UNIVERSAL COVERAGE, ENHANCING SPACECOM SECTOR GROWTH, AND SUPPORTING DEMOCRATIC ETHOS:

THE ROLE OF SATELLITE SPECTRUM ASSIGNMENT

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Abstract

Satellite communication is integral to Digital India, enabling ubiquitous broadband for the uncovered population and supporting satellite TV, the dominant source of infotainment. An enabling policy environment would help increase the market share of Indian satellite service providers from the current 2% of the global market. Satellite spectrum is a shared resource, in contrast to mobile and broadcast terrestrial services, that require exclusive assignment. It is imperative that the spectrum assignment policy leverages this aspect.

This paper develops criteria for assessment of the two possible policies - exclusive assignments through auctions and shared assignments administratively. We find that the latter meets the above stated policy objectives better, is in tune with global best practices and supports multiplicity of satellite TV channels providing plurality of content, critical for a functioning democracy.

It suggests an administered price model for allocation of satellite spectrum with a one-time payment of license fee and a revenue share of aggregate gross revenue, annually.

Keywords: Satellite communications, space, spectrum management, auctions

JEL classification: L13, L51, L96

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Universal Coverage, Enhancing Spacecom Sector Growth, and Supporting Democratic Ethos: The Role of Satellite Spectrum Assignment

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1. Objective

The objective of the paper is to identify the appropriate assignment method for spectrum for space-based communication that enable India to meet its policy objectives in the sector.

2. Background

Technological advances in wireless communications and the consequent fall in prices have been at the forefront of unprecedented connectivity for both voice and data and economic growth over the last two decades or so. A critical resource at the heart of wireless communication is radio spectrum (spectrum). Spectrum comprises a range of radio frequencies that are assigned in bands for specific uses (mobile, FM, DTH, V2V, IOT) at the national level, within an overall international framework. For certain use cases such as mobile, FM, TV, service providers are allocated sub bands within the identified bands. With the current state of technology, such specific assignments for terrestrial communication and broadcasting help to leverage the propagation characteristics of different bands and prevents interference among users and applications.

Regulatory developments that have enhanced competition, ensured fair and transparent allocation of critical resources to the regulated entities, and innovative instruments have also contributed to the tremendous growth in the communications space. Developments in the communications area in India generally mirror those in the rest of the world, albeit with a lag.

India has over 1.2 billion mobile phone users and 600 million smartphone users.[1] It has a large broadcasting and distribution sector, comprising around 900 channels on satellite television across India. There are nearly 6,000 Multi System Operators (MSOs), 60,000 LCOs (approximately), 7 DTH/ satellite TV operators and several IPTV service providers. The proliferation of mobile (4G, 5G) and satellite communications is creating demands for spectrum. Mobile traffic is expected to grow from 17.2 GB per user per month[2] data usage grew 13.6% on a year-over-year (YoY) basis in 2022[3] with streaming video, AR, VR, gaming constituting a major part.

With increasing demands on spectrum not only from satellite service providers but also for terrestrial networks, appropriate spectrum regulation for space-based communication is critical.

3. Role of Satellite Communication

Technological advances in satellites are enabling new areas of service provision, especially for broadband and broadcast - usually referred to as spacecom. Satellites play an important role in the Digital India initiative of the government. The emergence of high throughput, lower cost satellite services and regulatory changes such as allowing private participation in this sector have led governments, including in India, to consider mechanisms to facilitate space-based communication services.

Satellites provide the critical infrastructure and services for ubiquitous broadband connectivity, especially to those who remain uncovered, especially in rural areas or hard to reach terrains, despite the rapid proliferation of terrestrial. Satellites are also important to India as satellite TV is the dominant source of information and entertainment for a large part of the population. Terrestrial TV is mandated to be provided only by the state owned Prasar Bharti that has a low and fast declining viewership. Other important areas of satellite applications include satellite based IoT, emergency and disaster communications, climate and weather data collection and analysis.

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1 Ministry of Information and Broadcasting- 2022https://www.livemint.com/technology/gadgets/india-has-over-1-2-bn-mobile-phone-users-i-b-ministry-11668610623295.html

2 TRAI Quarterly Performance Indicator Report for Quarter ending Dec'22 published in May'23

3 https://www.nokia.com/about-us/company/worldwide-presence/india/mbit-index-2023

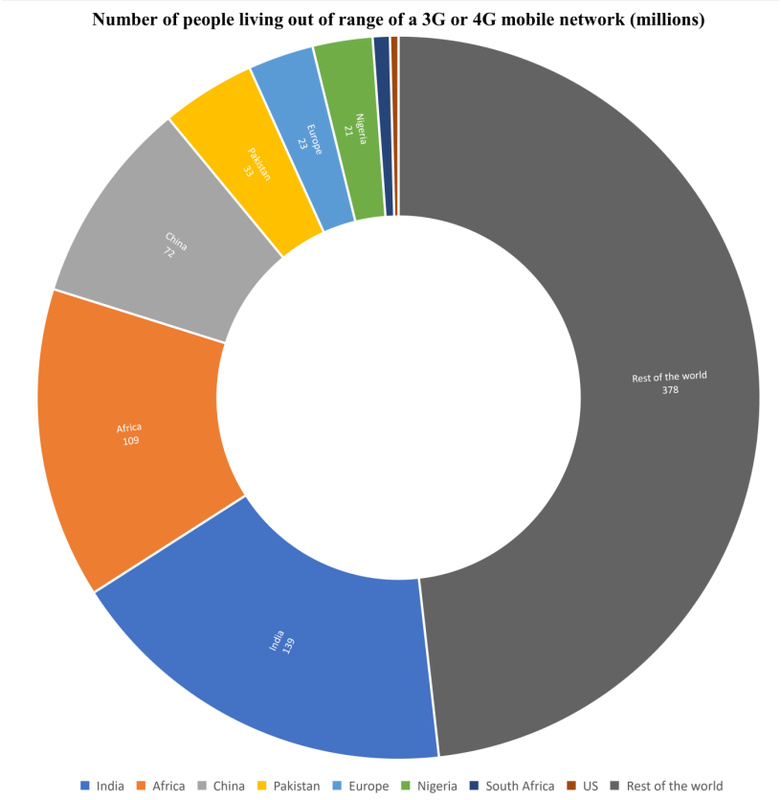
The global spacecom market is estimated to go from $65.68 billion in 2020 to $131.68 billion in 2028.[4] The Indian spacecom market is nascent and if provided policy and regulatory support, it is expected to increase its current share of 2% of the global market in 2020 to 10% by 2030.[5] The Draft Spacecom policy and the National Digital Communication Policy 2018 reflect policy intent to support growth.

While the proliferation of mobiles has been transformational with coverage of 88% global land mass[6], there continue to be geographic gaps in coverage. These exist even in developed countries, though significantly less pronounced. For example, it is estimated that 14.5 million Americans live in area without broadband Internet access. While urban areas in the USA have almost ubiquitous broadband coverage, nearly 17% of rural residents and 18% who live on tribal lands lacked broadband availability in 2020.[7]

Terrestrial mobile service globally covers 95%[8] of the nearly seven billion population. Most major towns and other areas of economic activity have a strong coverage of mobiles, including 4G. Further, nearly 55% of the world's population[9] is now connected to the mobile Internet but only about 35 percent of the population in developing countries has access to the Internet (versus about 80 percent in advanced economies).[10]

Providing coverage to this remaining 5% (the 'coverage gap') remains an important challenge. Figure 1 shows the "coverage gap", by countries/continents/groups of countries, with India and other populous countries accounting for the most part of it. Figure 2 shows the network coverage by subscribers.

Figure 1: Mobile Coverage Gap: India & a handful of other low- & middle-income countries account for most of the gap

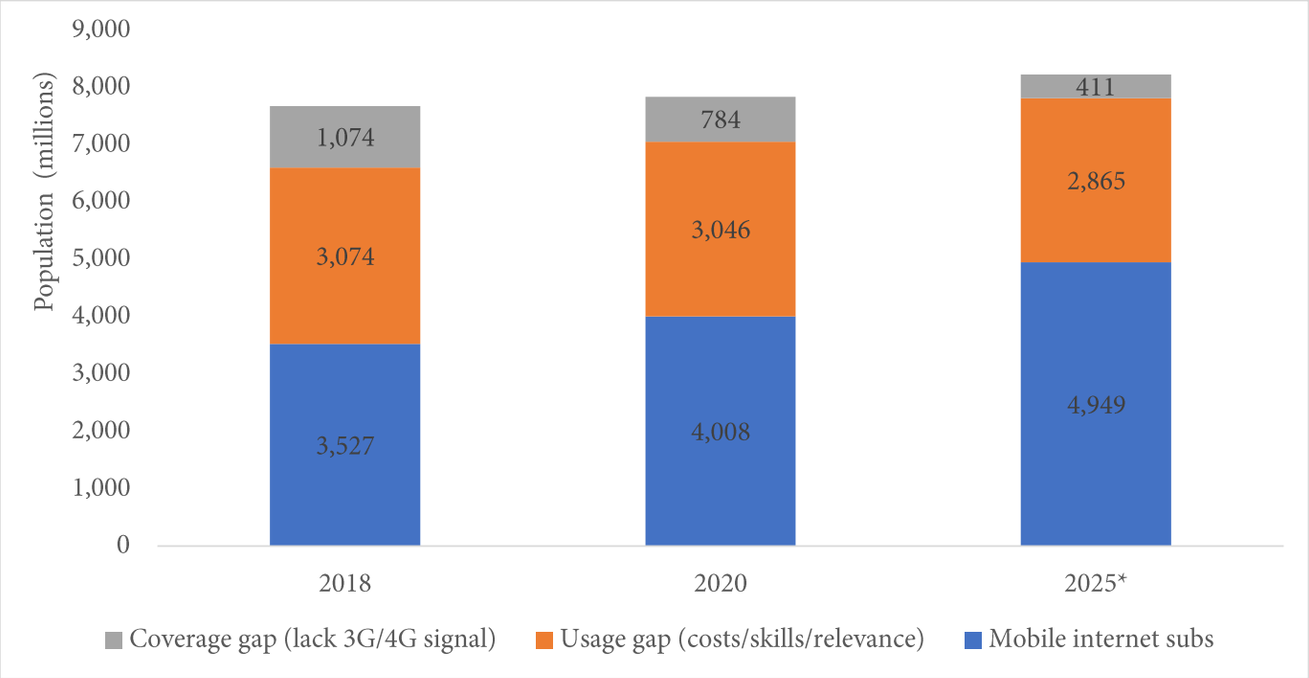


Note: The coverage gap for Africa excludes Nigeria & South Africa.

Source: GSMA Intelligence

4 https://www.prnewswire.com/news-releases/satellite-communication-market-size-worth--131-68-billion-globally-by-2028-at-9-10-cagr-verified-market-research-301394253.
5 https://www.businesstoday.in/magazine/industry/story/how-satellite-communications-could-propel-the-next-boom-in-the-telecom-space-313503-2021-11-26
6 https://www.itu.int/itu-d/reports/statistics/2021/11/15/mobile-network-coverage
7 https://www.gao.gov/blog/closing-digital-divide-millions-americans-without-broadband
8 https://www.itu.int/dms_pub/itu-d/opb/ind/d-ind-global.01-2022-pdf-e.pdf
9 State of Mobile Internet Connectivity Report-https://data.gsmaintelligence.com/research/research/research-2022/the-state-of-mobile-internet-connectivity-2022
10 https://www.worldbank.org/en/topic/digitaldevelopment/brief/connecting-for-inclusion-broadband-access-for-all

Figure 2: Coverage and Usage Gap 2025E



** Projected figure for 2025*

Source: GSMA Intelligence [11]

It is here that satellites play a unique role as they can provide ubiquitous coverage over the earth, including in the air, water, and hard to reach terrain. Therefore, satellites have new and emerging applications in water and air navigation, television distribution, weather and climate monitoring, and global time synchronization amongst various other uses. Besides other elements for policy and regulatory interventions for the growth of this sector, spectrum assignment is a critical aspect of spacecom regulation, especially because this aspect is also subject to international regulation.

4. Satellite Technology

Space-based communications technology has been in use for over 60 years. Recent technological developments such as High Throughput Satellites (HTS) have created new avenues for voice, broadband and Internet delivery. The emergence of Low Earth Orbiting (LEO) and Middle Earth Orbiting (MEO), called Non-Geostationary orbits (NGSO) platforms, that orbit 200-3000km above the earth as economically and technologically viable systems have led to a rise in the number of such systems in recent years. Some examples are OneWeb, Starlink, Amazon, Measat, O3B, etc (Appendix A).

Satellites have long been used for communication over oceans and air, initially as a global multilateral network (Intelsat, Inmarsat etc) or as regional satellite network (Thuraya). (Subsequently, Intelsat and Inmarsat were privatized). Satellites have been used for broadcast services (TV, DTH, World Radio, Sirius). Most of these were geostationary satellites, rendering them unsuitable for time critical applications such as emergency response, V2V communication etc due to the inherent latency of signals in a round trip from the earth to satellite and back. Terrestrial communications, especially 5G networks, handle latency well. However terrestrial networks are either difficult to implement, have prohibitive costs for hard-to-reach terrain, or/and do not have ubiquitous coverage.

5. Spectrum Regulation for Satellite Communication

Spectrum management issues related to satellite communications have become more complex as the demand for spectrum from new players, applications and systems is increasing. Spectrum being a limited resource, it is imperative that technological characteristics that enable maximal exploitation and supportive policy and

11 https://data.gsmaintelligence.com/research/research/research-2021/the-state-of-mobile-internet-connectivity-2021

regulation principles are adopted. Advances in satellite technology and new methods of sharing spectrum between GSOs and NGSOs, amongst NGSOs, help to mitigate some of the constraints on limits.

Satellite service providers face significant regulatory hurdles due to the more "international" nature of their business where the footprint of satellites may extend beyond national boundaries. Launching of the satellites and adhering to the spectrum regulation of each "covered" country are significant challenges.

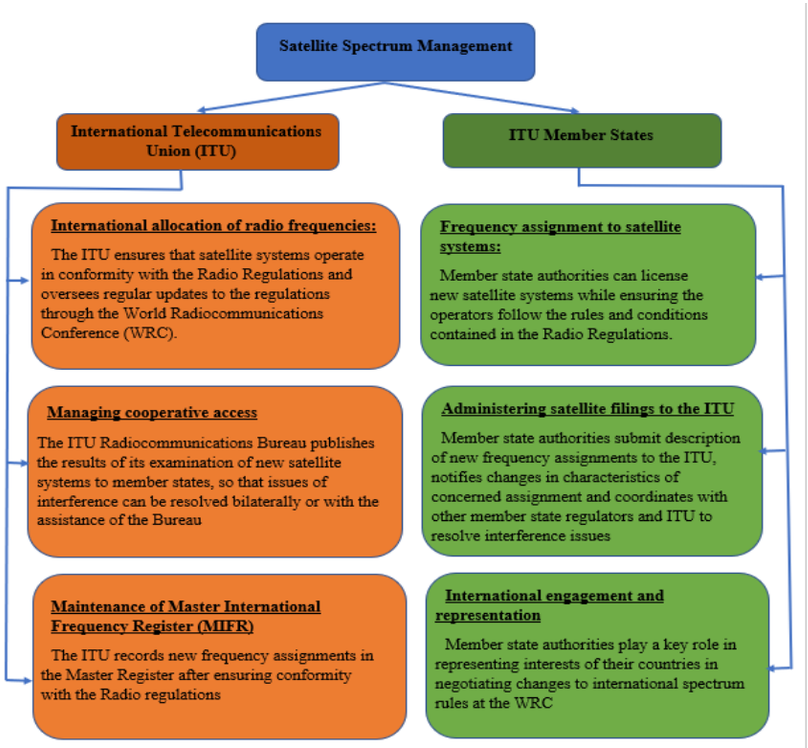
Satellite communication is characterized not only by the frequency band as in the case of terrestrial communications but also by the orbital slots in the various constellations. Operators need to file for both the frequency and orbital slots for the space segment with the ITU a UN body through the respective national administrations. This is a way of prioritizing allocation of these resources at the international level. For the earth segment, operators need to get licenses/authorizations from the individual countries. This is a time-consuming process and needs to be balanced with the national and international milestone regulations that require satellite operators to bring their spectrum into use in a timely manner. ITU provides for international spectrum assignments and requires advance publication/ coordination/notification, payment of filing fees on a cost recovery basis. However, given the need for international coordination for spectrum and orbital slots and the inherently bureaucratic processes, both in national administrations and the ITU, there are significant filing backlogs.

Spectrum cannot be limited to a given territory and therefore cooperation between countries is required to harmonize its usage. Satellite spectrum management therefore, is broadly a two-tiered system covering specific roles and responsibilities for the ITU and member states as shown in Figure 3.

a. National Satellite Spectrum Management

Each country has the sovereign right to manage the spectrum/orbit resources domestically within the overall ITU framework. As mentioned before, satellite network applications of the satellite service providers are routed through the national administrations.

Figure 3: Role and Responsibilities of ITU and Member States



Source: ITU[12] and OFCOM[13]

12 Master International Frequency Register (also called Master Register) is the ITU database of all registered frequency assignments. https://www.itu.int/en/ITU-R/terrestrial/Pages/by-categories-faq.aspx?subcategorizedby=6

13 Ofcom (November, 2022), Space Spectrum Strategy: Ofcom's duties & functions Ofcom (November, 2022), Space Spectrum Strategy: Ofcom's duties & functions

b. International Satellite Spectrum Management

At the global level, ITU is responsible for the coordination of spectrum and orbital slots across nations in an advisory capacity. By following a coordinated approach to spectrum and orbital assignments, national administrations could ensure that spectrum interference across services and nations is minimized. The advantages of coordination go beyond this, if we consider the economies of scale in equipment manufacturing and faster deployments and hence lower cost services when bands for different technologies/applications across nations are harmonized

ITU Radio Regulations (RR) is an International Treaty, which is binding on the administrations of different countries. Not only does the RR govern spectrum assignments for different services, it also identifies the mechanisms for obtaining orbital resources and spectrum. The World Radiocommunications Conference (WRC) - an inter-governmental treaty conference held every four years is the instrument through which changes to RR are made.

ITU Defined Satellite Bands

The ITU defined satellite bands are L, S, C, X, K, Ku, Ka, Q, V are shown in Table 1. Since satellite spectrum is a shared resource, mitigation from the consequent interference and management techniques have evolved. Interference in a shared mode is managed usually by specifying a primary user and identifying parameters for secondary usage in a way so as to prevent intentional or unintentional interference between wireless communication systems and devices as well as to guarantee acceptable levels of service for the users of all wireless communication systems.

Common techniques to facilitate sharing include: spatial isolation (e.g., GSO orbital slot separation), geographical separation (satellite earth terminals), time/frequency/code isolation (modulation), minimum look angle restrictions (sharing between earth terminals and the FS) and GSO arc avoidance (NGSO sharing with GSO FSS and BSS), co-coverage avoidance schemes (e.g., NOAA and Little LEOs) satellite, and ET power limitations.

Table 1: Satellite Spectrum Frequency Bands

Band Name	Assigned Frequency Range		Use Case
S-DAB	1.467 GHz	to 1.497 GHz	Satellite Audio Broadcasting to fixed & mobile units
L	1.518 GHz	to 1.675 GHz	Civilian Mobile-Satellite Services (two-way)
S	1.97 GHz	to 2.69 GHz	Satellite television & radio broadcasting and mobile BB services including inflight connectivity
C	3.4 GHz	to 7.025 GHz	Fixed-Satellite television and data services (including broadcasting)
Ku	10.7 GHz	to 14.5 GHz	Fixed-Satellite television & data services (including broadcasting)
Ka	17.3 GHz	to 30 GHz	Fixed-Satellite television & data services including fixed and mobile two-way broadband services
Q/V	37.5 GHz	to 51.4 GHz	Fixed and mobile high-speed broadband services including in-flight connectivity

Source: ITU[14]

6. Satellite Communication Services

Satellite communication services are also categorized by their use cases as follows:

Fixed Satellite Services (FSS)

IAs the name suggests FSS are used to provide services to earth stations at specific geographic locations. Virtually all primary FSS allocations between 2.5-40 GHz share spectrum with other terrestrial or space services.

14 https://www.unoosa.org/documents/pdf/unspace/iam/2017/ois-04E.pdf

Mobile Satellite Services (MSS)

Inmarsat (GSO), Thuraya (GSO) and Iridium (NGSO) are examples of satellites providing MSS. Some examples of deployment of commercial satellite services is IFC (In-Flight) Connectivity being deployed for large overseas carriers from Europe & APAC in particular. There are strategic satellite deployments both globally as well as in India in the S Band.

Broadcasting Satellite Services (BSS)

The radio signals from a satellite are intended for direct reception either by individual users or a community. BSS is a special case of FSS in which there is no return path.

BSS and FSS in Planned Bands

Planned bands refer to GSO in FSS and BSS. These bands ensure equitable access across each country. BSS and FSS may use the bands allocated for each other under specified conditions. For example, FSS may transmit in BSS assigned bands, provided that such transmissions "do not cause more interference or require protection from interference than BSS transmissions" (NFAP 2022 Appendix 5.492)

FSS in non-planned bands

FSS generally uses the C, Ku, and Ka bands. Spectrum sharing is coordinated under an administrative regime. Prioritization in these bands generally happens on a on a First Come First Serve basis.

7. Satellite Spectrum Sharing Techniques

Satellite spectrum has largely been allocated on an administrative basis since several operators may use the same frequency bands simultaneously. Since satellite services share spectrum not only across GSO and NGSO, but also across various NGSO systems and NGSOs and terrestrial services, there is a need to have a mechanism for ensuring proper coordination across the services.

Since GSO were established earlier, the NGSO systems as per the governing Article 22 of the ITU RR for space services [15]

"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'. Details are provided in the Appendix B.

ITU RR provides for various spectrum management techniques for mitigating interference for NGSO satellites[16] through Resolutions 130 and 538 for NGSO FSS sharing with other services and Resolution 46 (S9.11A) for NGSO MSS sharing with other services.

Various regulatory regimes have come out with the specifics of the sharing mechanism between GSO and NGSO, amongst NGSO and between terrestrial networks and NGSOs. For example, FCC has evolved a mechanism for introducing NGSO in "rounds" and prioritizing protection from those that are introduced in later rounds. Simultaneous introduction of NGSOs in rounds creates competition in the market. The fact that earlier round NGSO get priority in protection, creates competition for the market. (Appendix C). This allows sharing through coordination and prioritization.

8. Emerging Principles for Leveraging Satellite Spectrum

From the above, it is clear that to leverage the satellite spectrum, both Frequency Reuse for Leveraging the Capacity of the Satellite Spectrum and Coordination and Prioritization are critical.

a. Frequency Reuse for Leveraging the Capacity of the Satellite Spectrum

Frequency reuse in satellite spectrum differs from that of terrestrial. The high frequency reuse in terrestrial networks is possible because of the architecture of a terrestrial network comprising multiple BTS, each covering a small cell area where the signal does not attenuate, before handing over to the next BTS. This allows for the assigned spectrum to be broken into chunks for each BTS, where each chunk being reused in non-adjacent cells. For satellite networks, since the footprint of the spectrum beam is large in comparison

15 https://www.itu.int/en/ITU-R/space/WRS20space/27%20Non
16 https://www.itu.int/en/ITU-R/space/workshops/2016-NGSO/SiteAssets/Pages/programme2/4A%20WS%20panel%203%20REC-S.1431%20rev1.pdf

to the BTS coverage, different techniques are used for frequency reuse. This may be achieved by using orthogonal polarization states for transmission and/or by using satellite antenna (spot) beams that serve separate, non-overlapping geographic regions or geographical or arc separation.

Advances in satellite technology such as High Throughput Systems (HTS) enable much higher frequency reuse than conventional satellites for the same amount of radio frequency spectrum through spot beams technology, amongst others. Spot beams are many narrowly focused beams covering geographical area of the order of a few hundred kilometres in contrast to conventional satellite that utilizes a broad single beam (usually in the order of thousands of kilometres). The need to use several spot beams to cover the entire geographical area, allows for frequency reuse and hence higher throughput for the same frequency band. In addition, the narrower band also results in more power (for both transmission and reception) due to the higher directivity. This leads to smaller user terminals that permits the use of higher order modulations, thus achieving a higher rate of data transmission per unit of orbital spectrum.

b. Coordination and Prioritization

Since satellite services share spectrum not only across GSO and NGSO, but also across various NGSO systems, there is a need to have a mechanism for ensuring proper coordination across them. In addition, prioritization mechanisms, such as the one designed by FCC mentioned earlier, introduces NGSO in "rounds" and prioritizes protection from those that are introduced in later rounds as is elaborated in Appendix C.

Satellite spectrum is a shared resource, and national administrations have leveraged this aspect to ensure growth in the sector. An important aspect for leveraging the shared nature of satellite spectrum is facilitated not only by the underlying technological parameters (arc separation, polarization, geographical separation etc) but also through a focus on highly developed regulatory governance mechanism. While the ITU RR provides an overarching framework, national administrations have adopted mechanisms to ensure sharing as well as to provide competition.

9. Relationship between Satellite and Terrestrial Communications

Table 2 provides a comparative analysis of service coverage and costs of terrestrial wireless, fiber, copper and satellites and the relative deployment costs in rural areas. Satellite and terrestrial communications are seen as complementary in terms of their coverage and cost characteristics. Hence, the former is being considered as a viable technology for overcoming the coverage gap, as mentioned before.

Table 2: Comparison of Wireless, Fixed and Satellite Backhaul Deployments

	Terrestrial Wireless	Fiber Optic	Copper	Satellite
Coverage	5-30 km	<80 km	<15 km	Unlimited
Reliability	Medium to High	High	Medium	High
Deployment Costs in Rural Areas	High	High	Medium	Low

Source: ABI Research[17]

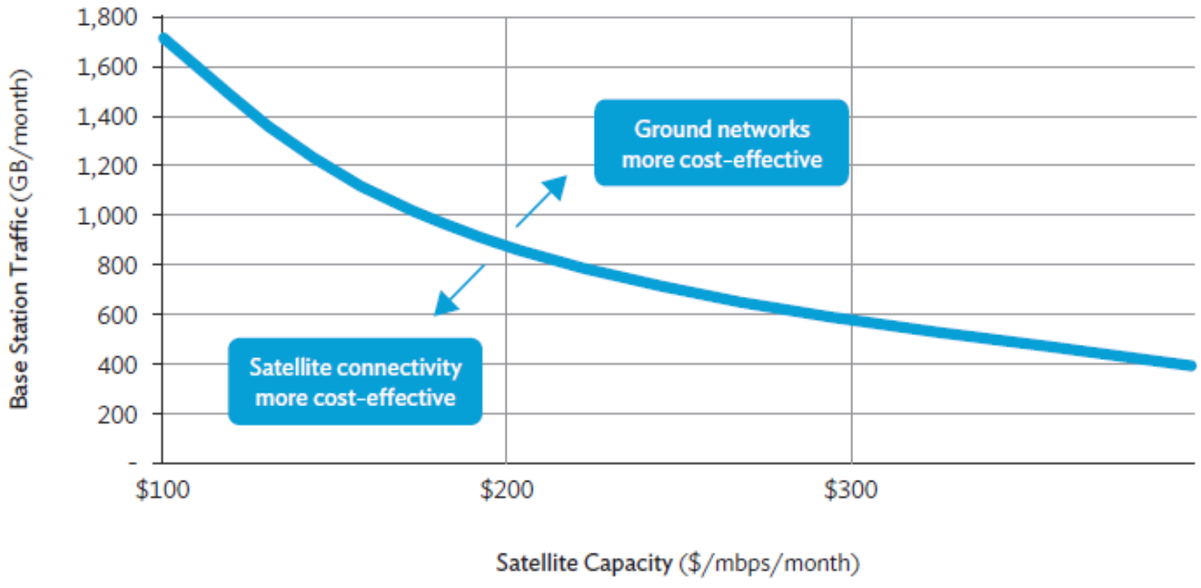
- The terrestrial utilized fiber capacity at 2000 terabytes per second (Tbps) is huge in comparison to the sellable satellite capacity at 3 Tbps as of 2020[18]. The cost of terrestrial rural backhaul is 5-10 times more expensive than for urban. In this context, the ability of a single satellite to cover a wide geographical area, falling capacity costs and declining user terminal costs make satellites an attractive complementary service to terrestrial network especially in the rural and remote areas.

- Since satellite bandwidth costs are still significant, in comparison to terrestrial fibre costs[19], satellite connectivity is cost-effective largely for remote

17 https://www.abiresearch.com/blogs/2023/05/09/building-the-case-for-satellite-backhaul-in-rural-regions/
18 www.adb.org/sites/default/files/publication/696521/sdwp-076-digital-connectivity-low-earth-orbit-satellite.pdf
19 "Wholesale prices also differ dramatically with international internet transit (IP transit) (which is largely submarine optical fibre) pricing as low as $1–$3 per megabit per second (Mbps) per month on major cross-country routes against wholesale prices for dedicated satellite capacity approaching $200–$400 Mbps per month" (https://www.adb.org/sites/default/files/publication/696521/sdwp-076-digital-connectivity-low-earth-orbit-satellite.pdf). Italicized portion is not a part of the original. It has been inserted by the author for clarity.

and dispersed locations where bandwidth requirements are not large. Higher data bandwidth requirements are more cost-effectively met by terrestrial ground networks. Obviously, network architecture (distance to the backbone node), throughput demand per node etc play a role in the relative cost effectiveness. This is shown in Figure 4. Thus, the complementarity in deployment would depend upon the price of satellite bandwidth and total traffic demand per month. But, given the huge gap between the relatively higher prices of satellite connectivity in relation to terrestrial for most use cases, it may be some time before satellite connectivity becomes competitive with terrestrial networks in general.

Figure 4: Price Optimization for Satellite Backhaul and Crossover Point



GB = gigabytes, Mbps = megabits per second.

Source: Reproduced from ADB Research[20]

- Satellite connectivity is also well suited for deployment in emergency situations, such as in response to natural disasters or other external shocks, that require expeditious deployment of network connectivity where terrestrial infrastructure is either non-existent or destroyed.

- In India, satellite communication plays a critical role in TV distribution as terrestrial TV is solely under the purview of Prasar Bharti, which has a very small and declining viewership. Therefore, it is important to strengthen satellite TV spectrum regulation as it remains an important source of information, entertainment, and education for the vast majority of people, especially in rural areas. Currently, spectrum for satellite TV is assigned on an administrative basis. Spectrum auctions may lead to the exclusion of smaller/ regional players as they may not being able to pay the resultant possibly higher prices or may end up not getting spectrum at all.

  The aspect of viability of small/regional players is highlighted by TRAI in its Recommendations on "Issues relating to Policy Guidelines for Uplinking & Downlinking of Television Channels in India", 4th April 2019. "A very high net-worth requirement would deter new entrepreneurs from entering into this sector. Reduced competition due to increase in entry barriers might also affect prices of the channels for the end consumer. Moreover, high net-worth criteria could also discourage the growth of local and regional channels, thereby affecting overall program diversity"[21]

20 ADB Research Sustainable Development Working Paper Series No. 76, https://www.adb.org/sites/default/files/publication/696521/sdwp-076-digital-connectivity-low-earth-orbit-satellite.pdf

21 https://www.trai.gov.in/sites/default/files/TRAI_Response_04042019.pdf, page 4

Diversity and plurality of views are critical in India as these reflect not only the inherent cultural, linguistic and regional diversity but most importantly, the democratic ethos, that is enshrined in the constitution. Article 19 (1) (a) provides protection of right for free speech and expression. Further, in this context, the SC in a 1995 judgment[22] with regard to the role of "public airwaves" has ruled:

a. The right of free speech and expression includes the right to receive and impart information.

b. For ensuring the free speech right of the citizens of this country, it is necessary that the citizens have the benefit of plurality of views and a range of opinions on all public issues.

c. This cannot be provided by a medium controlled by a monopoly – whether the monopoly is of the State or any other individual, group or organization.

Thus, satellite TV provides a mechanism that influence societal dynamics at a very fundamental level.

OTT may be considered a substitute for satellite TV, but taking into account that nearly 50% of rural population does not have smartphones and there were nearly 356 mn rural Internet users, while TV viewership in 2020 was estimated at nearly 892 mn in rural areas[23] indicates the strong role for satellite TV in the near future. Considering the growing role of OTT, DTH players are bundling OTT offerings, in order to sustain their market share vis-à-vis OTTs.

- Typically, the advanced satellite technologies operate in higher frequencies, while terrestrial mobile technology operate in the relatively lower frequencies. As demand for bandwidth heavy apps increases, the higher frequency bands, where satellites typically operate, become very attractive. Technological advancements are enabling use of terrestrial services in a large number of bands, including those earlier marked for TV broadcasting and satellite services (for example FCC_CBRS band, OFCOM DAB band[24]). This is in line with the 3GPP focus on identifying newer bands for 5G. Given the demand for 5G, globally, regulators have prioritized greater assignment of spectrum for 5G. For example, OFCOM allotted spectrum from DAB to 5G. Some of this 5G spectrum is adjacent to or is expected to be shared with satellite services.[25]

- Satellite spectrum faces significant challenges due to the need for harmonization across countries, .which is not the case for terrestrial service providers.

- The architecture of the underlying technologies differs. While terrestrial mobile has a more hierarchical architecture (MSC, BSC/BSS, RAN & BTS), satellite communications is rather flat. (Direct from user terminals to feeder links to transponder to antenna at the base station of the satellite). This leads to differences in how frequency reuse is materialized.

Thus, in the foreseeable future, terrestrial and satellite communications will have largely complementary uses in certain areas such as broadband access and broadcasting and unique positioning for satellite communication for disaster, emergency, weather monitoring etc

Strengthening the fledgling sector (India has a very small share of the global spacecom market) is important. Therefore, appropriate policies for spectrum regulation for satellites must be in coherence with the increasing national focus on the growth of the sector, including through liberalized policy of private participation in satellite services.

Besides differences in the drivers of growth, the relative size, the regulatory frameworks for terrestrial and satellite spectrum is different. Satellite spectrum regulation needs to integrate and harmonize with the international dimension of spectrum and orbital regulation. Thus, there is a need to abide by the underlying treaty regulations that govern spectrum for satellites.

22 https://mib.gov.in/document/supreme-court-judgement-airwaves
23 https://timesofindia.indiatimes.com/india/210-million-indian-homes-now-have-a-tv-women-owners-surge-by-7-barc/articleshow/82094407.cms
24 http://static.ofcom.org.uk/static/spectrum/map.html
25 https://www.ofcom.org.uk/__data/assets/pdf_file/0021/234633/spectrum-roadmap.pdf

Given the very differing characteristics of satellite and terrestrial spectrum in terms of use cases, size, technology architecture etc, the governance structure (entities involved, method of assignment) must be reflective of these and leverage the same for optimal utilization. Only then will citizens get maximal value from this scarce public resource.

10. Satellite Spectrum Regulation in India

In India, the Wireless Planning and Coordination (WPC) wing of the Department of Telecommunications (DoT) is the apex national decision-making body in the telecom sector that manages the spectrum.

While the frequency band and orbital slots are coordinated through the ITU process, DoT assigns the spectrum for the gateway and user links. For operating any space-based communication system, the concerned entities need to obtain both a service license and a wireless operating license. For service licenses for DTH, TV Uplink, Digital Satellite News Gathering etc., Ministry of Information &Broadcasting is the licensing authority. WPC, DoT is the licensing authority for the Wireless Operating License. For hybrid services, separate licenses have to be obtained from respective licensing authorities. For any interactive service, DoT is the licensing authority. For hybrid services, licenses have to be obtained from both authorities.

Wireless licenses and uplink clearances are provided by WPC and Network Operating Control Centre (NOCC), DoT for operating the satellite. The space segment assignments which were earlier made by DoS/NSIL, shall now be authorized by the IN-SPACe (as per the recently issued India Space Policy 2023). The WPC provides the frequency clearances and assignments and the NOCC provides the carrier plan approvals. An Apex Committee consisting of members from the various relevant departments/ ministries provides for "in-principle" approvals for new satellite players and new applications and services.

Telecommunication services are authorized by DoT under the Unified Licensing regime. These covers: Global Mobile Personal Communication Services, VSAT CUG for commercial services, In flight Maritime connectivity, Captive VSAT CUG, and NLD.

11. Assignment for Satellite Spectrum

We examine the spectrum assignment policy for satellite spectrum along the following dimensions:

a. The Technical Characteristics of the Relevant Bands

b. The "International" Dimension of Space Communication Regulation

c. Coherence with DoT's Existing Policy on Space-Based Communication Spectrum

d. The Integrity of the Sector Governance Structure

e. The Applicability of Auctions for Space-Based Communications

f. International Best Practices

g. Appropriate and Contextual Interpretation of the 2012 SC Judgment

h. Impact on the TV Broadcast Sector

i. DoT's Past Spectrum Assignment and Auction Design Outcomes

a. The Technical Characteristics of the Relevant Bands

The analysis in Section 5, 6 and 7 highlights that technical characteristics of the satellite bands support independent usage of spectrum by different service providers using the same band. A supporting regulatory framework facilitates this sharing. Exclusive assignment would allow the service provider to exclude other players from using the assigned portion, thus leading to smaller parts of the band to each player. Exclusive ownership will fragment the spectrum made available to operators, reducing their effectiveness. Even if the operators were to coordinate so that each utilizes the bandwidth of the other, there would be administrative costs associated with this method (which are detailed later) to ensure shared usage with exclusive ownership of smaller chunks.
Exclusive assignments would violate the principles of leveraging each band for most effectiveness. As a custodian of spectrum as a natural resource, DoT must ensure that spectrum is maximally utilized.

b. *The "International" Dimension of Space Communication Regulation*

While each country has sovereign rights over how it chooses to assign spectrum for services, it makes sense to work within the ITU regulatory framework, especially for satellite services as satellites also radiate outside national boundaries. Satellites operate in an inherently internationally regulated environment, both in terms of their orbital position in space, frequency assignments and their coverage areas, making any major spectrum policy shift away from the ITU on the part of an individual country vastly more complex.

c. *Coherence with DoT's Existing Policy on Space-Based Communication Spectrum*

Putting space based communication spectrum for exclusive assignments would at variance with DoT's its own mechanisms. In the NFAP 2022, which is harmonized with ITU, the DoT has envisaged sharing of space spectrum. For example, "For sharing of the band 1668.4-1675 MHz between the mobile-satellite service and the fixed and mobile services. For band 10.6-10.68 GHz between the Earth exploration-satellite (passive) service and the fixed and mobile, except aeronautical mobile, services. In the band 17.3-17.8 GHz, sharing between the fixed-satellite service (Earth-to-space) and the broadcasting-satellite service shall also be in accordance with the provisions[26]. For example, the 10.7-12.75 GHz band has been assigned to VSAT, IFMC, DTH, Teleport and DSNG services. The BSS services are also operating in the FSS band. Similar assignment is there in the 12.75 GHz - 13.25 GHz band. In the 13 GHz band, microwave access service which is used for cellular backhaul coexists with FSS. The sharing framework for the bands is given in Appendix B.

So far, DoT has assigned shared spectrum for space-based applications on an administrative pricing method. For example, the wireless backhaul has been allocated as per administered price of 0.15% of AGR.[27] **Further, TRAI in its Recommendations on** Issues relating to Uplinking and Downlinking of Television Channels in India, **2018 has recommended that auction for uplink and downlink frequencies for satellite TV is not feasible.**

"2.38 Accordingly, the Authority recommends that: i) The existing administrative system for grant of permissions for uplinking and downlinking of TV channels should be continued as auction process for grant of permissions for uplinking and downlinking of TV channels is not feasible"[28]

Despite the existing practices of DoT on shared assignment at administrative prices and TRAI's existing Recommendations, (although made in the context of TV channels, the underlying logic that is enunciated holds for all satellite services) it is not clear why DoT's Reference to TRAI was based on exclusive assignment of satellite spectrum. According to us, there could be the following two reasons:

a. "Flawed" interpretation of SC judgment of 2012 that according to DoT mandates auction for spectrum.
b. Revenue generation possibilities arising out of auctions.

d. *The Integrity of the Sector Governance Structure*

With respect to the DoT Reference and the TRAI CP, it is important to consider this aspect from the perspective of the scope and functioning of TRAI. As per the TRAI Act 1997 (Amendment 2000), the functions of TRAI are:

"Notwithstanding anything contained in the Indian Telegraph Act, 1885 (13 of 1885), the functions of the Authority shall be to—"

(a) make recommendations, either suo motu or on a request from the licensor, on the following matters, namely: —

(i) need and timing for introduction of new service provider;

…

…

(ii) efficient management of available spectrum;

In view of the above functions of TRAI to recommend on "efficient management of available spectrum", it would have been more appropriate for DoT to keep the issue of method of assignment open. It should have

26 Annex 4 of Appendix 30A. Resolution 744 (Rev.WRC-07) shall apply. (WRC-07).Resolution 751 (WRC-07) applies. https://dot.gov.in/sites/default/files/NFAP%20 2022%20Document%20for%20e- release.pdf?download=1
27 https://dot.gov.in/sites/default/files/Guidelines%20for%20allotment%20of%20E-band%20dated%2025%2007%202022%20signed.pdf
28 https://www.trai.gov.in/sites/default/files/RecommendationUL25062018.pdf

then been within TRAI's powers to specify the method of assignment. By not framing the issue of spectrum management for space- based communications as an open issue, DoT undermined the scope and integrity of the governance structure of the sector. Further, as mentioned above, TRAI in its 2019 Recommendations on uplink and downlink frequencies for TV Broadcast has specified that auction are not feasible for satellite spectrum. If an approach different from TRAI's Recommendations was to be adopted, then DoT needed to give a rationale for this.

e. The Applicability of Auctions for Space-Based Communications

For exclusive assignment of a public resource, it is generally considered that auctions are a fair and transparent mechanism. However, for auctions to work for public resources, the following conditions must be considered.

i. Auctions work as price discovery and allocation mechanism amongst competing bidders when the demand is more than supply. Various previous TRAI auctions have gone without getting a single bid in some of the bands as there was no demand at the reserve price (Appendix D). If the number of players is less than the number of slots, there is no logic for having an auction, since supply is more than demand.

ii. Designing an auction for resources that may be shared has few examples in practice, let alone in a spectrum context. There are very few research articles in this area and these are highly theoretical and not relevant to the current context. Designing auctions is not about just examining a theoretical model. Any auction design, especially a new one, requires understanding the market dynamics, designing simulation models, tweaking rules and reviewing the rules. FCC undertook such an exercise when it introduced the Simultaneous Multiple Round Auctions.

iii. Auctioning of any band, which allows for sharing or has existing services will create market dynamic distortion. Different services will have varying valuation of the same underlying spectrum. These valuations will depend on thSoe market size, revenue, existing regulation etc. If auctions are held for each service, then it may result in different prices for the same spectrum band. Given the existing mechanism of space-based communication services as a shared resource, designing auctions will not achieve the objective of reaching a market discovered price.

iv. Auction for space based communications has valuation challenges not only due to the shared nature of the underlying spectrum bands but also because satellite service providers lease transponder capacity (with a particular satellite characterised by the frequency band and orbital slot among other aspects). The uplinking and downlinking frequencies are tightly coupled with the satellite transponder capacity. Thus, bidders in any satellite spectrum who have leased transponder capacity would necessarily require confirmation of availability of the requisite uplinking and downlinking frequencies. This is not always guaranteed by auction outcomes as bidder may not win the specific frequencies in an auction. One could argue that the service providers should first acquire the specific bands through auctions and then acquire transponder capacity. Besides the time that goes into finalizing the contracts for transponder capacity, the clock ticks away, eating into the time period of validity of the license. Further, since transponder capacity providers would be aware of the time pressures, they could raise prices. This would lead to increased prices for satellite services.

f. International Best Practices

A review of the international best practices covering USA, UK, Brazil, Germany, Mexico, and Thailand show administrative assignment for space-based communications. In the USA, the ORBIT Act (The ORBIT Act SEC. 647. SATELLITE AUCTIONS) specifies "Notwithstanding any other provision of law, the Commission shall not have the authority to assign by competitive bidding orbital locations or spectrum used for the provision of international or global satellite communications services. The President shall oppose in the International Telecommunication Union and in other bilateral and multilateral fora any assignment by competitive bidding of orbital locations or spectrum used for the provision of such services[29] prohibits FCC from auctioning space spectrum.

29 https://www.congress.gov/106/plaws/publ180/PLAW-106publ180.pdf

There are reports in the media[30] that one of the submissions has cited Brazil, Mexico, Thailand and Saudi Arabia as examples of countries where the satellite spectrum was auctioned. We give below our understanding of the situation.

A detailed review of those regimes is provided in Appendix E.

Brazil: Anatel, the regulatory agency was auctioning orbital slots and the associated frequencies for which it had filed with the ITU. This was being done pre-emptively, so that it could make those slots/frequencies available when the demand from operators arose. But it stopped this practice since 2000, since when it has been assigning spectrum on a FCFS basis and going through the filing process with ITU subsequent to the demand of the service provider

Mexico: Orbital slots for domestic satellites are authorized through auctions. However, the response to the auctions for GSO slots did not receive any proposal. For foreign satellites, there is an administrative process.

Saudi Arabia: There was an auction of 2100 MHz for a new generation of NTN technologies, including Mobile Satellite Services (MSS), wireless connectivity on aircraft (A2G), Internet of Things through satellites (Sat-IoT) and hybrid 5G connectivity (5G CGC). This wireless connectivity A2G technology utilises LTE terrestrial and not satellites. Saudi Telecom Company (STC) won both spectrum blocks.

This band is not under discussion in India, as it has been primarily allotted to the TSPs for offering 4G/ LTE Services. The specific spectrum band being auctioned 1908-2010 and 2160-2190 MHz is not available in India for commercial services as it is exclusively given to government users for strategic use. Hence, this example is not relevant.

Thailand: The space communication auction in Thailand covered only orbital slots. Spectrum allocations/assignments were not a part of this. Even here, of the five orbital slots made available, two did not receive any bids. The other three bids saw winning bids very close to the reserve price. Only one slot saw two bidders, one of whom withdrew after the first round (Appendix E). For the two unsold orbital slots, NBTC in consultation with public and private stakeholders have agreed to assign through alternatives to an auction. One proposed solution was to assign through 'beauty contest' whereby slots are assigned to those with best qualifications and proposals.

Germany: The allocation for satellite spectrum has been done without an auction process.[31]

OneWeb: Empirical evidence from service providers based on a meeting 16 May 2023 (from Airtel discussion) that in 171 countries in which One Web plans to operate for FSS, there are no spectrum auctions. In these countries, there are three categories of reporting done. In 40 countries the satellite operators report to the relevant authority regarding the usage of specific bands that the operator plans to operate in and in few countries like the US, EU the operator has to seek authorisation

In the countries whose context is elaborated above (other than USA and Saudi Arabia), there have been auctions of orbital slots only and not for spectrum. Here, too, the competition has been poor, with the slots either not being bid for or going away at the reserve price. In the USA, there are no auctions for either orbit or spectrum, as per the ORBIT Act. The Saudi Arabia auction was for the LTE band and is not a relevant example as highlighted above.

g. Appropriate and Contextual Interpretation of the 2012 SC Judgment

DoT/TRAI have held that the 2012 SC judgment[32] and the subsequent Presidential Reference[33] has mandated allocation of spectrum through auction. The question then arises is whether the SC mandate and the Presidential Reference apply ***without qualification to the entire spectrum*** i.e., the entire electromagnetic bands that the DoT manages.

We need to examine the following aspects of the 2012 SC judgment and the Presidential Reference:

i. The judgment and the Presidential Reference refer only to a specific context of 2G allocation of spectrum

30 https://m.economictimes.com/industry/telecom/telecom-news/oneweb-counters-jios-claims-of-satellite-service-auctions-in-brazil/articleshow/89028734.cms?_oref=cook
31 https://www.bundesnetzagentur.de/SharedDocs/Pressemitteilungen/EN/2020/20201218_Starlink.html
32 https://main.sci.gov.in/pdf/SupremeCourtReport/2012_v11_piv.pdf
33 https://main.sci.gov.in/pdf/SupremeCourtReport/2012_v9_pii.pdf

The Reference clarifies that there is no universal applicability of any judgment (referring to the context of using auctions for delineation of natural resource) and each judgment is *"heavily grounded in the facts and circumstances of the case… The answer to the question would necessarily have to be read in the context of what is set out in the judgment and not in isolation.*

"71. The ratio of the 2G Case must, therefore, be understood and appreciated in light of the above guiding principles." (Highlights inserted) Appendix F provides the extracts that refer to this aspect.

ii. The 2G spectrum (also 3G, 4G, 5G) is designated for terrestrial services and needs to be assigned exclusively to prevent interference. The basis of the SC judgment and the Presidential Reference consider resources that may only be assigned exclusively. The references did not deal with resources that may be shared. Public good doctrine will emphasize that shared goods must not exclude others and must be shared in totality.

iii. The SC judgment and the Presidential Reference did not cover all spectrum bands and their technological characteristics. The Wi-Fi, Bluetooth bands and other bands are delicensed and do not require exclusive assignments to particular operators or users as multiple users may be accommodated in the same band without interference. Therefore, no assignment process is needed, leave alone auction. DoT made additional 45 MHz available as unlicensed 5.8 GHz spectrum in 2020[34]. The underlying principle being that there is no need for exclusive allocations and auctions when the technological characteristics of the underlying resource i.e. spectrum allows for sharing.

iv. Assignment by auction alone is not specified for all parts of the spectrum in the judgment. From various parts of the judgment, it is clear that the SC did not mandate auctions for all parts of the spectrum

"To put it differently, the State and its agencies/ instrumentalities must always adopt a rational method for disposal of public property and no attempt should be made to scuttle the claim of worthy applicants. When it comes to alienation of scarce natural resources like spectrum, etc. it is the burden of the State to ensure that a non-discriminatory method is adopted for distribution and alienation, which would necessarily result in protection of national/public interest."

"95. In our view, a duly publicised auction conducted fairly and impartially is perhaps the best method for discharging this burden.

In the Presidential Reference ***"the Court was not considering the case of auction in general, but specifically evaluating the validity of those methods adopted in the distribution of spectrum from September 2007 to March 2008. It is also pertinent to note that reference to auction is made in the subsequent paragraph (96) with the rider 'perhaps'. It has been observed that "a duly publicized auction conducted fairly and impartially is perhaps the best method for discharging this burden." We are conscious that a judgment is not to be read as a statute, but at the same time, we cannot be oblivious to the fact that when it is argued with vehemence that the judgment lays down auction as a constitutional principle, the word "perhaps" gains significance."*** *(highlights have been inserted).*

The details are provided in Appendix G.

v. The entire spectrum is not a homogenous resource. It is divided into different bands, each having a specific characteristic and outcomes with respect to communication service. The SC judgment and the Presidential Reference were in the context of 2G spectrum which has to be exclusively assigned due to its propagation characteristics. The judgment, therefore, does not refer to a single model of assignment for the entire band. In such a situation to treat the entire spectrum band under the same judgment does not seem appropriate.

vi. DoT's reference on auction of satellite spectrum is at variance with its own processes as shown below.

   a. Assignment of space spectrum to BSNL without an auction.

   b. Assignment of backhaul spectrum for cellular operators[35]

34 https://dot.gov.in/spectrummanagement/delicensing-24-24835-ghz-band-gsr-45-e-5150-5350-ghz-gsr-46-e-and-5725-5875-ghz
35 https://dot.gov.in/sites/default/files/Guidelines%20for%20allotment%20of%20E-band%20dated%2025%2007%202022%20signed.pdf

"In view of the increased backhaul capacity requirements of TSPs with Access Service authorization/license and having Access Spectrum in the IMT bands, especially on account of 5G, it has been decided to allot carriers in E-band spectrum for the purpose of backhaul on interim basis as per the following guidelines:

i. TSPs, based upon their application, would be allotted a maximum of 2 (two) carriers of 250 MHz each (paired) bandwidth in E-band (71-76/81-86) GHz for their backhaul purpose in the LSAs where they are holding Access Spectrum in IMT bands.

ii. For each E band carrier of 250 MHz paired bandwidth, **Spectrum Charges will be charged @ 0.15% of AGR (Adjusted Gross Revenue) of the TSPs. All E-band carriers assigned, as an interim measure, will be purely on temporary and provisional basis and all such assignees will have to participate in the auction and/or any other assignment methodology,** as decided by the Government after considering the recommendations of the TRAI in this regard."

A more nuanced analysis of the SC judgment and the Presidential Reference, as done above, would show that spectrum auction is not the only assignment method for any natural resource, including spectrum. This perspective would allow DoT/TRAI to fulfil their mandate of leveraging space-based communication spectrum by administratively assigning it for shared use.

h. Impact on the TV Broadcast Sector

The proposed auction of satellite spectrum will have a detrimental effect on the operations of the satellite TV industry. The smaller players may not be able to pay the high prices that may result after auctions. High prices aside, some of the players may not get spectrum. Consequently, their long term contracts for transponder space, would go waste.

In the satellite TV industry, auctions would not only lead to possibly more costly operations for players, accentuated for the smaller and regional players, (as highlighted above in the context of TRAI Recommendations on Satellite TV). but also would destroy the vibrant diversity and plurality of the existing TV industry. This would have long term negative effect on the structure of society and its governance.

i. DoT's Past Spectrum Assignment and Auction Design Outcomes

DoT has so far licensed some frequency bands 2G, 3G, 4G, 5G for exclusive use, others for shared use (satellite spectrum) and unlicensed other bands. Some of the licenses have been given through auctions (2G, 3G, 4G, 5G), while others through an administrative process (microwave backhaul, satellite spectrum, broadcasters, E band).

A majority of spectrum auctions, especially after 2012, have left large amounts of spectrum unallocated and most bids either at reserve price or close to it (Appendix E). Though, by adopting auctions, DoT was able to implement a fair and transparent method of allocations (unlike the vitiated FCFS during 2007-08), the design did not lead to competitive bidding. ***Essentially and effectively, this is like an administered price.*** Further, it led to unallocated spectrum that was not being used for any kind of service provision and lay fallow with the DoT leading to an unproductive use. This outcome inadequacy should be seen in the context of design of auctions for mobile services that necessarily requires exclusive allocations and for which a large body of knowledge, both theoretical and empirical, including for India, exists. If in this situation, DoT has not been able to meet the spectrum policy goals of efficient and effective spectrum regulation, then to expect very different outcomes for spacecom spectrum where spectrum is shared and there is hardly any example, either theoretical or empirical, would be unrealistic.

Summary

Based on prior experiences, DoT spectrum allocation and licensing outcomes have not been very efficient and effective even for spectrum that was to be exclusively assigned. This was an area where prior significant empirical evidence existed both in India and globally regarding parameters for auction design. Therefore, exclusive assignments and auctions for space-based communication, for the relevant spectrum which is essentially ***a shared resource and for which no prior model exists for auctions,*** is extremely challenging.

12. Evaluation of Auctions for Satellite Spectrum with respect to Policy Objectives

Since spectrum is held in a fiduciary capacity by the DOT and is a public, limited, scarce natural resource, the proposed choice of auction as an assignment mechanism needs to be evaluated against the extent it accomplishes the policy objectives of spectrum management and regulation. We present the following criteria for evaluating this:

a. *Effective Utilization by Service Providers*

b. *Facilitating Competition*

c. *Fair and Transparent Allocation Process*

d. *Harmonization with Best International Practices*

e. *Maximal Productive Use of Spectrum*

f. *Achieves the Public Policy Aims of Universal Coverage*

g. *Preserves and Enhances the Diversity and Plurality in the TV Industry*

h. *Helps the Satellite Sector to Take Off, and*

i. *Enables Indian Telecom Companies to be Globally Competitive.*

For each of the above, we analyse the consequences of exclusive assignments and auctions

a. Effective Utilization by Satellite Service Providers:

If satellite spectrum was to be auctioned on an exclusive basis, then spectrum would be fragmented, as each service provider would be allocated a part of the entire available bandwidth. Fragmentation of spectrum leads to lower data rates and capacity and hence inefficient use.

b. Facilitating Competition:

If auctions provided for a single winner (so as not to fragment the band), then there would be the creation of a gatekeeper role and no competition for services. So, while, auction of the entire band would lead to competition for the market, in effect, there would be no or little competition in the market. This would also prevent any smaller player from participation. Such player dynamics would distort the competitive provisioning of services.

Even if the winning bidder was mandated to share the band with other players, it could set high prices or specify stringent conditions for sharing, making it difficult for other operators to provide services. In effect, the winning bidder would become the band regulator. Therefore, a private operator would have the role that is essentially DoT's. Going further, even if the DoT/TRAI specified coordination parameters, the issue of monitoring adherence would be open. Given the technical sophistication required to do so, DoT would be very susceptible to regulatory capture.

However, a well-established coordination system exists under the ITU RR framework where multiple types of satellite providers coexist in the same frequency band and deliver optimal outcomes. This has been empirically found to be effective. Therefore, there is no need for exclusive allocations. Managing the shared spectrum has required involvement of the regulator in tweaking the rules and being responsive on an ongoing basis. For example, after coming out with a sharing framework in September 2017, FCC revised it in December 2021. In facilitating better coordination, FCC's stated objective in developing the sharing framework was to bring in more competition. The details of the mechanism are given in Appendix C. A proactive approach on the part of the DoT/TRAI are preconditions for effective coordination to take into account ground realities on an ongoing basis.

Thus, the proposed auction process would result in: inefficient use of spectrum, creation of gatekeepers, no competition in services, assignment of DoT's role to a private entity, and difficulties for smaller players.

c. Fair and Transparent Allocation Process:

Auction is one of the instruments for fair and transparent allocation for resources which need to be allocated exclusively. For shared resources, other allocation methods are applicable that are fair and transparent. As long as allocations are done in an open manner through a prior announced mechanism, players are treated in an equitable way, a transparent and fair mechanism can be implemented. This has done by the FCC through an automated process of prioritization that is

open and transparent. The 2012 SC judgment also supports giving policy makers the responsibility to design such mechanisms for alienating public resources.

d. Harmonization with Best International Practices:

The analysis in Section 10 suggests that exclusive allocations and auctions have not worked effectively even when tried for orbital slots. One could argue that since other countries have not made exclusive assignments or designed auctions, should not be an impediment for India to try these out. Before going further along this line of analysis, one should consider that the harmonization of space-based spectrum has international dimensions and therefore, any adoption instrument must be in line with other countries. If satellite service providers do not have the same spectrum bands or bandwidth they have in other countries, then it would be difficult for them to provide services.

e. Maximal Productive Use of Spectrum:

Fragmentation is inefficient from a spectrum regulation and management perspective. There would be parts of the spectrum that would only be partially used. This would also be against the objectives of DoT/TRAI, both of which are responsible for efficient management of spectrum, a public resource. Since technology does not mandate exclusive assignment, but doing so without a logical rationale will result in a regulatory quagmire. Given the challenges faced by DoT/TRAI to deal with monitoring of spectrum usage by government and take corrective action[36] it is a moot point, if it can effectively implement a coordination mechanism where the winning bidder does not have any incentive to participate effectively.

f. Achieves the Public Policy Aims of Universal Coverage:

Provision of a exclusive assignment and auction mechanism will lead to regulatory delays and uncertainty as satellite operators review their participation in a regulatory regime that is not harmonized with any other country. Thus, the proposed objective of universal coverage at an accelerated pace would not be met.

Further, if exclusive assignment through auctions are adopted, satellite operators would have to wait until auctions are done to know what spectrum assignments (if any) they get and then work out for contracting the transponder space/launching satellite constellation etc. This uncertainty and delays are detrimental to provision of broadband services in hard to serve areas etc.

Since terrestrial networks are not cost effective in rural areas or are not implementable in hostile terrain, having auctions for exclusive assignment of spectrum would impede the involvement of private operators and delay the provision of universal coverage.

g. Preserves and Enhances the Diversity and Plurality in the Satellite TV Industry:

Having auctions for exclusive assignments would greatly reduce the number of players in the satellite TV industry due to the inability to get spectrum or pay high prices. This would be detrimental to the diversity and plurality of views aired through the channels which are no longer able to participate. The reduction in the number of players would be a violation of the principles of protection of freedom of expression of free speech enshrined in the constitution and reflected in the SC 1995 judgment with regard to the role of "public airwaves" in supporting it. This would have obvious negative long-term influence on society and its governance.

h. Helps the Satellite Sector to Take Off:

Satellite services are useful for a variety of economic activities. Spectrum assignment mechanisms that are not coherent with the rest of the world are unlikely to see global satellite service providers be interested in the Indian markets. Companies seek regulatory certainty, which exclusive assignments and auction mechanism is unlikely to provide.

36 https://cag.gov.in/en/audit-report/details/116503 (CAG Audit on spectrum Management)

i. Enables Indian Telecom Companies to be Globally Competitive:

The New Spacecom Policy, Digital India, and NDCP 2018 foresee a vibrant, competitive telecom sector and a growing satellite segment. However, auctioning spectrum for space-based communication is likely to see dampening in the fledgling satellite sector in India as the policy and regulatory framework would likely see a delay and poor private sector participation. Policies that are not harmonized across the value and supply chain of the operators are likely to increase cost of service provision, decreasing the competitiveness of operators in/from India.

Thus, on all the dimensions identified above, we see that exclusive assignmentss through auction for space-based communication spectrum inadequately matches the policy objectives.

13. Conclusions

We conclude that exclusive assignments and auctions for space-based communication does not meet the policy objectives of effective and efficient spectrum management and regulation adequately. The evaluation is based on the following criteria: *Effective Utilization by Service Providers, Facilitating Competition, Fair and Transparent Assignment Process, Harmonization with Best International Practices, Maximal Productive Use of Spectrum, Achieves the Public Policy Aims of Universal Coverage, Preserves and Enhances the Diversity and Plurality in the Satellite TV Industry, Helps the Satellite Sector to Take Off, and, Enables Indian Telecom Companies to be Globally Competitive.*

As a trustee of the spectrum, a scarce public natural resource, DoT/TRAI will not be fulfilling its remit by adopting exclusive assignments and auctions for space-based communication services. Satellite spectrum is a shared resource, and there are hardly any empirically or practical models of assignments through auction. An administrative assignment of space-based communication spectrum on a shared basis takes into account the international best practices. We suggest an administered price model that has a one time license fee and an annual revenue share based on the AGR. The determination of the actual quantum is beyond the scope of this paper.

Using prioritization and coordination mechanism for spectrum sharing within the overall ITU RR, contextualized to our domestic environment will provide regulatory certainty and thus enable the objectives of universal coverage, help the fledgling satellite sector to take off and allows Indian telecom companies to be globally competitive. Further, and more importantly, it would help preserve or enhance the diversity and plurality of content that is the bedrock of a vibrant democracy.

Appendix

Appendix A: Satellite Service Offerings

Table 2: Sample Retail Satellite Service Offerings (Advertised Maximum Speeds, Not Dedicated or Committed Throughput)

Satellite Provider	Country of Service Offering	Local Service Provider	Download Speed	Upload Speed	Data Cap	Price per month ($)	Price per Mbps per month (download; $)
SES	Philippines	iGSat Satellite Broadband/ Delco Telecoms	Up to 5 Mbps	Up to 1 Mbps	40 GB	276.65	55.33
Thaicom/ IPStar	Philippines	We are IT Phils. Inc.	Up to 4 Mbps	Up to 1 Mbps	Unlimited	79.27	19.82
Hughes (JUPITER)	Indonesia	Telkomsat/ Mangoesky	Up to 6 Mbps	n/a	10 GB	52.02	8.67
Hughes	United States	HughesNet	Up to 25 Mbps	Up to 3 Mbps	50 GB	149.99	6.00
ViaSat	United States	Viasat/Exede	Up to 25 Mbps	Up to 3 Mbps	60 GB soft cap	100	4.00
MEASAT	Malaysia	CONNECTme	Up to 25 Mbps	Up to 1 Mbps	60 GB	47.83	1.91
Sky Muster	Australia	ipstar/nbn	Up to 25 Mbps	Up to 5 Mbps	50 GB peak + 50 GB offpeak	47.47	1.90
Eutelsat	France	Orange/Nordnet	Up to 100 Mbps	Up to 5 Mbps	150 GB prioritized/soft cap	79.85	0.80

GB = gigabyte, Kbps = kilobits per second, Mbps = megabits per second.

Source: ABD Research[37]

Appendix B: ITU RR for Space Services Governing Interferences[38]

ITU provides elaborate framework including the following:

(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

37 www.adb.org/sites/default/files/publication/696521/sdwp-076-digital-connectivity-low-earth-orbit-satellite.pdfr
38 https://www.itu.int/en/plenipotentiary/2014/newsroom/Documents/backgrounders/pp14- backgrounder-sharing-the-sky.pdf

Table 3: FSS frequency bands and coordination provisions

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

Source: ITU

Appendix C: FCC Sharing Mechanism[39]

FCC Fact Sheet*

Revising Spectrum Sharing Rules for Non-Geostationary Orbit, Fixed-Satellite Service Systems Report and Order and Further Notice of Proposed Rulemaking – IB Docket No. 21-456

Background:

In recent years, the Commission has received an unprecedented number of satellite license applications for non-geostationary satellite orbit, fixed-satellite service (NGSO FSS) constellations. The International Bureau has also initiated several "processing rounds" for NGSO FSS system applications, in which timely filed applications are considered together on an equal basis. The Commission's rules establish a default spectrum-splitting procedure absent coordination between two or more NGSO FSS systems.

39 https://docs.fcc.gov/public/attachments/DOC-392201A1.pdf

What the Report and Order Would Do:

- Limit the default spectrum-splitting procedure to NGSO FSS systems approved in the same processing round, before sunsetting.
- Require NGSO FSS systems approved in a later processing round to coordinate with, or demonstrate they will protect, earlier-round systems.
- Require all NGSO FSS grantees to coordinate with each other in good faith.
- For inter-round sharing, require later-round systems to submit an interference analysis based on a degraded throughput methodology to demonstrate that they will protect earlier-round systems in the event that an earlier- and a later-round system do not reach a coordination agreement.
- Address conflicting views concerning "good faith" coordination and information sharing as part of good-faith coordination.
- Adopt a sunsetting provision that entitles NGSO FSS systems to protection from systems approved in a subsequent processing round until ten years after the first authorization or market access grant in that subsequent processing round.
- Apply the rule changes adopted in this Report and Order to all current NGSO FSS licensees and market access grantees, as well as pending and future applicants and petitioners

Appendix D: Spectrum Auction History

Table 4: Spectrum Auction History

Auction Period	Total Spectrum put to Auction *(MHz)*	Total Spectrum Sold *(MHz)*	Total Spectrum Unsold *(MHz)*	Proportion of Spectrum Remaining Unsold *(%)*	Spectrum Valuation at Reserve Price *(Rs Cr)*	Spectrum Auction Outcome *(Rs Cr)*	Ratio of Auction Outcome Vs Reserve Price
May-10	1785.0	1785.0	0		14,330	76,789	5.36
Nov-12	390.0	127.5	262.5	67	49,042	9,408	0.19
Mar-13	195.0	30.0	165.0	85	45,525	3,639	0.08
Feb-14	431.2	353.2	78.0	18	49,143	61,152	1.24
Mar-15	470.8	418.3	52.5	11	80,180	1,09,875	1.37
Oct-16	2354.8	964.8	1390.0	59	5,67,256	65,789	0.12
Mar-21	2308.8	855.6	1453.2	63	4,00,396	77,815	0.19

Source: DoT, TRAI and Author's Analysis

Appendix E: International Regime for Satellite Spectrum Auction

Brazil

Auctions in Brazil need to be viewed in the context of the role of ANATEL, its regulatory agency with respect to acquisition of orbital slots and frequency bands. "Unlike most countries, which file with the ITU on behalf of satellite operators having actual planned satellite networks, Anatel submits filings before ever having received an application from a satellite operator. In other words, Anatel files for an orbital position and several frequency assignments within different unplanned FSS allocations with a variety of parameters within which a future satellite company might operate". It then auctions these slots. There is some cost it pays to ITU for these filings, but that is recovered through the auction process.

It was these orbital slots that Brazil was auctioning since 2000. It adopted the FCFS administrative process as in other countries vide Law No. 13,879/2019 in 2019. The change happened as a consequence of Brazil's impact assessment of its auction methodology. Since

auctions were held at specified periodicity (sometimes with an intervening period of 5 years), there was often incongruence in the supply and demand for new exploration rights. There were other associated costs of designing the bidding process and administrative delays in implementing the resulting outcomes. This put Brazilian service providers at a disadvantage vis-a-vis foreign operators and was a disincentive for foreign operators who otherwise went through an administrative process in other jurisdictions.

Consequently, Brazil also adopted an administrative FCFS assignment process. In fact, it could not even prioritize domestic service operators in the queue, as given the ITU regulatory framework, foreign operators may have obtained higher priority in the ITU filings (which also follows the first-come-first-serve policy)

Mexico

Mexico is one of the few countries that still has the requirement of authorizing domestic satellite slots through auctions[40]. However, in 2014, the Institute of Federal Telecommunications declared void, the auction for two geostationary orbital positions (113° West and 116.8° West), when it did not receive any proposals from participants[41].Moreover, although national satellites are authorised through tenders, authorization of foreign satellites is given after an administrative procedure and through payment of applicable fees. This is one of the factors that has resulted in certain imbalance in supply of satellites operating over Mexican territory. For instance, as of 2020, the 93 satellites that were authorized to cover Mexican territory, 9 were Mexican satellites, whereas 84 were foreign satellites[42].

Saudi Arabia

In Saudi Arabia, there was an auction of 2100 MHz for new generation of NTN technologies, including Mobile Satellite Services (MSS), wireless connectivity on aircraft (A2G), Internet of Things through satellites (Sat-IoT) and hybrid 5G connectivity (5G CGC).

There was an auction of 2100 MHz for a new generation of NTN technologies, including Mobile Satellite Services (MSS), wireless connectivity on aircraft (A2G), Internet of Things through satellites (Sat-IoT) and hybrid 5G connectivity (5G CGC). This wireless connectivity A2G technology utilises LTE terrestrial and not satellites. Saudi Telecom Company (STC) won both spectrum blocks.

This band is not under discussion in India, as it has been primarily allotted to the TSPs for offering 4G/ LTE Services. The specific spectrum band being auctioned 1908-2010 and 2160-2190 MHz is not available in India for commercial services as it is exclusively given to government users for strategic use. Hence, this example is not relevant.

Thailand

Package	Orbital Slot	Starting Price *(Mn Baht)*	Auction Round-Bids Placed		Auction -Outcome *(Mn Baht)*	
			First	Second	Winner	Slots Awarded at Price
First	50.5° East and 51° E	374	NO BID			
Second	78.5° E	360	Space Tech Innovation and Prompt Technical Services	Space Tech Innovation	Space Tech Innovation	380
Third	119.5° E and 120° E	397	Space Tech Innovation	Space Tech Innovation	Space Tech Innovation	417.4
Fourth	126° E	8.6	NT	NT	NT	9
Fifth	142° E	189	NO BID			

Source: NTBC Thailand

40 https://www.ift.org.mx/sites/default/files/contenidogeneral/asuntos-internacionales/federaltelecommunicationsandbroadcastinglawmexico.pdf
41 https://www.elfinanciero.com.mx/empresas/ift-declara-desierto-proceso-de-licitacion-de-posiciones-orbitales/
42 https://sei.anatel.gov.br/sei/modulos/pesquisa/md_pesq_documento_consulta_externa.php?eEP-wqk1skrd8hSlk5Z3rN4EVg9uLJqrLYJw_9INcO4VHI0rtE6YCCAUB2fRQNe6ty4akeSgVi64BglYKwobRqhRC52rdTYhpMDm_frMHWapM0ukqsp3mDZTbgIy31bH

Appendix F: The Context of Applicability of the SC Judgment

"70. It is also important to read a judgment as a whole keeping in mind that it is not an abstract academic discourse with universal applicability, but heavily grounded in the facts and circumstances of the case. Every part of a judgment is intricately linked to others constituting a larger whole and thus, must be read keeping the logical thread intact. In this regard, in ***Islamic Academy of Education and Anr. V. State of Karnataka and Ors.*** *MANU/SC/0580/2003: (2003) 6 SCC 697, the Court made the following observations:*

The ratio decidendi of a judgment has to be found out only on reading the entire judgment. In fact, the ratio of the judgment is what is set out in the judgment itself. The answer to the question would necessarily have to be read in the context of what is set out in the judgment and not in isolation. In case of any doubt as regards any observations, reasons and principles, the other part of the judgment has to be looked into. By reading a line here and there from the judgment, one cannot find out the entire ratio decidendi of the judgment.

"71. The ratio of the 2G Case must, therefore, be understood and appreciated in light of the above guiding principles." (Highlights inserted)

Appendix G: Applicability of Auctions with Reference to the SC Judgment to All Parts of the Spectrum

"75. *On a reading of the above paragraphs, it can be noticed that the doctrine of equality; larger public good, adoption of a transparent and fair method, opportunity of competition; and avoidance of any occasion to scuttle the claim of similarly situated applicants were emphasised upon. While dealing with alienation of natural resources like spectrum, it was stated that it is the duty of the State to ensure that a non- discriminatory method is adopted for distribution and alienation which would necessarily result in the protection of national/ public interest.*

76. Paragraphs 85 and 89, while referring to the concept of 'public trust doctrine', lay emphasis on the doctrine of equality, which has been segregated into two parts - one is the substantive part and the other is the regulatory part. In the regulatory facet, paragraph 85 states that the procedure adopted for distribution should be just and non- arbitrary and must be guided by constitutional principles including the doctrine of equality and larger public good. Similarly, in paragraph 89 stress has been laid on transparency and fair opportunity of competition. It is further reiterated that the burden of the State is to ensure that a non-discriminatory method is adopted for distribution and alienation which would necessarily result in the protection of national and public interest.

79. Further, the final conclusions summarized in paragraph 102 of the judgment (SCC) make no mention about auction being the only permissible and intra vires method for disposal of natural resources; the findings are limited to the case of spectrum. In case the Court had actually enunciated, as a proposition of law, that auction is the only permissible method or mode for alienation/allotment of natural resources, the same would have found a mention in the summary at the end of the judgment".

*"94. To put it differently, the State and its agencies/ instrumentalities must always adopt a rational method for disposal of public property and no attempt should be made to scuttle the claim of worthy applicants. When it comes to alienation of scarce natural resources like spectrum, etc. it is the burden of the State to ensure that a non-*discriminatory method is adopted for distribution and alienation, which would necessarily result in protection of national/public interest.

95. In our view, a duly publicised auction conducted fairly and impartially is perhaps the best method for discharging this burden

In the Presidential Reference, (please refer to the portion in bold. Emphasis added)

"76. *Our reading of these paragraphs suggests that the* ***Court was not considering the case of auction in general, but specifically evaluating the validity of those methods adopted in the distribution of spectrum from September 2007 to March 2008. It is also pertinent to note that reference to auction is made in the subsequent paragraph (96) with the rider 'perhaps'. It has been observed that "a duly publicized auction conducted fairly and impartially is perhaps the best method for discharging this burden." We are conscious that a judgment is not to be read as a statute, but at the same time, we cannot be oblivious to the fact that when it is argued with vehemence that the judgment lays down auction as a constitutional principle, the word "perhaps" gains***

significance. This suggests that the recommendation of auction for alienation of natural resources was never intended to be taken as an absolute or blanket statement applicable across all natural resources, but simply a conclusion made at first blush over the attractiveness of a method like auction in disposal of natural resources. The choice of the word 'perhaps' suggests that the learned Judges considered situations requiring a method other than auction as conceivable and desirable".

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