introducing some mechanisms

[38] Doctoring Adam Smith: The Fable of the Diamonds and Water Paradox, Michael V. White History of Political Economy ,Duke University Press ,Volume 34, Number 4, Winter 2002 pp. 659-683

[39] The Theory of Political Economy- W. Stanley Jevons

such as limiting the number of successful bidders, specifying the periodicity of auctions etc. these are explained below.

Assume Total spectrum = T, divided into t blocks

Let T=100 MHz, t=10 and Block size =10 MHz

Assume reserve price per Block = Rs P1 crore

Let n be the existing number of service providers/licensees, and n+ **Δ (where Δ > 0)** be the maximum number of bidders to whom spectrum will be assigned

Assume n=3 and **Δ**=1, thus spectrum can be assigned to maximum 4 bidders (i.e. n+ **Δ)** and assuming that 6 bidders participated in auction for a block t.

Bidders	**Round 1**	**Round 2**	**Round 3**	**Price paid by each bidder (Rs crore)**
Clock round price (Rs crore)	P1	P2	P3	P2 =Winning price (Second best price auction)
Bidder 1	✓	✓	✓	P2
Bidder 2	✓	✓	✓	P2
Bidder 3	✓	✓	✓	P2
Bidder 4	✓	✓	✓	P2
Bidder 5	✓	✓	X	-
Bidder 6	✓	X	X	-

3.136 As stated above, the satellite spectrum is non-rivalrous in nature, i.e., the use of the same spectrum by one user does not cause any significant negative

externality[40] on the utility of another user, that is, considering the above example though the block size of say 10MHz will be shared amongst n+ Δ users (Maximum), however each user will have access to full 10 MHz of spectrum. Hence, it is rational that even though the spectrum will be shared amongst multiple users, each user must pay the full price for the spectrum.

3.137 In the above model, four successful highest bidders acquire spectrum and two are excluded. The two excluded bidders cannot seek spectrum from other successful bidders and can only acquire spectrum in next auction, which will be conducted after (say) 5 years.

3.138 However, if the number of successful bidders are less than n+ Δ and if some left out/ unsuccessful bidder(s) later on modifies his valuation and expresses his willingness to acquire spectrum, he may be given spectrum only at an auction price discovered by the successful bidders, only on the condition that the maximum number of bidders to whom spectrum is assigned should not exceed n+ Δ.

3.139 The merit of this model is that the fear of getting excluded may drive incentives of the bidders to bid close to their true valuation, leading to efficient price discovery. Moreover, this model will exhibit inbuilt sharing of spectrum amongst successful bidders, which will enable sharing of higher frequency bands leading to efficient utilization of spectrum in these bands.

3.140 In this background, the Authority solicits comments of stakeholders on the following:

Issues for Consultation

Q29. What could be the likely issues, that may arise, if the following auction design models (described in para 3.127 to 3.139) are implemented for assignment of spectrum for user links in higher bands (such as C band, Ku band and Ka band)?

[40] The Theory of Externalities, Public Goods, and Club Goods, Richard Cornes, Todd Sandler · 1996

a. **Model #1: Exclusive spectrum assignment**
b. **Model#2: Auction design model based on non-exclusive spectrum assignment to only a limited number of bidders.**

What changes should be made in the above models to mitigate any possible issues, including ways and means to ensure competitive bidding? Response on each model may kindly be made with justification.

Q30. In your opinion, which of the two models mentioned in Question 29 above, should be used? Kindly justify your response.

Q31. In case it is decided to assign spectrum for user links using model # 2 i.e., non-exclusive spectrum assignment to limited bidders (n+ Δ), then what should be -

(a) the value of Δ, in case it is decided to conduct a combined auction for all services

(b) the values of Δ, in case it is decided to conduct separate auction for each type of service

Please provide detailed justification.

Q32. Kindly suggest any other auction design model(s) for user links including the terms and conditions? Kindly provide a detailed response with justification as to how it will satisfy the requirement of fair auction i.e., market discovery of price.

Assignment of spectrum for Gateway Links

3.141 Gateway links require large quantum of spectrum for both uplink and downlink. In its letter 16.08.2022, DoT has mentioned that entire band can be used by NGSO FSS networks.

3.142 As mentioned earlier, the number of satellite gateways required in case of NGSO satellite constellations vary depending on the altitude of the NGSO satellite constellation and the capacity requirement to meet the customer demand. In case of GSO satellites, the number of earth station gateways required could vary depending on the beam size. For instance, if a GSO satellite is using a wide beam covering the entire nation, the satellite operator may decide to have one of two earth station gateways; however, in case a GSO satellite is a HTS using spot beams, the number of earth stations required to be put in place in the country may be more.

Suggested spectrum assignment options for gateway links

Option # 1: Area specific assignment of gateway spectrum on administrative basis

3.143 Spectrum for satellite gateway links is required to be assigned for specific geographical location. Therefore, one option could be that assignment of spectrum for gateway links be made on administrative basis for use in specific geographical area, and possibly auction determined price for user links in a band could be used as a basis for charging for spectrum for gateway links in that spectrum band.

Option # 2: **Assignment of gateway spectrum through auction for identified areas/ regions/ districts**

3.144 While deciding the location of the satellite gateways, factors such as land with clear visibility, cost of land, site having fiber connectivity, power supply, favourable climate, etc., play a major role. For this reason, there could be interest from multiple service providers to deploy satellite gateway at a particular location. During the preparatory discussions with stakeholders, it was suggested that for auction of spectrum for gateway links, it is possible to identify certain areas which are suitable for deployment of gateways.

Competitive bidding may be envisaged among service providers for deployment of satellite gateways at such specific areas/ regions/ districts. However, counter argument could be that separate auction of identified locations could result in a situation where a service licensee who has acquired spectrum for user links through auction, may not be able to acquire spectrum at the desired location(s) for gateway links.

3.145 In this background, the Authority solicits comments of stakeholders on the following set of questions:

Issues for Consultation

Q33. What could be the likely issues, that may arise, if Option # 1: (Area specific assignment of gateway spectrum on administrative basis) is implemented for assignment of spectrum for gateway links? What changes could be made in the proposed option to mitigate any possible issues?

Q34. What could be the likely issues, that may arise, if Option # 2: Assignment of gateway spectrum through auction for identified areas/ regions/ districts is implemented for assignment of spectrum for gateway links? What changes could be made in the proposed option to mitigate any possible issues? In what manner, areas/ regions/ districts should be identified?

Q35. In your view, which spectrum assignment option for gateway links should be implemented? Kindly justify your response.

Q36. Kindly suggest any other auction design model(s) for gateway links including the terms and conditions? Kindly provide a detailed response with justification as to how it will satisfy the requirement of fair auction i.e., market discovery of price?

J. Any other relevant issues

3.146 As already mentioned, the Authority is undertaking the exercise for assignment of spectrum for space-based communication services through a market mechanism for the first time. There is not sufficient international experience available on the matter. There might be certain other issues, which may be required to be examined, but have not been covered in the above sections in this consultation paper. Therefore, for any other issues that might not have been covered in the above sections, the stakeholders are requested to provide their valuable inputs with detailed justification.

Issue for Consultation

Q37. Any other issues/suggestions relevant to the subject, may be submitted with proper explanation and justification.

3.147 The following chapter examines the issues related to valuation of spectrum for space-based communication services.

CHAPTER-IV: EXAMINATION OF ISSUES RELATED TO VALUATION OF SPECTRUM FOR SPACE-BASED COMMUNICATION SERVICES

4.1 In chapter VII, Article 44 of the constitution of the International Telecommunication Union (ITU), dealing with the 'Use of the Radio-Frequency Spectrum and of the Geostationary-Satellite and Other Satellite Orbits', it has been mentioned that radio frequencies and any associated orbits, including the geostationary satellite orbit, are limited natural resources and that they must be used rationally, efficiently and economically, in conformity with the provisions of the Radio Regulation. It therefore follows that an optimal allocation and spectrum charging mechanism must be designed for the assignment of satellite frequencies to enable pareto efficiency41 in the utilization of these frequencies.

Spectrum Charging Mechanism

4.2 DoT vide its reference dated 13.09.2021 has requested TRAI, along with other aspects, to provide recommendations on applicable reserve price and other associated conditions of auction of spectrum for space-based communication services. Further, DoT vide letter dated 16.08.2022 mentioned that the spectrum for space-based communications services is presently being assigned through administrative mechanism with formula-based charging for some applications and percentage of AGR-based charging for others.

4.3 The spectrum charges for assignment of frequencies are being levied as per DoT's administrative orders issued vide letter no. P-11014/34/2009-PP(III) dated 22nd March 2012 as attached at Annexure IV to the DoT's letter dated 16.08.2022, which inter alia states that:

[41] Pareto efficiency refers to allocating resources in such a way that it is not possible to improve one individual's lot without impairing the lot of at least one other individual. The concept is named after Italian economist, Vilfredo Pareto. Pareto efficiency originated from Pareto's study income distribution and economic efficiency; *Welfare economics and the scope of markets, Cambridge University Press, June, 2012*

".....Royalty charges for Assignments of Frequencies to 'Captive Users' (users being charged on formula basis) including all Government Users, involving all Satellite based systems (i.e. Broadcasting, Radio, Television, DSNG etc.; and ii. Other networks: ILD, INMARSAT, NLD, Teleport, VSAT etc.).

....

The Standard Annual Royalty Factor shall be Rs. 35,000/- per Frequency."

4.4 As per the said order, the Annual Royalty payable is calculated, as briefly given below:

Royalty, R (in Rs.) = 35000 x Bs;

where (Bs) is the Bandwidth Factor for Satellite Communications

4.5 Further, for commercial VSAT networks, the spectrum charges are being levied as a percentage of Adjusted Gross Revenue (AGR), based on data rate range as per DoT's circular no. R-11014/2001-LR dated 16th April 2003. DoT vide its letter dated 16.08.2022 has mentioned that this order is under revision, where the percentage AGR basis charging has been retained but a uniform rate of charging is proposed. The Authority, in the past has recommended that spectrum usage charges in respect of commercial VSAT services should be kept at 1% of AGR.

4.6 The Authority in its recommendations on "Methodology for levy of Spectrum Charges for provision of Satellite based Services using Gateway installed in India under 'sui-generis' category" dated 27th December 2018, recommended that the spectrum charges should be levied at 1% of the AGR of BSNL's satellite-based services under 'sui-generis' category. These recommendations have been accepted by the Government and the spectrum charges for BSNL's satellite-based services under 'sui-generis' category has been prescribed as 1% of the AGR vide DoT's order dated 28.06.2021.

4.7 As an interim measure, DoT vide its order dated 17.01.2023, has continued frequency assignment for satellite-based applications (incl. DTH, Teleport, DSNG,

VSAT, NLD, ILD, INMARSAT) on administrative basis for a period of six months w.e.f. 13.1.2023, subject to the conditions reproduced below: -

i The allotment of spectrum is provisional and subject to Govt's decision on allotment & pricing of spectrum;

ii. In the event of final decision to allot spectrum only through auction process, the provisional allotment of spectrum shall be withdrawn;

iii. In case the provisional allotment of spectrum is withdrawn, payment made towards spectrum charges or part thereof shall not be refunded;

…….

v. The respective wireless users would be required to give an undertaking to pay the revised spectrum charges, as finally determined through market related mechanism or otherwise as may be applicable, from the date of Letter of Intent (LoI) for provisional allotment of spectrum.

3.1. Upon shift/ change in policy from administrative allotment, due notice of 3 months of such change, time to make appropriate arrangements, etc. will be given and the same has to be complied with by the wireless users."

4.8 DoT vide its reference dated 13.09.2021 also, sought TRAI's recommendations on applicable reserve price of spectrum to be auctioned and associated conditions for space-based communication services. In the previous chapter, issues relating to assignment of spectrum for space-based communication services have been raised for soliciting comments of stakeholders. In case the stakeholders are of the opinion that administrative assignment should be continued, the question arises as to what should be the spectrum charging mechanism.

4.9 In this background, the Authority solicits comments of stakeholders on the following:

Issues for Consultation

Q38. In case it is decided for assignment of spectrum on administrative basis, what should be the spectrum charging mechanism for assignment of spectrum for space-based communications services

i. For User Link

ii. For Gateway Link

Please support your answer with detailed justification.

Valuation of frequency bands

4.10 DoT, vide its letter dated 16.08.2022 stated that:

1. *"TRAI can consider following frequency bands for providing recommendations with respect to space based communications services:*

   i. *10.7- 12.75 GHz (space to Earth)*
   ii. *12.75-13.25 GHz (Earth-to-space)*
   iii. *13.75- 14.5 GHz (Earth-to-space)*
   iv. *17.7-18.6 GHz (space to Earth) [17.7- 18.4 is used for earth to space also]*
   v. *18.8-19.3 GHz (space to Earth)*
   vi. *19.3-19.7 GHz (space to Earth)*
   vii. *19.7-21.2 GHz (space to Earth)*
   viii. *27.5-29.5 GHz (Earth-to-space) [27.5-28.5 has been identified for implementation of IMT in India]*
   ix. *29.5- 31 GHz (Earth-to-space)*

2. *TRAI can however provide recommendations for other frequency bands also."*

4.11 DoT, through the letter dated 16.12.2022, conveyed that TRAI may provide suitable recommendations for each of the space-based communication services

after detailed examination. Hence, for the purpose of valuation, the present consultation paper requires to consider all the spectrum bands relevant for space-based communication services as indicated by DoT in the letter mentioned above. As already discussed in detail at para 2.16 of this Consultation Paper, the popular frequency bands used for providing space-based communication services are as follows:

(a) L-band: ranging from 1 GHz to 2 GHz

(b) S-band: ranging from 2 GHz to 4 GHz

(c) C-band: ranging from 4 GHz to 8 GHz

(d) Ku-band: ranging from 10 GHz to 15 GHz

(e) Ka-band: ranging from 17 GHz to 31 GHz

4.12 The Authority for the purpose of valuation of spectrum bands and fixation of reserve price for IMT services has used various techno-financial modelling exercises such as production function model, producer surplus model, multiple regression model, trend line method etc. These models relied on extensive datasets consisting of certain market parameters, financial parameters related to the particular band, existing spectrum holding of the particular band, past auction prices etc. However, in case of the satellite-based communication spectrum bands, there is no historical auction data available to conduct comparative analysis involving auction determined prices in India or using valuation models involving data related to the spectrum bands. Thus, the Authority intend to explore following alternative approaches for valuation of the satellite-based communication spectrum bands:

- Technical/Spectral efficiency approach
- Using current spectrum charges as a basis
- Use of Revenue Surplus model
- Use of International benchmarking

4.13 **Technical/Spectral efficiency approach**

- An alternative approach for valuation of these bands could be based on comparative values that can be achieved by using relative spectral efficiency approach where characteristics like capacity of a particular band can be compared with the same characteristics of another spectrum band and a spectral efficiency factor can be derived as a ratio.
- However, it may be noted that spectral efficiency factor is available only with respect to IMT/5G. It can be explored if the same can be utilized as a basis for valuation of satellite spectrum bands.
- Moreover, the auction determined prices of mmWave bands as well as C-band for IMT/5G, across all the 22 licensed service areas is available from the recently concluded August 2022 IMT/5G auctions., it can be explored whether these prices can be used as a basis for valuation of satellite spectrum bands.

Q39. Should the auction determined prices of spectrum bands for IMT /5G services be used as a basis for valuation of space-based communication spectrum bands

i. For user link

ii. For gateway link

Please support your answer with detailed justification.

Q40. If response to the above question is yes, please specify the detailed methodology to be used in this regard?

Q41. Whether the value of space-based communication spectrum bands

i. For user link

ii For gateway link

be derived by relating it to the value of other bands by using a spectral efficiency factor? If yes, with which spectrum bands should these bands be related to and what efficiency factor or formula should be used? Please support your response with detailed justification.

4.14 **Using Current Spectrum Charges as a basis**

- As stated in para 4.3 to 4.5, that presently spectrum for satellite-based services is assigned administratively and spectrum charges are levied either on a formula basis or as a percentage of AGR.
- It can be explored that the current spectrum charges being paid by operators in each type of satellite service may be used as a basis for valuation of spectrum for each type of service.

Q42. In case of an auction, should the current method of levying spectrum fees/charges for satellite spectrum bands on formula basis/ AGR basis as followed by DoT, serve as a basis for the purpose of valuation of satellite spectrum

i. For user link

ii. For gateway link

If yes, please specify in detail what methodology may be used in this regard.

4.15 **Use of Revenue Surplus model**

- The revenue surplus model was used by the Authority in its Recommendations on 'Auction of Spectrum in frequency bands identified for IMT/5G'[42]

- This model is primarily based on financial parameters, spectrum holdings etc. The model for valuation of spectrum is premised on the assumption that the net

[42] https://trai.gov.in/sites/default/files/Recommendations_11042022.pdf

present value (NPV) of the projected revenue surplus over the next 20 years could potentially represent the maximum amount which a service provider would be willing to pay for additional spectrum in that band. The detailed explanation of this model has been given at Annexure 3.4 of above Recommendations.

Q43. Should revenue surplus model be used for the valuation of space-based spectrum bands

i. For user link

ii. For gateway link

Please support your answer with detailed justification.

4.16 **Use of International benchmarking**

Using some other alternative approaches such as international benchmarking can also be explored for these bands. The international spectrum charges/price can serve as a basis for valuation of satellite spectrum bands. For this, it might be useful to obtain insights regarding the assignment and spectrum pricing mechanism followed internationally. The following paras deals with the assignment and spectrum charging mechanism being followed in some of the other countries: -

A. Satellite Bands in Canada[43]

- Satellite spectrum licences for Fixed-Satellite Service (FSS) and Broadcasting-Satellite Service (BSS) are typically issued for a term of 20 years. The fee is payable on an annual basis.

[43] https://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/h_sf01713.html

- The annual radio authorization fee of $137.86 per megahertz (MHz) is imposed to authorize the use of FSS and BSS spectrum.

- The annual radio authorization fee of $620.39 per 100 kHz, or portion thereof is imposed for assigned spectrum to provide mobile satellite services for above 1GHz spectrum

- The annual radio authorization fee is $1309.71 per 100 kHz, or portion thereof, is imposed for assigned radio spectrum for the use of radio frequency bands below 1 GHz to provide mobile satellite services

B. Satellite Bands in Europe and UK: [44]

- Annual license fee is currently applied to the licence products for permanent and transportable earth stations and VSATs. The licence fees are based on algorithms incorporating the bandwidth to which access is authorised, the peak transmit power and a number of modifiers used to capture aspects of satellite operation that might affect the spectrum access denied to other users[45]

- Annual license fee for a permanent earth station is £ 200 and for earth station(Non-Fixed Satellite Service) is £ 500[46]

- The Satellite (earth station network) – for NGSO license authorizes the use of NGSO user terminals. Annual license fee of £200 is charged for a NGSO Network(user terminal) licence.

- **Satellite (Transportable Earth Station) licence fees**

  The appropriate sum is the amount in pounds payable for each earth station operating in one of the bands specified in Columns 2, 3 or 4 of the table

[44] https://www.esa.int/Applications/Telecommunications_Integrated_Applications/Satellite_frequency_bands

[45] https://www.ofcom.org.uk/__data/assets/pdf_file/0010/50014/spec_pricing.pdf

[46] https://www.ofcom.org.uk/__data/assets/pdf_file/0020/27461/fees.pdf

below as determined by the range of p specified in Column 1 of the same table.

"OMP" means the number corresponding to the number of the Operational Maximum

Power (in Watts) as declared by the licensee;

"p" means the product of OMP multiplied by WBW; and

"WBW" means the number corresponding to the number of the widest bandwidth (in

MHz) as declared by the licensee.

Annual Fees - Transportable Earth Station

Column 1: Range of p	Column 2: Fee per earth station in the band **5.925-7.075 GHz**	Column 3: Fee per earth station in the band **13.78-14.5 GHz**	Column 2: Fee per earth station in the bands **27.5-27.8185 GHz, 28.4545-28.8265 GHz, 29.4625-30 GHz**
0 < p ≤ 100	£ 500	£ 300	£ 200
100 < p ≤ 2,500	£ 2,400	£ 1,400	£ 800
P > 2,500	£ 7,400	£ 4,300	£ 2,600

C. Allocation and charging mechanism of satellite spectrum bands in USA[47] [48]

- Applications may be filed by going online at licensing.fcc.gov/myibfs and submitting the application through the International Bureau Filing System (IBFS).

[47] https://www.ecfr.gov/current/title-47/chapter-I/subchapter-B/part-25
[48] https://en.wikipedia.org/wiki/Ku_band

- The bands are assigned through a licensing procedure. License applications must be filed electronically on FCC Form 312 in accordance with the applicable provisions.

- An applicant must pay the appropriate filing fee in accordance with part 1, subpart G , at the time when it files a FCC Form 312.

- Annual regulatory fee for VSAT and Equivalent C-Band Antennas operating in the 12 and 14 GHz is $595 per license or authorization, and $595 for each associated Hub Station [49]

D. Satellite Bands in Brazil[50]

- According to the relevant ANATEL regulations, the operation of satellites in and from Brazil must be carried out exclusively through the frequency bands specifically allocated to satellite services compatible with Brazilian telecommunications services (e.g., Ka-band, Ku-band).

- The operation of satellites associated with fixed satellite, mobile satellite and broadcasting satellite services is subject to a satellite landing right authorisation, which grants operators the right to use specific spectrum and orbital positions to perform satellite communications and to provide satellite capacity to interested third parties

- The Satellite Landing Right is granted for a period of up to 15 (fifteen) years and can be renewed once[51]

- Anatel conducts a bidding process for conferring the Landing Right, which will have as its object an authorization for satellite telecommunication and for the

[49] https://docs.fcc.gov/public/attachments/DOC-375657A1.docx
[50] https://www.lexology.com/library/detail.aspx?g=d4e86825-aee7-4ed9-a7c9-3f03d0f02c12
[51] https://www.gov.br/anatel/pt-br/regulado/satellite/process-for-granting-satellite-landing-rights

provision of satellite capacity over the Brazilian territory, with orbit and spectrum resources associated with a Brazilian satellite network.

4.17 In the above countries, the spectrum is allotted through a non-auction based administrative procedure. Even in Brazil though satellite landing right is assigned through bidding, but the spectrum to be used for satellite services is not auctioned separately. As per media reports, countries like the US, Mexico, and Brazil had attempted to sell frequencies for satellite usage but eventually did not succeed and at last resorted to administrative licensing[52].

4.18 It may be noted that recently, the Communications and Information Technology Commission (CITC) of Saudi Arabia conducted an auction for spectrum in the 2100MHz band for Non-Terrestrial Networks (NTN) technologies in November 2022. The spectrum will be used for various NTN technologies such as 5G-non-terrestrial networks (5G-NTN), mobile satellite services (MSS), internet on airplane (A2G), and internet of things via satellite (MSS-IoT). CITC's awarded 30 MHz paired spectrum in range 1980MHz-2010MHz/2170MHz-2200MHz. Spectrum was divided into 2 blocks of 15 MHz each. Both the blocks were acquired by Saudi telecom Company after 32 rounds of bidding.[53]

4.19 The 2 blocks were as follows;

Block	Frequencies
A1 (technology neutral)	1980 – 1995 MHz / 2170 – 2185 MHz
A2 (MSS)	1995 – 2010 MHz / 2185 – 2200 MHz

Block A2 is limited initially to the provision of Mobile Satellite Services (MSS). The winner of Block A2 may subsequently apply for an upgrade of its license to authorise the use of terrestrial technologies.

[52] https://www.telecomreview.com/articles/reports-and-coverage/6110-above-and-beyond-satellite-spectrum-and-space-based-internet

[53] https://www.techafricanews.com/2022/12/08/stc-wins-the-spectrum-auction-in-the-2100mhz-band-for-non-terrestrial-networks/

4.20 The reserve price of the blocks were as follows:[54]

Block	Reserve price (in SAR) (11 Year Validity)
A1 (technology neutral)	396,000,000
A2 (MSS)	14,300,000 (For MSS Only) Annual Upgrade Fee -34,700,000

Q44. Whether international benchmarking by comparing the auction determined prices of countries where auctions have been concluded for space-based communication services, if any, be used for arriving at the value of space-based communication spectrum bands:

i. For user link

ii For gateway link

If yes, what methodology should be followed in this regard? Please give country-wise details of auctions including the spectrum band /quantity put to auction, quantity bid, reserve price, auction determined price etc. Please support your response with detailed justification.

Q45. Should the international administrative spectrum charges/fees serve as a basis/technique for the purpose of valuation in the case of satellite spectrum bands

i. For user link

ii. For gateway link

[54] Spectrum Auction of 2100 MHz Radio Licenses for Non-Terrestrial Networks: Information memorandum CITC

Please give country-wise details of administrative price being charged for each spectrum band. Please specify in detail terms and conditions in this regard.

Q46. If the answer to above question is yes, should the administrative spectrum charges/fees be normalized for cross country differences? If yes, please specify in detail the methodology to be used in this regard?

Q47. Apart from the approaches highlighted above which other valuation approaches can be adopted for the valuation of space-based communication spectrum bands? Please support your suggestions with detailed methodology, related assumptions and other relevant factors.

4.21 It may be noted that the afore-mentioned valuation approaches can be used for arriving at the valuation of satellite-based spectrum; irrespective whether it is used for user link or gateway link. However as cited in para 3.88 to 3.90 of this Consultation Paper, frequency spectrum for user links may be required in a ubiquitous manner to fulfil the user requirement, which may be comparable to the access spectrum in mobile services but spectrum for gateway links is required for a specific geography and therefore, same frequency spectrum can be reused by satellite gateways as long as they do not cause interference to one another. Thus, it is to be decided that whether the arrived valuation of satellite spectrum to be used for gateway links need to be adjusted on a pro-rata basis, considering the specific geography to which the spectrum will be used.

Issue for Consultation:

Q48. Should the valuation arrived for spectrum for user link be used for valuation for spectrum for gateway links as well? Please justify.

Q49. If the answer to the above is no, what should be the basis for distinction as well as the methodology that may be used for arriving at the valuation of satellite spectrum for gateway links? Please provide detailed justification.

4.22 Further, the Authority, since September 2013, has taken a consistent view that instead of depending on the valuation arrived at using any single approach, it would be better to rely on a number of such approaches to arrive at a final reasonable valuation and then determine reserve price based on such valuation. Accordingly, the Authority has been using various approaches to arrive at the valuation of different spectrums bands and to determine the reserve price of different spectrum bands for the auction of various bands of spectrum from time to time. All of these valuation approaches have their merits as well as demerits and it would be appropriate to rely on a number of such approaches to arrive at a final reasonable valuation rather than depending on the valuation arrived at using any one approach. The Authority in its spectrum valuation exercises has used probabilistic average valuation (simple mean) of the valuations obtained through the different approaches attempted for valuation of a particular spectrum band. Taking into account the principle of equal probability of occurrence of each valuation, will it be appropriate to take the average valuation (simple mean) of the valuations obtained through the different approaches attempted for valuation of a particular spectrum band, as adopted by the Authority since September 2013 recommendations or some other methodology be used for valuation exercise.

Q50. Whether the value arrived at by using any single valuation approach for a particular spectrum band should be taken as the appropriate value of that band? If yes, please suggest which single approach/ method should be used. Please support your answer with detailed justification.

Q51. In case your response to the above question is negative, will it be appropriate to take the average valuation (simple mean) of the

valuations obtained through the different approaches attempted for valuation of a particular spectrum band, or some other approach like taking weighted mean, median etc. should be followed? Please support your answer with detailed justification.

Reserve price estimation

4.23 For arriving at the reserve prices, the Authority in its recommendation dated 11.04.2022 had primarily set reserve price equal to 70% of the mean of value the spectrum derived from all possible approaches.

4.24 A reserve price is the starting point for an ascending price auction and bidding is the means to true price discovery. It ensures a minimum guaranteed amount for the owner/ seller of goods and prevents excessive bargaining in the auction process. The reserve price set at too low level is inefficient in deterring collusion and if set at a too high level it can negatively impact participation in the auction. Thus, to ensure efficiency of the auction process, setting of reserve price at an optimal level is a prerequisite. Accordingly, various aspects of the satellite spectrum bands assignment must be examined before arriving at the reserve price.

4.25 As cited in para 3.83 above that the demand side of the spectrum meant for space-based communication services will be generated by operators providing distinct services with different market and financial parameters, and if separate auctions are to be held, it is to be decided further what should the reserve price for each of these class of services.

4.26 Moreover, if the spectrum for space-based communication services is to be assigned on a shared basis it is to be decided whether the reserve price also needs to be adjusted for the same.

4.27 Accordingly, the following questions arise for consultation:

Issues for consultation

Q52. Should the reserve price for spectrum for user link and gateway link be taken as 70% of the valuation of spectrum for shared as well as for exclusive assignment? If not, then what ratio should be adopted between the reserve price for the auction and the valuation of the spectrum in different spectrum bands in case of (i) exclusive (ii) shared assignment and why? Please support your answer with detailed justification.

Q53. If it is decided to conduct separate auctions for different class of services, should reserve price for the auction of spectrum for each service class be distinct? If yes, on what parameter basis such as revenue, subscriber base etc. this distinction be made? Please support your answer with detailed justification for each class of service.

Payment Terms for spectrum assignment

4.28 Presently, as discussed at para 4.3 to 4.7 above, the spectrum for space-based communication services is being assignment on administrative basis and spectrum charges are being paid on annual basis.

4.29 However, in case of auctioned spectrum, as in IMT/5G services, the following payment terms have been prescribed as per Notice Inviting Applications (NIA) 2022. The same have been briefly discussed below: -

1. Upfront Payments

As per NIA dated 15th June, 2022 for 'Auction of Spectrum in 600 MHz, 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz, 2500 MHz, 3300 MHz, and 26 GHz Bands, provides option of part upfront payment. It states that:

Where part upfront payment has been made, which can be a multiple of complete years with a minimum of two years, the buyer shall have the option of availing ***moratorium*** *for the corresponding number of years for which the upfront payment has been made*

An upfront payment of 50% was fixed in the case of 1800 MHz, 2100 MHz, 2300 MHz & 2500 MHz bands. in the NIA of 2021 & 2016. However, for the preceding years (viz. the years 2015, 2013 and 2012), the upfront payment rate in case of above 1 GHz spectrum bands was fixed at 33%. On the other hand, in case of sub-1 GHz bands viz. 700 MHz, 800 MHz and 900 MHz, the upfront payment rate was fixed at 25% and upfront payment criteria remained consistent in earlier NIAs also.

2. Prepayment option

As per prepayment option given in the NIA 2022: -

"Pre-payment of one or more instalments will be allowed on any date, based upon the principle that the NPV of the due amount is protected at the applicable interest rate."

3. No. of instalments

As per NIA 2022, for the case of deferred payments, the balance amount shall be payable in equal annual instalments over the remaining period, payable in advance at the beginning of each year, after the period of moratorium if any, duly protecting the Net Present Value (NPV) of the bid amount at the applicable rate of interest.

4. Rate of Discount

As per NIA 2022, a rate of discount of 7.2% was fixed in case if prepayment/deferred payment option was used, to ensure that the net present value of payment/ bid amount is protected.

4.30 In this regard, the following questions arise for consultation: -

Issues for consultation

Q54. In case of auction based and/or administrative assignment of spectrum, what should the payment terms and associated conditions for the assignment of spectrum for space-based communication services relating to:

i. Upfront payment

ii. Moratorium period

iii. Total number of installments to recover deferred payments

iv. Rate of discount in respect of deferred payment and prepayment

Please support your answer with detailed justification.

4.31 The following chapter lists the issues for consultation.

CHAPTER- V: ISSUES FOR CONSULTATION

Stakeholders are requested to provide responses to the following questions with detailed justifications:

Q1. For space-based communication services, what are the appropriate frequency bands for (a) gateway links and (b) user links, that should be considered under this consultation process for different types of licensed telecommunications and broadcasting services? Kindly justify your response with relevant details.

Q2. What quantum of spectrum for (a) gateway links and (b) user links in the appropriate frequency bands is required to meet the demand of space-based communication services? Information on present demand and likely demand after about five years may kindly be provided in two separate tables as per the proforma given below:

Type of service	Name of the satellite system	Type of satellite (GSO/ LEO/ MEO)	Frequency range and quantum of spectrum required							
			User Link (Earth to space UL)		User Link (Space to Earth DL)		Gateway Link (Earth to space UL)		Gateway Link (Space to Earth DL)	
			Frequency range	Quantum (in MHz)	Frequency range	Quantum (in MHz)	Frequency range	Quantum (in MHz)	Frequency range	Quantum (in MHz)
Access										
Internet										
NLD										
ILD										
GMPCS										

VSAT CUG (Commercial)										
Captive VSAT CUG										
Machine to Machine (M2M)										
DTH										
Teleport										
DSNG										
HITS										
IFMC										
Any other relevant service (please specify)										

Q3. Whether there is any practical limit on the number of Non-Geo Stationary Orbit (NGSO) satellite systems in Low Earth Orbit (LEO) and Medium Earth Orbit (MEO), which can work in a coordinated manner on an equitable basis using the same frequency range? Kindly justify your response.

Q4. For space-based communication services, whether frequency spectrum in higher bands such as C band, Ku band and Ka band, should be assigned to licensees on an exclusive basis? Kindly justify your response. Do you foresee any challenges due to exclusive assignment? If yes, in what manner can the challenges be overcome? Kindly elaborate the challenges and the ways to overcome them.

Q5. In case it is decided to assign spectrum in higher frequency bands such as C band, Ku band and Ka band for space-based communication services to licensees on an exclusive basis,

(a) What should be the block size, minimum number of blocks for bidding and spectrum cap per bidder? Response may be provided separately for each spectrum band.

(b) Whether intra-band sharing of frequency spectrum with other satellite communication service providers holding spectrum upto the prescribed spectrum cap, needs to be mandated?

(c) Whether a framework for mandatory spectrum sharing needs to be prescribed? If yes, kindly suggest a broad framework and the elements to be included in the guidelines.

(d) Any other suggestions to ensure that that the satellite communication ecosystem is not adversely impacted due to exclusive spectrum assignment, may kindly be made with detailed justification.

Kindly justify your response.

Q6. What provisions should be made applicable on any new entrant or any entity who could not acquire spectrum in the auction process/assignment cycle?

(a) Whether such entity should take part in the next auction/ assignment cycle after expiry of the validity period of the assigned spectrum? If yes, what should be the validity period of the auctioned/assigned spectrum?

(b) Whether spectrum acquired through auction be permitted to be shared with any entity which does not hold spectrum/ or has not been successful in auction in the said band? If yes, what measures should be taken to ensure rationale of spectrum auction and to avoid adverse impact on the dynamics of the spectrum auction?

(c) In case an auction based on exclusive assignment is held in a spectrum band, whether the same spectrum may again be put to auction after certain number of years to any new entrant

including the entities which could not acquire spectrum in the previous auction? If yes,

(i) After how many years the same spectrum band should be put to auction for the potential bidders?

(ii) What should be the validity of spectrum for the first conducted auction in a band? Whether the validity period for the subsequent auctions in that band should be co-terminus with the validity period of the first held auction?

Kindly justify your response.

Q7. Whether any entity which acquired the satellite spectrum through auction/assignment should be permitted to trade and/or lease their partial or entire satellite spectrum holding to other eligible service licensees, including the licensees which do not hold any spectrum in the concerned spectrum band? If yes, what measures should be taken to ensure rationale of spectrum auction and to avoid adverse impact on the dynamics of the spectrum auction? Kindly justify your response.

Q8. For the existing service licensees providing space-based communication services, whether there is a need to create enabling provisions for assignment of the currently held spectrum frequency range by them, such that if the service licensee is successful in acquiring required quantum of spectrum through auction/ assignment cycle in the relevant band, its services are not disrupted? If yes, what mechanism should be prescribed? Kindly justify your response.

Q9. In case you are of the opinion that the frequency spectrum in higher frequency bands such as C band, Ku band and Ka band for space-based communication services should be assigned on shared (non-exclusive) basis, -

(a) Whether a broad framework for sharing of frequency spectrum among satellite communication service providers needs to be prescribed or it should be left to mutual coordination? In case you are of the opinion that broad framework should be prescribed, kindly suggest the framework and elements to be included in such a framework.

(b) Any other suggestions may kindly be made with detailed justification.

Kindly justify your response.

Q10. In the frequency range 27.5-28.5 GHz, whether the spectrum assignee should be permitted to utilize the frequency spectrum for IMT services as well as space-based communication services, in a flexible manner? Do you foresee any challenges arising out of such flexible use? If yes, in what manner can the challenges be overcome? Kindly elaborate the challenges and the ways to overcome them.

Q11. In case it is decided to permit flexible use in the frequency range of 27.5 - 28.5 GHz for space-based communication services and IMT services, what should be the associated terms and conditions including eligibility conditions for such assignment of spectrum? Kindly justify your response.

Q12. Whether there is a requirement for permitting flexible use between CNPN and space-based communication services in the frequency range 28.5-29.5 GHz? Kindly justify your response.

Q13. Do you foresee any challenges in case the spectrum assignee is permitted to utilize the frequency spectrum in the range 28.5-29.5 GHz for cellular based CNPN as well as space-based communication services, in a flexible manner? What could be the measures to mitigate such challenges? Suggestions may kindly be made with justification.

Q14. Whether space-based communication services should be categorized into different classes of services requiring different treatment for spectrum assignment? If yes, what should be the classification of services and which type of services should fall under each class of service? Kindly justify your response. Please provide the following details:

a) Service provider-wise details regarding financial and market parameters such as total revenue, total subscriber base, total capital expenditure etc. for each type of service (as mentioned in the Table 1.3 of this consultation paper) for the financial year 2018-19, 2019-20, 2020-21, 2021-22, and 2022-23 in the format given below:

Type of service: _____				
Financial Year	**Revenue (Rs. lakh)**	**Subscriber base**	**CAPEX for the year (Rs. lakh)**	**Depreciation for the year (Rs. lakh)**
2018-19				
2019-20				
2020-21				
2021-22				
2022-23				

b) Projections on revenue, subscriber base and capital expenditure for each type of service (as mentioned in the Table 1.3 of this consultation paper) for the whole industry for the next five years starting from financial year 2023-24, in the format given below:

Type of service: _____			
Financial Year	**Revenue (Rs. lakh)**	**Subscriber base**	**CAPEX for the year (Rs. lakh)**
2023-24			

2024-25			
2025-26			
2026-27			
2027-28			

Q15. What should be the methodology for assignment of spectrum for user links for space-based communication services in L-band and S-band, such as-

(a) Auction-based
(b) Administrative
(c) Any other?

Please provide your response with detailed justification.

Q16. What should be the methodology for assignment of spectrum for user links for space-based communication services in higher spectrum bands like C-band, Ku-band and Ka-band, such as

(a) Auction-based
(b) Administrative
(c) Any other?

Please provide your response in respect of different types of services (as mentioned in Table 1.3 of this consultation paper). Please support your response with detailed justification.

Q17. Whether spectrum for user links should be assigned at the national level, or telecom circle/ metro-wise? Kindly justify your response.

Q18. In case it is decided to auction user link frequency spectrum for different types of services, should separate auctions be conducted for each type of services? Kindly justify your response with detailed methodology.

Q19. What should be the methodology for assignment of spectrum for gateway links for space-based communication services, such as

(a) Auction-based

(b) Administrative

(c) Any other?

Please provide your response in respect of different types of services. Please support your response with detailed justification.

Q20. In case it is decided to auction gateway link frequency spectrum for different types of services, should separate auctions be conducted for each type of services? Kindly justify your response with detailed methodology.

Q21. In case it is decided to assign frequency spectrum for space-based communication services through auction,

(a) What should be the validity period of the auctioned spectrum?

(b) What should be the periodicity of the auction for any unsold/ available spectrum?

(c) Whether some mechanism needs to be put in place to permit the service licensee to shift to another satellite system and to change the frequency spectrum within a frequency band (such as Ka-band, Ku-band, etc.) or across frequency bands for the remaining validity period of the spectrum held by it? If yes, what process should be adopted and whether some fee should be charged for this purpose?

Kindly justify your response.

Q22. Considering that (a) space-based communication services require spectrum in both user link as well as gateway link, (b) use of frequency spectrum for different types of links may be different for different satellite systems, and (c) requirement of frequency

spectrum may also vary depending on the services being envisaged to be provided, which of the following would be appropriate:

(i) to assign spectrum for gateway links and user links separately to give flexibility to the stakeholders? In case your response is in the affirmative, what mechanism should be adopted such that the successful bidder gets spectrum for user links as well as gateway links.

or

(ii) to assign spectrum for gateway links and user links in a bundled manner, such that the successful bidder gets spectrum for user link as well as gateway link? In case your response is in the affirmative, kindly suggest appropriate assignment methodology, including auction so that the successful bidder gets spectrum for user links as well as gateway links.

Q23. Whether any protection distance would be required around the satellite earth station gateway to avoid interference from other satellite earth station gateways for GSO/ NGSO satellites using the same frequency band? If yes, what would be the protection distance (radius) for the protection zone for GSO/ NGSO satellites?

Q24. What should be the eligibility conditions for assignment of spectrum for each type of space-based communication service (as mentioned in the Table 1.3 of this Consultation Paper)? Among other things, please provide your inputs with respect to the following eligibility conditions:

(a) Minimum Net Worth

(b) Requirement of existing agreement with satellite operator(s)

(c) Requirement of holding license/ authorization under Unified License prior to taking part in the auction process.

Kindly justify your response

Q25. What should be the terms and conditions for assignment of frequency spectrum for both user links as well as gateway links for each type of space-based communication service? Among other things, please provide your detailed inputs with respect to roll-out obligations on space-based communication service providers. Kindly provide response for both scenarios viz. exclusive assignment and non-exclusive (shared) assignment with justification.

Q26. Whether the provisions contained in the Chapter-VII (Spectrum Allotment and Use) of Unified License relating to restriction on crossholding of equity should also be made applicable for satellite-based service licensees? If yes, whether these provisions should be made applicable for each type of service separately? Kindly justify your response.

Q27. Keeping in view the provisions of ITU's Radio Regulations on coexistence of terrestrial services and space-based communication services for sharing of same frequency range, do you foresee any challenges in ensuring interference-free operation of space-based communication network and terrestrial networks (i.e., microwave access (MWA) and microwave backbone (MWB) point to point links) using the same frequency range in the same geographical area? What could be the measures to mitigate such challenges? Suggestions may kindly be made with justification.

Q28. In what manner should the practice of assignment of a frequency range in two polarizations should be taken into account in the present exercise for assignment and valuation of spectrum? Kindly justify your response.

Q29. What could be the likely issues, that may arise, if the following auction design models (described in para 3.127 to 3.139) are implemented for assignment of spectrum for user links in higher bands (such as C band, Ku band and Ka band)?

a. **Model #1: Exclusive spectrum assignment**
b. **Model#2: Auction design model based on non-exclusive spectrum assignment to only a limited number of bidders**

What changes should be made in the above models to mitigate any possible issues, including ways and means to ensure competitive bidding? Response on each model may kindly be made with justification.

Q30. In your opinion, which of the two models mentioned in Question 29 above, should be used? Kindly justify your response.

Q31. In case it is decided to assign spectrum for user links using model # 2 i.e., non-exclusive spectrum assignment to limited bidders (n+ Δ), then what should be

(a) the value of Δ, in case it is decided to conduct a combined auction for all services

(b) the values of Δ, in case it is decided to conduct separate auction for each type of service

Please provide detailed justification.

Q32. Kindly suggest any other auction design model(s) for user links including the terms and conditions? Kindly provide a detailed response with justification as to how it will satisfy the requirement of fair auction i.e., market discovery of price.

Q33. What could be the likely issues, that may arise, if Option # 1: (Area specific assignment of gateway spectrum on administrative basis) is implemented for assignment of spectrum for gateway links? What changes could be made in the proposed option to mitigate any possible issues?

Q34. What could be the likely issues, that may arise, if Option # 2: Assignment of gateway spectrum through auction for identified areas/ regions/ districts is implemented for assignment of spectrum

for gateway links? What changes could be made in the proposed option to mitigate any possible issues? In what manner, areas/ regions/ districts should be identified?

Q35. In your view, which spectrum assignment option for gateway links should be implemented? Kindly justify your response.

Q36. Kindly suggest any other auction design model(s) for gateway links including the terms and conditions? Kindly provide a detailed response with justification as to how it will satisfy the requirement of fair auction i.e., market discovery of price?

Q37. Any other issues/suggestions relevant to the subject, may be submitted with proper explanation and justification.

Q38. In case it is decided for assignment of spectrum on administrative basis, what should be the spectrum charging mechanism for assignment of spectrum for space-based communications services

i. For User Link

ii. For Gateway Link

Please support your answer with detailed justification.

Q39. Should the auction determined prices of spectrum bands for IMT /5G services be used as a basis for valuation of space-based communication spectrum bands

i. For user link

ii. For gateway link

Please support your answer with detailed justification.

Q40. If response to the above question is yes, please specify the detailed methodology to be used in this regard?

Q41. Whether the value of space-based communication spectrum bands

i. For user link

ii For gateway link

be derived by relating it to the value of other bands by using a spectral efficiency factor? If yes, with which spectrum bands should these bands be related to and what efficiency factor or formula should be used? Please support your response with detailed justification.

Q42. In case of an auction, should the current method of levying spectrum fees/charges for satellite spectrum bands on formula basis/ AGR basis as followed by DoT, serve as a basis for the purpose of valuation of satellite spectrum

i. For user link

ii. For gateway link

If yes, please specify in detail what methodology may be used in this regard.

Q43. Should revenue surplus model be used for the valuation of space-based spectrum bands

i. For user link

ii. For gateway link

Please support your answer with detailed justification.

Q44. Whether international benchmarking by comparing the auction determined prices of countries where auctions have been concluded for space-based communication services, if any, be used for arriving at the value of space-based communication spectrum bands:

i. For user link

ii For gateway link

If yes, what methodology should be followed in this regard? Please give country-wise details of auctions including the spectrum band

/quantity put to auction, quantity bid, reserve price, auction determined price etc. Please support your response with detailed justification.

Q45. Should the international administrative spectrum charges/fees serve as a basis/technique for the purpose of valuation in the case of satellite spectrum bands

i. For user link

ii. For gateway link

Please give country-wise details of administrative price being charged for each spectrum band. Please specify in detail terms and conditions in this regard.

Q46. If the answer to above question is yes, should the administrative spectrum charges/fees be normalized for cross country differences? If yes, please specify in detail the methodology to be used in this regard?

Q47. Apart from the approaches highlighted above which other valuation approaches can be adopted for the valuation of space-based communication spectrum bands? Please support your suggestions with detailed methodology, related assumptions and other relevant factors.

Q48. Should the valuation arrived for spectrum for user link be used for valuation for spectrum for gateway links as well? Please justify.

Q49. If the answer to the above is no, what should be the basis for distinction as well as the methodology that may be used for arriving at the valuation of satellite spectrum for gateway links? Please provide detailed justification.

Q50. Whether the value arrived at by using any single valuation approach for a particular spectrum band should be taken as the appropriate value of that band? If yes, please suggest which single approach/ method should be used. Please support your answer with detailed justification.

Q51. In case your response to the above question is negative, will it be appropriate to take the average valuation (simple mean) of the valuations obtained through the different approaches attempted for valuation of a particular spectrum band, or some other approach like taking weighted mean, median etc. should be followed? Please support your answer with detailed justification.

Q52. Should the reserve price for spectrum for user link and gateway link be taken as 70% of the valuation of spectrum for shared as well as for exclusive assignment? If not, then what ratio should be adopted between the reserve price for the auction and the valuation of the spectrum in different spectrum bands in case of (i) exclusive (ii) shared assignment and why? Please support your answer with detailed justification.

Q53. If it is decided to conduct separate auctions for different class of services, should reserve price for the auction of spectrum for each service class be distinct? If yes, on what parameter basis such as revenue, subscriber base etc. this distinction be made? Please support your answer with detailed justification for each class of service.

Q54. In case of auction based and/or administrative assignment of spectrum, what should the payment terms and associated conditions for the assignment of spectrum for space-based communication services relating to:

i. Upfront payment

ii. Moratorium period

iii. Total number of installments to recover deferred payments

iv. Rate of discount in respect of deferred payment and prepayment

Please support your answer with detailed justification.

Annexure-1: DoT letter dated 13th September 2021 (without Annexures)

Government of India
Ministry of Communications
Department of Telecommunications
Wireless Planning & Coordination (WPC) Wing
6th floor, Sanchar Bhawan,
20, Ashoka Road, New Delhi – 110001.

No.: L-14006/01/2021-NTG Date: 13.09.2021

To,

The Secretary
Telecom Regulatory Authority of India
Mahanagar Doorsanchar Bhawan
Jawahar Lal Nehru Marg (Old Minto Road)
New Delhi-110002.

Subject: Seeking TRAI recommendations for the auction of spectrum in the frequency bands identified for International Mobile Telecommunications (IMT)/ 5G.

Sir,

In response to DoT's reference dated 17.04.2017, TRAI provided its recommendations dated 01.08.2018 on various issues involved in the auction of spectrum in 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz, 2500 MHz and 3300-3600 MHz bands. Based on the TRAI recommendations dated 01.08.2018 and response dated 08.07.2019 on DoT's back-reference, Government conducted auction of spectrum in 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz and 2500 MHz bands in March 2021. A total of 2308.80 MHz spectrum worth Rs. 400396.20 Crore at Reserve Price in different band-LSA combinations was put to auction, out of which 855.60 MHz quantum was sold in the auction resulting in total winning bids worth Rs. 77820.81 Crore. No bids were received in 700 MHz and 2500 MHz bands. Spectrum unsold in the auction held in March 2021 may be put to auction in the forthcoming auction. LSA-wise quantum available with the Government in these bands after the auction is given in ***Annexure-I***.

2. In the recommendations dated 01.08.2018, spectrum in 3300-3600 MHz band was also included. However, due to certain issues, the Government decided to initiate action to auction spectrum in this band separately after resolution of these issues and, therefore, it was not a part of the auction held in March 2021. Now, as the issues have been resolved as well as the range of available frequencies in this range has slightly gone up, it has been decided by the Government that spectrum in the frequency range 3300-3670 MHz should be made available to the Telecom Service Providers for IMT/ 5G through auction, except in few areas/locations (details of excluded areas/locations in ***Annexure-II***).

3. In addition to the above, new frequency bands (mentioned below) have also been decided to be used for IMT/5G:

(i) 526-582 MHz in all the LSAs in coordination with Ministry of Information & Broadcasting. The use will be coordinated with minimum keep out distance from MIB transmitters.

(ii) 582-617 MHz in all the LSAs. This band will be available for IMT/5G and rural point to point links.

(iii) 617-698 MHz in all the LSAs, except few areas/locations (details of excluded areas/locations in ***Annexure-II***).

(iv) 24.25 to 28.5 GHz in all the LSAs except at 5 locations (details of locations in ***Annexure-II***) with protection distance of 2.7 km.

4. DoT has also received few requests regarding spectrum requirements for captive usage of 5G applications by some industries e.g. Industry 4.0. COAI has also submitted a letter regarding Private Captive Networks, wherein they have *inter alia* requested not to reserve any spectrum which has been identified for IMT, for Private Captive Networks.

5. Parliamentary Standing Committee on Information Technology in its report on "India's preparedness for 5G" has made certain observations on pricing of spectrum. Also, DoT has received request from COAI regarding effective spectrum pricing. Copy of the relevant pages of the Standing Committee report is enclosed as ***Annexure-III***.

6. Department of Space (DoS) had invited comments on Draft Spacecom Policy liberalizing space segment for private sector participation to provide commercial communication services in India. This includes the Low Earth Orbit (LEO) and Medium Earth Orbit (MEO) satellite constellations operational over India. In case of satellite communication, the subscriber is accessed from the satellite through "Access spectrum"

similar to "Access spectrum" in terrestrial network and the demand for such spectrum will potentially increase in the future.

7. In view of the above, under the terms of clause 11 (1)(a) of TRAI Act, 1997 as amended by TRAI Amendment Act 2000, TRAI is requested to:

(a) provide recommendations on applicable reserve price, band plan, block size, quantum of spectrum to be auctioned and associated conditions for auction of spectrum in 526-698 MHz, 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz, 2500 MHz, 3300-3670 MHz and 24.25-28.5 GHz bands for IMT/ 5G.

(b) provide recommendation on quantum of spectrum/bands, if any, to be earmarked for private captive/isolated 5G networks, competitive/transparent method of allocation, and pricing, for meeting the spectrum requirements if captive 5G applications of industries for machine/plant automation purposes/M2M in premises.

(c) provide recommendation on appropriate frequency bands, band plan, block size, applicable reserve price, quantum of spectrum to be auctioned and associated conditions for auction of spectrum for space-based communication services, in view of para 6 above.

(d) provide any other recommendations deemed fit for the purpose of spectrum auction in these frequency bands, including the regulatory/ technical requirements as enunciated in the relevant provisions of the latest ITU-R Radio Regulations.

This issues with the approval of the competent authority.

13/9/2021

(Sukhpal Singh)
Joint Wireless Adviser

Enclosure:

i) ***Annexure-I***: LSA-wise quantum available with the Government in 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz and 2500 MHz bands after March' 2021 auction and after earmarking of 5 MHz (paired) to Indian Railways in 700 MHz band.

ii) ***Annexure-II***: Details of the areas/locations where certain spectrum would not be available for IMT/5G.

iii) ***Annexure-III***: Copy of the relevant pages of Parliamentary Standing Committee Report on "India's Preparedness for 5G".

Copy to:

Secretary, DoS, for kind information please.

Annexure-2: DoT letter dated 16.08.2022 (with its Annexure-I, III and IV)

Government of India
Ministry of Communications
Department of Telecommunications
Wireless Planning & Coordination (WPC) Wing

6th Floor, Sanchar Bhawan,
20 Ashoka Road, New Delhi-110001

No. J-19022/01/2022-SAT Date: 16 August, 2022

To

The Secretary
Telecom Regulatory Authority of India
Mahanagar Doorsanchar Bhawan
Jawahar Lal Nehru Marg (Old Minto Road)
New Delhi-110002

Subject: Seeking TRAI recommendations for the auction of spectrum in the frequency bands identified for International Mobile Telecommunications (IMT)/5G-reg.

Reference: TRAI letter No. C-15/2/(1)/2021-NSL-II dated 23rd November 2021.

Sir,

In response to DoT's reference dated 13.09.2021, Telecom Regulatory Authority of India (TRAI), vide its above referenced letter (enclosed), requested DoT to provide additional information in respect of space-based communication services.

2. In this regards, the following information is provided to TRAI with a request to provide the recommendations on 7(c) of the DoT's letter No. L-14006/01/2021-NTG dated 13.09.2021 (enclosed).

2.1 **Details of the frequency bands and quantum of spectrum available in each band required to be put to auction and associated information in respect of space-based communication:**

(a) The frequency bands and quantum of spectrum that may be considered by TRAI for providing recommendations with respect to space-based communication services are provided in **Annexure-I**.

(b) These frequency bands include "Planned bands" that when used by GSO systems in accordance with Appendices 30, 30A & 30B of Radio Regulations are reserved by ITU for use by National systems. Use of 'Planned Bands' by foreign GSO satellites is not permitted in India. TRAI may, *inter-alia*, take into account this aspect with respect to GSO systems, in the consultation process. Further, the NGSO network has to provide the protection to GSO networks as per ITU framework.

(c) While Annexure-1 includes both spectrum band and quantum of spectrum in each band, however, the demand of spectrum is not known. Therefore, TRAI, through consultations, may assess the demand for space-based communication services and accordingly provide recommendations on the quantum of spectrum in each band required to be put to auction.

2.2 **Whether spectrum for space-based communication is being envisaged to be assigned on exclusive basis or will the same be shared among multiple service licensees:**

(a) It is envisaged to auction the Space Spectrum on exclusive basis. TRAI may explore the feasibility and procedure of sharing auctioned spectrum among multiple service licensees. TRAI may provide recommendations on sharing of auctioned frequency bands between satellite networks and terrestrial networks also, the criteria for sharing and appropriate interference mitigation techniques for sharing and coexistence.

(b) In frequency bands 27.5-28.5 GHz (identified for IMT) and 28.5-29.5 GHz (being studied for Captive Non-Public Networks), TRAI may recommend mechanism for sharing of auctioned frequency bands in which both IMT/CNPN and satellite based services (both user terminal and Gateways) can be provided in a flexible manner.

2.3 **Details of spectrum assignment mechanism and methodology of charging currently being followed by DoT for space-based communication services:**

(a) Spectrum for space based communications services is currently being assigned through administrative mechanism with formula-based charging for some applications and percentage AGR based charging for others. This assignment is subject to conditions provided in the WPC Wing OM No. R-11014/15/2012-NT(Pt.) dated 05 January 2021(revised from time to time)- **Annexure-III**.

(b) Relevant spectrum charging orders are provided in **Annexure-IV**. Spectrum charges are levied as per administrative orders issued in 2012. Commercial VSAT operations are governed by an order issued in 2003 where charges were levied on a revenue sharing basis. This order is under revision, where the percentage AGR basis charging has been retained but a uniform rate of charging is proposed. Until June, 2021, the spectrum charges for Mobile Satellite Service provided by BSNL ("Sui generis") were being levied on formula basis. However, in June 2021, a separate order for this service has been issued, as per which spectrum charges are being collected from M/s BSNL on a revenue sharing basis, with retrospective effect (from the date of inception of this service). In 2021, spectrum charges for captive VSAT users were also modified.

3. Since the service providers may require spectrum both in user link as well as in feeder link, TRAI may take inputs from the stakeholder and recommend the appropriate auction methodology so that the successful bidder gets spectrum for user link (shared with IMT in flexible) as well as feeder link.

4. In addition, TRAI is requested to provide any other recommendation as deemed fit for the purpose of spectrum auction in these frequency bands, including the regulatory/technical requirements as enunciated in the relevant provisions of the latest ITU-R Radio Regulations.

This issues with the approval of the competent authority.

(Gulab Chand)
Joint Wireless Advisor

Enclosure:

1. **Annexure-I**: Frequency bands to be considered by TRAI for providing recommendations with respect to space-based communication services.
2. **Annexure-II**: Frequency assignment issued in these bands.
3. **Annexure-III**: WPC Wing OM No. R-11014/15/2012-NT(Pt.) dated 05 January 2021
4. **Annexure-IV**: Extant Spectrum charging orders.
5. TRAI letter No. C-15/2/(1)/2021-NSL-II dated 23rd November 2021.
6. DoT letter No. L-14006/01/2021-NTG dated 13.09.2021.

Annexure-I

Frequency bands to be considered by TRAI for providing recommendations with respect to space-based communication services

1. TRAI can consider the following frequency bands for providing recommendations with respect to space-based communication services.

   i. 10.7- 12.75 GHz (space to Earth)
   ii. 12.75-13.25 GHz (Earth-to-space)
   iii. 13.75- 14.5 GHz (Earth-to-space)
   iv. 17.7-18.6 GHz (space to Earth) [17.7-18.4 is used for Earth to space also]
   v. 18.8-19.3 GHz (space to Earth)
   vi. 19.3-19.7 GHz (space to Earth)
   vii. 19.7-21.2 GHz (space to Earth)
   viii. 27.5-29.5 GHz (Earth-to-space) [27.5-28.5 GHz has been identified for implementation of IMT in India]
   ix. 29.5- 31 GHz (Earth-to-space)

2. TRAI can however provide recommendations for other frequency bands also.

Note: The Planned bands are:

i. 12.75 -13.25 GHz & 6725–7025 MHz (Uplink) and 10.7-10.95 GHz, 11.2-11.45 GHz & 4500-4800 MHz (Downlink): FSS Plan (RR Appendix 30B)
ii. 11.7-12.2 GHz (Downlink) : BSS Plan (RR Appendix 30)
iii. 14.5-14.8 GHz & 17.3-18.1 GHz (Uplink): BSS feeder links Plan (RR Appendix 30A)

Quantum of Spectrum

S. No.	Downlink (GHz)	Total Spectrum (GHz)	Uplink (GHz)	Total Spectrum (GHz)	Current Users	Applications	Remarks
1.	10.7 – 12.75*	2.05	12.75 – 13.25** 13.75 – 14.5	1.25	**Terrestrial networks**		• Entire band can be used by Non-GSO FSS networks. • Currently, MWA in 12.75 – 13.25 GHz coexists with FSS. * 11.7 – 12.2 GHz, Only National system For GSO. ** For GSO national systems only. Corresponding downlink of 500 MHz in 10.7-10.95 GHz and 11.2 – 11.45 GHz.
					Telecom Service Providers/ISP	Microwave Access	
					GSO Systems#		
					Dish TV India Ltd., Sun TV Ltd., Tata Play Ltd., Bharti Telemedia Pvt. Ltd., Doordarshan	DTH	
					Nelco Ltd., Hughes Communications India Pvt. Ltd.	Commercial VSAT/IFMC	
					HCL Comnet, Infotel Satcom, BSNL	Commercial VSAT	
					Cloudcast	IFMC	
					Planetcast Media Services Ltd., TV18, TV Today, AIR, Lamhas Satellite Services Ltd., Indiasign Pvt. Ltd.	DSNG	
					ONGC, AAI, ISRO, DRDO	Captive VSAT	

2.	17.7 – 18.6 18.8 - 21.2	3.3	27.5 – 31***	2.5***	**Terrestrial networks**		• Available total spectrum can be used by Non-GSO FSS Networks. • Currently, MWA in 17.7 – 19.7 GHz coexists with FSS. *** CoS decision: 27.5-28.5 GHz identified for IMT.
					Telecom Service Providers/ISP	Microwave Access	
					GSO Systems#		
					BSNL	IFMC	
					Hughes Communications India Pvt. Ltd.	Commercial VSAT	
					ISRO	High Throughput Satellites' Gateways	
Total (1+2)		**5.35**	-	**3.75**		-	

Note: These bands are both for Geo-stationary orbit (GSO) & Non-GSO networks. In general, Non-GSO networks shall not cause unacceptable interference to and, unless otherwise specified in the Radio Regulations, shall not claim protection from GSO satellite networks in the fixed-satellite service and the broadcasting-satellite service.

Showing major users only.

Existing/Planned deployments by various satellite operators in NGSO

(as per information available in Public domain)

Sl. No	Satellite Operator	Deployment (Frequency Bands)	Planned Satellite numbers	Live Satellite numbers	Frequency Bands (in GHz)			
					User Link		Feeder Link	
					Space to Earth	Earth to Space	Space to Earth	Earth to Space
1.	SpaceX (USA)	Ku/Ka* (1st Gen)	4408	**1892**	10.7-12.75	14-14.5	17.8-18.6 18.8-19.3	27.5-29.1 29.5-30.0
		Ku/Ka/E* (2nd Gen)	30000	-	10.7-12.75 17.8-18.6 18.8-19.3 19.7-20.2	12.75-13.25 13.85-14.5 28.35-29.1 29.5-30.0	17.8-18.6 18.8-19.3 71-76	27.5-29.1 29.5-30.0 81-86
		V Band*	7518	-	37.5-42.5	47.2-50.2 50.4-52.4	37.5-42.5	47.2-50.2 50.4-52.4
2.	Kuiper Systems (Amazon) (USA)	Ka Band	3236	-	17.7-18.6 18.8-20.2	28.35-29.1 29.5-30	17.7-18.6 18.8-20.2	27.5-30 37.5-42.0 42.0-42.5
		Ku/V***	7774	-	10.7-12.7 37.5-42.0 42.0-42.5	12.75-13.25 14-14.5 47.2 – 50.2 50.4 – 51.4	37.5-42.0 42.0-42.5	47.2-50.2 50.4-51.4
3	Boeing (USA)	V	5921	-	37.5-42	47.2-50.2 50.4-51.4	37.5-42	47.2-50.2 50.4-51.4
4	Astra Space (USA)	V	13620	-	37.5-42	47.2-50.2 50.4-51.4	37.5-42	47.2-50.2 50.4-51.4
5	OneWeb (UK)	Ku/Ka (Phase 1)	648	**394**	10.7-12.7	12.75-13.25 14-14.5	17.8-18.6 18.8-19.3 19.7-20.2	27.5-29.1 29.5-30.0
		Ku/Ka (Phase 2)	6372	-	10.7-12.7	12.75-13.25 14-14.5	17.8-18.6 18.8-19.3 19.3-19.7 19.7-20.2	27.5-29.1 29.1-29.5 29.5-30.0
		V Band	6372	-	40.0-42.0	48.2-50.2	37.5-42.5	42.5-43.5 47.2-50.2 50.4-51.4
6	O3B (UK)	Ka	70	**20**	17.8-18.6 18.8-20.2	27.5-30	17.8-18.6 18.8-20.2	27.5-30
		V	24	-	37.5-42	47.2-50.2 50.4-51.4	37.5-42	47.2-50.2 50.4-51.4
7	Telesat (CANADA)	Ka Band**	300	-	17.8-18.6 18.8-19.3 19.7-20.2	27.5-29.1 29.5-30	17.8-18.6 18.8-19.3 19.7-20.2	27.5-29.1 29.5-30
		V Band**	1671	-	37.5-42	47.2-50.2 50.4-51.4	37.5-42	47.2-50.2 50.4-51.4

*SpaceX not seeking authorization in USA for 12.7-12.75 GHz; 40-42.5 GHz & 51.4-52.4 GHz

**The frequency band 50.4-51.4 GHz is presently not identified in the USA for FSS.

*** 42-42.5 GHz (non-USA only)

Annexure-III

Government of India
Ministry of Communications
Wireless Planning & Coordination Wing
Sanchar Bhawan, 20-Ashoka Road, New Delhi-110 001

No. R-11014/15/2012-NT (Pt.) Date:5th January, 2021

OFFICE MEMORANDUM

It has been decided, as an interim measure, for a period of **Six months** from the date of issue of this OM, to continue to make frequency assignments for broadcasting (including community radio), H/V/UHF/SHF fixed/mobile networks (including CMRTS), radars, experimentation, demonstration and satellite based applications (including DTH, Teleport, DSNG, VSAT, NLD, ILD, INMARSAT).

2. The annual spectrum usage charges shall be continued to be levied as per Orders No. P-11014/34/2009-PP(I), (II), (III) & (IV) dated 22nd March, 2012 and VSAT Order No. R-11014/9/2001-LR dated 16th April, 2003 unless otherwise amended.

3. The allotment of the spectrum would be made with the following conditions and upon obtaining an undertaking from applicants that they would agree for assignment of frequencies with the following conditions:

(i) The allotment of spectrum is provisional and subject to Govt's decision on allotment & pricing of spectrum;

(ii) In the event of final decision to allot spectrum only through auction process, the provisional allotment of spectrum shall be withdrawn;

(iii) In case the provisional allotment of spectrum is withdrawn, payment made towards spectrum charges or part thereof shall not be refunded;

(iv) In case the provisional allotment of spectrum is withdrawn, respective wireless users would obtain Non Dealer Possession Licence (NDPL) for possessing the wireless equipment or return the equipment to a DPL holder or shall be disposed-off the same as per procedure.

(v) The respective wireless users would be required to give an undertaking to pay the revised spectrum charges, as finally determined through market related mechanism or otherwise as may be applicable, from the date of Letter of Intent (LoI) for provisional allotment of spectrum.

05/01/2021

(BHAGENDRA SINGH)
Assistant Wireless Advisor
Dept. of Telecom, Govt. of India

No. R-11014/15/2012-NT (Pt.) Date:5th January, 2021

3.1. Upon shift/ change in policy from administrative allotment, due notice of 3 months of such change, time to make appropriate arrangements, etc. will be given and the same has to be complied with by the wireless users.

4. The above conditions in Para 3 and 3.1 will be added in the Letter of Intent (LoI), Decision to grant License (D/L) and the Wireless Operating Licence (WOL) also.

05/01/2021

(Khagendra Singh)
Asstt. Wireless Adviser
to the Government of India
Ph- 011 2303 6633

To,
All concerned

(KHAGENDRA SINGH)
Asstt. Wireless Adviser
Dept. of Telecom, Govt. of India
New Delhi/New Delhi

Copy for information to:

I. DDG (WPF), Wireless Finance Division.
II. Director, Wireless Monitoring Organisation.
III. JWA WPC (HQ)/ JWA, RLO (WR/ER/NR/SR)/ Sr. DWA, RLO(NE)
IV. All Sr. DWAs, WPC Wing, DoT HQ.
V. Director (IT), DoT, for uploading on DoT's website.
VI. Sr. DWA (ASMS), for uploading on WPC Wing's website.

Annexure-IV

Government of India
Ministry of Communications & IT
Department of Telecommunication
Wireless Planning & Co-ordination (WPC) Wing

Sanchar Bhavan,
20, Ashoka Road,
New Delhi-110 001

No. P-11014/34/2009-PP (III)

Date: 22nd March, 2012

ORDER

Subject: Royalty charges for Assignments of Frequencies to 'Captive Users' (users being charged on formula basis) including all Government Users, involving Satellite based systems.

In pursuance of Power conferred by section 4 of the Indian Telegraph Act, 1885(13 of 1885) and in supersession of this Ministry's Orders order no. J-19011/1/98-SAT, dated 14/09/1998, and No. R-11014/26/2002-LR,Dated 06/05/2003, the Central Government has decided the following Royalty charges for Assignments of Frequencies to 'Captive Users' (users being charged on formula basis) including all Government Users, involving all Satellite based systems (i. Broadcasting: Radio, Television, DSNG etc; and ii. Other networks:, ILD, INMARSAT, NLD, Teleport, VSAT etc)-

2. *The Standard Annual Royalty Factor shall be Rs.35000 per Frequency.* It shall be applied to the total licensed bandwidth of each frequency of any type of satellite-based *Radio-communication Network* (including ILD, NLD, Teleport, DSNG, DTH, VSAT, INMARSAT and Satellite Radio), together with the relevant *Bandwidth Factor* (B_f) given in *Table D* below, to arrive at the amount of *Annual Royalty per Frequency, R*, payable for an Uplink or a Downlink as per the following formula:

$$\text{Royalty, R (in Rs.)} = 35000 \times B_f$$

Table D: Bandwidth Factor (B_f) for Satellite Communications

Bandwidth Assigned to a Frequency (W kHz)	Bandwidth Factor, B_f for an uplink		Bandwidth Factor B_f for a downlink	
	Broadcast	Others	Broadcast	Others
Up to and including 100 KHz	0.25	0.20	NIL	0.20
More than 100 KHz and Up to and including 250 KHz	0.60	0.50	NIL	0.50
More than 250 KHz and upto 500 kHz	1.25 @	1.00 @	NIL	1.00@
For every 500 kHz or part thereof	1.25 @	1.00 @	NIL	1.00@

[@ for every 500 kHz or part thereof]

3. In addition to above, the explanatory "Notes" on the applicability of royalty charges, are as follows:

i. As a principle, charges for radio spectrum be levied for both uplinks and downlinks, as the nature of the resource remains the same. Charging will however only be in respect of the frequencies transmitted from or into Indian Territory.

ii. The DSNG, SNG etc., be levied royalty charges for radio frequencies used on both Uplinks and Downlinks, because these are dedicated links that cannot be equated with broadcasting service.

iii. For DSNG's, in case the same frequency carrier is used by the user (assignee of RF) from different OB vans belonging to him, additional royalty @ 25% of the basic royalty be charged from him, however if the additional OB vans are located within the same premises additional royalty @ 25% of the basic royalty will not be charged.

iv. For Temporary Unlinking, a minimum royalty equivalent to that for one month be charged.

4. For Charging of "Licence fee and other fees, Surcharge/ late fee and Charging Methodologies for Royalty / licence fees, Order No. No. P-11014/34/2009-PP (IV) dated 22nd March, 2012 shall be applicable.

5. This issues with the concurrence of the Wireless Finance Division, vide their Dy. No.482/Sr.DDG(WPF), dated 19/3/12.

6. This Order shall come into force from 1st April 2012.

(Viresh Goel)
Deputy Wireless Advisor
to the Government of India

Copy to:

1. All concerned
2. Wireless Finance Division
3. Wireless Monitoring Organisation
4. Director, IT DoT for uploading on DoT website
5. DWA(ASMS) for uploading on WPC Wing website

Government of India
Ministry of Communications & IT
Department of Telecommunication
Wireless Planning & Co-ordination (WPC) Wing

Sanchar Bhavan,
20, Ashoka Road,
New Delhi-110 001

No. P-11014/34/2009-PP (IV)

Date: 22nd March, 2012

ORDER

Subject: Licence fee and other fees, Surcharge/ late fee and Charging Methodologies for Royalty / licence fees for 'Captive Users' (users being charged on formula basis) including all Government Users.

In pursuance of Power conferred by section 4 of the Indian Telegraph Act, 1885(13 of 1885) and in supersession of this Ministry's Orders No. R-11014/28/2004-LR dated 23.03.2005, and No. R-11014/4/87-LR dated 20.07.1995 the Central Government has decided the following rates of Licensee fees, and other fees, Surcharge/ late fee and Charging Methodologies for Royalty / licence fees for different types of Assignments of Frequencies to 'Captive Users' (users being charged on formula basis) including all Government Users. :-

2. **License Fees**

Sl. No.	Type of License	Annual License Fee, Rs.	Remarks
i.	Fixed/ Land Station	500	Per station
ii.	Land Mobile Station	250	Per station
iii.	Captive paging (Hub)	2000	Per Hub
iv.	Maritime Mobile Station (fishing trawlers)	500	Per trawler
v.	Maritime Mobile Station (Ships)	5000	Per ship
vi.	Aero-mobile Station	5000	Per aircraft
vii.	USR (short range)	250	Per station
viii.	Fixed station of Microwave links/ Radar Station/NLD station/BTS	1000	Per station
ix.	CMRTS fixed station	500	Per fixed station
x.	CMRTS Mobile Station	250	Per mobile station; vehicle mounted or hand-held
xi.	Fixed station in Satellite Network, e.g., DTH/ Teleport/ DSNG/ NLD/ ILD/ DCP/ IP-II	1000	Per Fixed Station
xii.	Captive V-SAT	500	Per Hub or Terminal
xiii.	INMARSAT	250	For Mobile terminal
xiv.	INMARSAT	500	For Fixed terminal

NOTE: License Fee for standby sets shall also be charged at the same rates.

3. **Fees for issuing duplicate copies and License Modification**

Sl. No.	Type	Fee in Rupees
i.	Duplicate copy of License (Without Schedule)	500
ii.	Duplicate copy of Schedule(s) of a License	500
iii.	Duplicate copy of Renewal Certificate	250
iv.	License Modification	1000

4. **Charging Methodologies** for Royalty / licence fees:

i. No radio frequency be assigned, reserved, or blocked through a Decision Letter, Agreement-in-Principle, or any other instrument of like nature *unless* the applicant pays, in advance, all applicable license fees and royalty charges for the full duration of authorization/ assignment of the radio frequency, or minimum of one year, whichever is less.

ii. Upon successful processing of an application requesting for an assignment of radio frequency (RF), the applicant be informed about the License Fees and Royalty required to be deposited by him. These shall be calculated for the full period of the requested assignment. Where the period is greater than one year, the wireless user/ applicant has to pay the license fee and royalty in annual installments in advance every year.

iii. Immediately thereafter, but in no case later than thirty (30) days from the date of issue of the said letter, the applicant shall pay the charges for issue of License/ DL/AIP, if otherwise permissible. If, on the other hand, the payment is not received within this period of 30 days, the application will be treated as ***cancelled*** and the frequencies shall be freed for being assigned to others. If the same applicant wants to subsequently pursue the application, he shall be required to submit a ***fresh*** application.

iv. The amounts due for different periods may be determined as follows.

License Period	License Fee payable	Royalty payable from the date of DL/ AIP/ WOL, as the case may be	Method of payment
One month or less	At specified flat rate.	Annual royalty divided by 12.	Full license fee & royalty to be paid in advance at the time of issue of DL/AIP/ license.
More than one month but up to one year	At specified flat rate.	On pro-rata basis. However, part of a month shall be taken as one month.	-- do --
More than one year	At specified flat rate.	On pro-rata basis. However, part of a month shall be taken as one month.	Pay the L/fee plus Royalty for the entire duration in advance at issue of DL/AIP/ license, OR pay it in annual advance instalments.

v. In case the licensee defaults on one of the annual installment payments, all the remaining installments shall become immediately payable.

vi. A Licensee shall be responsible to apply for the renewal of his/ her existing frequency authorization or wireless operating license (WOL), within a period of thirty (30) days *before* the expiry of the said WOL/ AIP/ DL.

vii. **Surrender of a License/ AIP/ DL:** Spectrum charges are payable minimum for one month and thus on surrender of licenses the Royalty charges in excess of one month can be adjusted. However, any monetary refund can only be made if the payments have been received for more than one year and surrender results the Royalty charges in excess of 1 year. The word "surrender" in this paragraph shall mean surrender of a complete **License/ AIP/ DL** with all its frequency assignments.

5. **Surcharge/Late Fee for Late Renewal of Wireless Station Licenses:** Surcharge/ Late fee for delayed renewal of various licenses shall be levied on the total amount due (i.e. license fee *plus* royalty charges) @ 2% per month or part thereof, subject to the minimum of Rs. 250/- per license. In case the delay is more than one year the said late fee shall be applied in an *annually compounded* manner.

6. This issues with the concurrence of the Wireless Finance Division, vide this Dy. No.482/Sr.DDG(WPF), dated 19/3/12.

7. This Order shall come into force from 1st April 2012.

22/3/12

(Viresh Goel)
Deputy Wireless Advisor
to the Government of India

Copy to:

1. All concerned
2. Wireless Finance Division
3. Wireless Monitoring Organisation
4. Director, IT DoT for uploading on DoT website
5. DWA(ASMS) for uploading on WPC Wing website

Government of India
Ministry of Communications & Information Technology
Department of Telecommunications
(WPC Wing)

No.R-11014/9/2001-LR Dated: 16th April,2003

ORDER

Subject: WPC spectrum charges (Royalty and License fee) for Commercial/Captive VSAT Networks - Change over to Revenue Share.

The issue regarding the payment of WPC spectrum charges (Royalty and License fee) for commercial and captive VSAT networks has been reviewed and the following has been decided by the competent authority:

1. **Commercial VSAT networks**

1.1 WPC spectrum charges under the Revenue Share Regime shall come into force from the quarter beginning 1st January, 2003 and shall be as under:

Range of data rate	Revised WPC spectrum charges
Up to 128 KBPS	3.0% of AGR
Higher than 128 KBPS and up to 512 KBPS	3.5% of AGR
Higher than 512 KBPS and up to 2 MBPS	4.0% of AGR

Note: (A) The percentage of revenue share as WPC spectrum charges indicated above comprises both royalty and license fee.

(B) The highest data rate of any VSAT in the network shall be the deciding factor for the percentage revenue share towards the spectrum charges.

1.2 Adjusted Gross Revenue (AGR) for the purpose of levying WPC spectrum charges shall be same as specified under the main DOT License Agreement.

1.3 Payment of WPC spectrum charges shall be on advance quarter basis and payable within 15 days of the commencement of the respective quarter; failing otherwise the same shall invoke panel interest as per the procedure in vogue in the main DOT License.

1.4 Penal interest shall be levied as per existing norms, procedure terms and conditions in vogue for delayed/ non payments for main DOT License Agreement.

1.5 Financial settlement/accounting of spectrum charges based on Estimated/Actual/Audited AGR's(subject to physical verification) shall be undertaken on quarterly/financial year basis on the same line/procedure and term and conditions as applicable in main DOT license agreement.

1.6 Estimated/Actual AGR's duly authenticated by the authorized signatory have to be submitted at the time of making quarterly payments.

1.7 All dues up to 31st December,2002 shall be settled on the basis of the then existing formulae.

2. Captive VSAT Networks:

The issue of WPC spectrum charges for captive networks has also been reviewed and it has been decided to maintain the status quo, while allowing data rate up to 512 KPBS, as there is no concept of revenue share in captive VSAT networks.

3. These orders come into force from the quarter commencing 1st January, 2003.

4. This issues with concurrence of Wireless Finance branch of WPC Wing vide their U.O. no. 323/WPF/03 dated 10/4/2003.

(ASHOK KUMAR)
Joint Wireless Advisor
To the Government of India

Copy to:

1. All VSAT Captive/Commercial Service Providers.
2. WPC, Finance Branch.
3. VSAT Service Providers Association

Government of India
Ministry of Communications
Department of Telecommunications
Wireless Planning & Coordination (WPC) Wing
6th Floor, Sanchar Bhawan, 20 Ashoka Road, New Delhi-110 001

No. J-19044/03/2015-SAT Date: 28/06/2021

Office Memorandum

Subject: Spectrum charges for Inmarsat based Global Satellite Phone Services under 'sui-generis' category offered by M/s BSNL-reg.

Levy of spectrum charges to the users of Inmarsat Global Satellite Phone Services (GSPS) – operated by M/s BSNL under the sui generis category license granted by DOT, will be as follows:

1. M/s BSNL shall pay spectrum charges as a percentage of its Adjusted Gross Revenue (AGR). These charges would cover the entire spectrum charges for handsets and for the gateway.

2. The applicable charges shall be 1% of the AGR of BSNL's satellite based services under 'sui-generis' category. The spectrum charges shall be applicable from the date of inception of GSPS services by BSNL.

2.1 The proceeds from the sale of handsets shall be included in the AGR.

2.2 Excess payment, if any, made by BSNL with regard to this service will be adjusted against the other SUC dues payable by BSNL to DOT.

2.3 The Pr. CCA, Delhi is assigned the responsibility for the AGR based assessment and related matters.

3. M/s BSNL, being the licensee, is hereby allowed to act as a single window agency to obtain NOC/ clearance from Ministry of Home Affairs (MHA) directly and other security vetting from other security agencies, wherever applicable, as per the policy to be laid down by DoT.

(i) M/s BSNL will furnish a list of its subscribers to WPC Wing on a half-yearly basis for endorsement on its Wireless Operating License (WOL).

(ii) Also, Inmarsat satellite phone users, including those users who were issued Wireless Operating Licenses (WOL) by WPC Wing will now be included under the provision of the service (GSPS) provided by M/s BSNL. These old users will no more be required to pay any spectrum charges separately to WPC Wing. Their existing licenses will stand terminated with effect from date of issue of this OM.

(ARUN VERMA)
उप सलाहकार (वायरलेस)
Deputy Wireless Adviser
दूरसंचार विभाग, भारत सरकार
Deptt. of Telecom, Govt. of India
नई दिल्ली/New Delhi

4. This order is applicable to the services, provided by BSNL under 'sui generis' category only.

5. This issues with the approval of the competent authority.

Yours Faithfully

28.06.2021

(Anil Verma)
Deputy Wireless Advisor (Satellite)
to the Government of India

To:

1. M/s BSNL, Bharat Sanchar Bhawan, Harish Chandra Mathur Lane, Janpath, New Delhi-01
2. Joint Secretary(IS-I), Ministry of Home Affairs, with request to inform users under MHA regarding the changed procedure.
3. Pr. Controller of Communication Accounts, Prasad Nagar, Karol Bagh, New Delhi, Delhi 110005.
4. DDG(Satellite), Satellite Division, DoT, Sanchar Bhawan/ DDG (WPF), DoT
5. Secretary, Telecom Regulatory Authority of India
6. Sr.DWA(ASMS), WPC Wing, may kindly arrange to upload this letter on DoT website.

Government of India
Ministry of Communications
Department of Telecommunication
Wireless Planning & Co-ordination (WPC) Wing
6th Floor, Sanchar Bhavan, 20, Ashoka Road, New Delhi-110001

No. J-19045/03/2018-SAT Date: 13.09.2021

OFFICE MEMORANDUM

Subject: Royalty Charges applicable for Captive VSAT networks

In pursuance of the power conferred by Section 4 of the Indian Telegraph Act, 1885 (13 of 1885), the Central Government hereby prescribes the following methodology for calculation of Royalty Charges on Captive VSAT networks:-

1.1 Royalty Charges on Captive VSAT networks will be levied as per WPC Wing's Order No. P-11014/34/2009-PP (II) dated 22nd March, 2012. The amount of Royalty Charges will be calculated by multiplying annual royalty factor with bandwidth factor for each carrier in the network. The 25% additional Royalty Charge for the remote VSAT terminals will not be levied.

1.2 The Wireless Operating License (WOL) will continue to be issued for a period upto 5 years, on request of the applicant. The validity of the WOL shall however be limited to the validity date of the space segment allocation. No radio frequency will be assigned, reserved or blocked through a WOL or any other instrument of like nature unless the applicant pays, in advance, all applicable license fees and royalty charges for the full duration of authorization/ assignment of the radio frequency.

2. Other charges such as License fee, late fees, Licence modification fee, fees for issue of duplicate license etc will continue to be applied as per WPC Wing order No. P-11014/34/2009-PP (IV) dated 22nd March, 2012.

3. This order issues with the concurrence of the Member (Finance) DCC vide Dy. No. 207/M/F/2021 dated 22/07/2021.

4. This Order shall come into force from the date of its issue.

13.09.2021

(Anil Verma)
Deputy Wireless Advisor (Satellite)
to the Government of India

Copy to:

1. All Captive VSAT Licensees
2. Wireless Planning Finance Division
3. DDG(Satellite), Satellite Division, DoT, Sanchar Bhawan/ DDG (WPF), DoT
4. Secretary, Telecom Regulatory Authority of India
5. Sr.DWA(ASMS), WPC Wing, may kindly arrange to upload this letter on DoT website

Government of India
Ministry of Communications & IT
Department of Telecommunication
Wireless Planning & Co-ordination (WPC) Wing

20, Ashoka Road,
Sanchar Bhavan, New Delhi-110 001

No. P-11014/03/2012 - PP

Date: 04th September, 2012

Corrigendum

Subject: Revision of Spectrum usage Charges (Royalty charges, Licence fee and other charges/ fees) for captive users (users being charged on formula basis) including all Government Users.

In pursuance of Power conferred by section 4 of the Indian Telegraph Act, 1885(13 of 1885) the following modifications have been made:

A. Replacement of existing text in the respective orders:

Order No.	Replace the existing text
P-11014/34/2009-PP (I) Dated 22nd March, 2012	Replace the Para 2 (ix) 6th Bullet with the following text: "Before issuing any DL/AIP/WOL, full amounts of royalty shall be deposited by the applicant in advance for the entire duration of the DL/AIP/WOL OR pay it in annual advance instalments." Replace the Para 2 (x) with the following text: "The most highly demanded VHF/UHF bands of 146-174 MHz and 338-470 MHz the rates of Annual Royalty given above be increased by 15% and 10% respectively in the Municipal/ state areas of Mumbai (including Navi Mumbai and Brihan Mumbai), Delhi(including Ghaziabad, Faridabad, Noida, and Gurgaon), Tamil Nadu, Karnataka and Andhra Pradesh. The enhanced charges shall become applicable to any wireless circuit whose even one station falls within these Service Areas."
P-11014/34/2009-PP (II) Dated 22nd March, 2012	Replace the Para 2 (vii) 3rd Bullet with the following text: "Before issuing any DL/AIP/WOL, full amounts of royalty shall be deposited by the applicant in advance for the entire duration of the DL/AIP/WOL OR pay it in annual advance instalments."

P-11014/34/2009-PP (III) Dated 22nd March, 2012	Replace Replace the text in Para 1 immediately after the words "....involving all Satellite based systems" with the following text: "(i. Broadcasting: Satellite Radio, Teleport, DTH, HITS etc; and ii. Other: ILD, NLD, DSNG, INMARSAT, VSAT, IP-II etc):-" Replace the text "order no. J-19011/1/98-SAT, dated 14/09/1998" in Para 1 with the following text: "order no. J-19016/1/98-SAT, dated 14/09/1998"
P-11014/34/2009-PP (TV) Dated 22nd March, 2012	Replace the Sl. No. xi. of Para 2. License Fees at by the following: xi. | Station in Satellite Network, e.g., Satellite Radio, DTH/ Teleport/ HITS, DSNG/ NLD/ ILD/ DCP/ IP-II etc. | 1000 | Per Fixed / Mobile Station

B. Addition

Order No.	Addition
P-11014/34/2009-PP (TV) Dated 22nd March, 2012	Add below Sl. No. xiv of Para 2. License Fees the following: xv. | Import License | 500 | Per Licence

2. This issues with the concurrence of the Wireless Finance Division, vide their Dy. No.1618-Sec/DDG(WPF), dated 30-08-12.

(Viresh Goel)
Deputy Wireless Advisor
to the Government of India

To,

All concerned