NALSAR University of Law, Hyderabad, India.

M.A Space and Telecommunication Laws Classes

Issues in Satellite Communications

(International Telecommunication laws)

11-04-2023 at **14:00-16:00 Hrs**

Presentation by Dr K S Mohanavelu formerly ISRO

Acknowledgements

I take this opportunity to thank **Prof. V. Balakista Reddy Registrar NALSAR University of Law Hyderabad** for giving me an opportunity to present the lecture "**Issues in Satellite Communications** (International Telecommunications laws)" for the Post graduate Students.

I am grateful to **Mrs. Bangaru Laxmi Jasti Research Associate, Centre for Aerospace and Defence Laws (CADL), NALSAR University of Law, Hyderabad,** for many valuable suggestions for presentation on the topic of "**Issues in Satellite Communications** (International Telecommunications laws)".

Since long time I have been working with **Dr Subba Rao Pavuluri Chairman and Managing Director, Ananth Technologies Limited Bangalore i**n the areas of Satellite Communications. I take this opportunity to thank Dr Rao.

I also want to clarify that short falls in this paper, if any are entirely due to me.

K S MOHANAVELU

Issues in Satellite Communications

(International Telecommunications laws)

Overview

Plan For Discussions

- UN Outer Space Treaty and related laws / procedures.
- ITU Radio Regulations (ITU RR).
- ITU RR regulatory framework and procedures for International Coordination for ensuring interference free operations.
- SPACE Activities Bill; New Spacecom Policy;

  IN-SPACe; Considerations for Auction of Satellite Spectrum
- Characteristics of Satellite Systems, Frequency Bands, GSO Orbital Slots, Capex, New Satellite Technology Trends, etc.
- Satellite vs. Terrestrial Systems - Internet Connectivity Services
- Integrated system i.e. Satellite + Terrestrial Cellular (LTE/4G/5G) Systems - Edge over Traditional Stand Alone satellite systems.

Issues in Satellite Communications

(International Telecommunications laws)

Overview

- Launching and Operations of Communication satellites are subject to UN Outer Space Treaty and related laws / procedures.
- Definition of “Launching States” – Countries are responsible as “Launching States” for all space activities like launching and owning satellites by companies/entities within their jurisdiction i.e. registered in their countries.
- Launching states control and operate their satellites without causing damage to all other countries. Problems may arise due to uncontrolled satellites / space debris / mitigation aspects.
- Communication satellites operate their services using the radio frequency spectrum and orbits need to Internationally Coordinate as per ITU Radio Regulations (ITU RR).
- ITU RR provides the regulatory framework and procedures for conducting International Coordination for ensuring interference free operations.

Issues in Satellite Communications
(International Telecommunications laws)
Overview (Contd.)

The following aspects relating to Satellite Communications in India are also discussed:

- **SPACE ACTIVITIES BILL OF INDIA**
  (To ensure compliance with UN Treaty Obligations & other Regulations)

- **The New Spacecom Policy**
  (Set to revolutionize Satellite Communications in India)

- **INDIAN NATIONAL SPACE PROMOTION AND AUTHORIZATION CENTER (IN-SPACe)**
  (Provides basis for Single Window Regulatory Clearances for Space matters)

- **Orbit - Spectrum – TRAI Studies on Auction of Satellite Spectrum?**
  (Procedures for Assignment of Satellite Spectrum)

The Discussions included Satellite vs. Terrestrial Systems related considerations for providing Internet Connectivity Services.

Issues in Satellite Communications
(International Telecommunications laws)
Overview (Contd.)

- There are wide variations in technical and operational characteristics of communication satellites launched and operated. Wide ranging parameters are: Frequency Bands, Orbits (GSO and non GSO), Coverage (National, Regional and Global), Conventional wide area coverage Beam or Use of multiple spot beams like High Throughput Satellites, Applications and Services (DTH, Internet Access, VSAT, SNG, etc.), Satellite Size (Big, Small, etc.) and other factors.

- Taking into account such wide variations ITU RR regulatory framework and procedures are reviewed and developed accordingly at ITU WRC Conferences held every four years and applied for Orbit and Frequency usage, International Coordination and other technical and regulatory aspects.

Issues in Satellite Communications
(International Telecommunications laws)
Overview (Contd.)

- Compliances with various ITU RR provisions and successful completion of International Coordination and Notification (i.e. Registration with ITU BR) of the intended Orbit-Spectrum parameters with ITU Radiocommunication Bureau (BR) are necessary for ensuring interference free operations.
- Only such Notified Communication Satellite Networks are internationally recognised and protected.
- Compliance with ITU RR provisions is normally a pre-requisite for funding, commercial operation of satellites and obtaining national licenses or landing rights.

SATELLITE ORBITS ARE IN OUTER SPACE
UN SPACE LAWS ARE APPLICABLE

SATELLITES OPERATE IN DIFFERENT ORBITS (LEO, MEO, HEO, GEO)

SATELLITE ORBITS FORM PART OF OUTER SPACE

UN OUTER SPACE TREATY (1967) AND OTHER LAWS PROVIDE INTERNATIONAL LEGAL FRAMEWORK

OUTER SPACE FREE FOR EXPLORATION AND USE IN CONFORMITY WITH INTERNATIONAL REGULATIONS

Registration of Space Objects with UN Office for Outer Space Affairs (UNOOSA)

SATELLITE ORBITS ARE IN OUTER SPACE
UN SPACE LAWS ARE APPLICABLE
(Contd.)

STATE RIGHTS AND RESPONSIBILITIES:

STATES REMAIN JURISDICTION AND CONTROL OVER OBJECTS LAUNCHED INTO OUTER SPACE

OUTER SPACE NOT SUBJECT TO NATIONAL APPROPRIATION (SEIZURE) BY CLAIM OF SOVREIGNTY BY MEANS OF USE OR OCCUPATION OR BY ANY OTHER MEANS

STATES SHALL BE LIABLE FOR DAMAGE CAUSED BY THEIR OBJECTS

Problems due to Uncontrolled Space Objects

- **Collision of Uncontrolled Space Objects**
- **Space Debris Causing Damage to Space Missions**

Space Debris Issue

The current legal framework **does not specifically impose any prohibition on the creation of space debris** and nor does it obligate on states and their space actors to remove debris created in the orbit.

Article VII of Outer Space Treaty (OST), which declares that:
State Party from whose territory or facility an object is launched, is internationally liable for damage to another State Party to the Treaty and Article IX of OST, which prescribes that the launching state should take '**appropriate measures**' in case it believes that their space exploration will lead to '**harmful contamination**' of outer space.

The current legal regime provides a guiding direction for co-operation between various participants of outer space. Majority of the mitigation measures are either voluntary or non-binding that have only been partly adopted by some states in their domestic framework on space law.

Space Debris - Mitigation

US Authority / FCC Rules include certain mandatory requirements for removal of space objects after their EOL preventing formation of unwanted space debris.

When India adopts space policy (**SPACE ACTIVITIES BILL**) in the near future, we can expect certain regulations on control of space debris.

Senechal, Thierry, Orbital Debris: Drafting, Negotiating, Implementing a Convention (May 11 2007) http://web.mit.edu/stgs/pdfs/Orbital%20Debris%20Convention%20Thierry%20Senechal%2011%20May%202007.pdf accessed on 14th�May 2020

Popova, Rada; Schaus, Volker, The Legal Framework for Space Debris Remediation as a Tool for Sustainability in Outer Space (9 May 2018) https://www.mdpi.com/2226-4310/5/2/55/pdf-vor accessed on 15th�May 2020

https://www.legalserviceindia.com/legal/article-3427-legal-regime-of-space-debris-and-legal-proposals-to-mitigate-the-negative-effects-of-space-debris.html

INDIA SPACE ACTIVITIES BILL

DRAFT SPACE ACTIVITIES BILL, 2017

A **legal framework** on Space was always required not only because the private sector is coming up. The private sector is needed as it fosters greater development and innovation. Such developments cannot be sustained if there are no legal safeguards. Therefore, the said bill was drafted back in 2017 and is still being processed.

It is a bill proposed to facilitate and regulate India's space activities. It encourages private sector organizations to participate in space activities in India under the guidance and authorization of the G**overnment of India / IN-SPACe/DOS.**

https://www.linkedin.com/pulse/applicable-space-laws-india-apurva-agarwal?trk=pulse-article_more-articles_related-content-card

DRAFT SPACE ACTIVITIES BILL, 2017 (PDF FILE)

https://www.isro.gov.in/media_isro/pdf/Publications/Vispdf/Pdf2017/seeking_comments_on_draft_space_activities_bill201710.pdf

The New Spacecom Policy

The new Spacecom Policy pertains to satellite communication sector. The Policy is about to be issued.

In Satcom, the proposed Policy would promote private investment as well as private sector participation along with Government of India efforts.

It will facilitate technology transfer, use of ISRO infrastructure by the industry and Consultations.

With the space sector privatized, Reliance Jio's Space Technology Ltd. and Bharti Airtel-backed OneWeb are getting ready to provide satellite based internet services. Jio has applied to DOT for GMPCS licence. SpaceX Starlink, Amazon's Project Kuiper and Tata Telesat combine have also expressed interest to provide internet connectivity services in India.

The new Spacecom Policy will bring many possibilities & activities including providing internet connectivity in rural and remote areas and thereby enable **Digital India** possible.

https://www.communicationstoday.co.in/new-spacecom-policy-to-be-released-as-early-as-april/

https://www.drishtiias.com/pdf/1606296978-the-big-picture-draft-spacecom-policy-and-india-s-space-sector.pdf

https://dipa.co.in/contentpdf/Department%20of%20Telecommunications/Spacecom%20Policy%202020%20and%20Spacecom%20NGP%202020-15-10-2020.pdf

IN-SPACe

INDIAN NATIONAL SPACE PROMOTION AND AUTHORIZATION CENTER (IN-SPACe)

IN-SPACe will enable a single window based procedure for all Space matters.

IN-SPACE WEBSITE GIVES MORE INFORMATION AND ITS CURRENT ACTIVITIES:

Indian National Space Promotion and Authorization Center
ISROhttps://www.isro.gov.in › IN-SPACe
https://www.inspace.gov.in/inspace

Orbit - Spectrum– TRAI Studies on Auction of Satellite Spectrum?

- ITU allocates orbital slots on a 'first-come first served' basis to countries, and not to private companies. Companies negotiate with a country in order to gain rights to a particular slot. Satellite regulations differ from country to country. Some countries have auctioned-off their orbital slots to the highest bidder.
- About 10 years back or so Brazil has auctioned 4 of their slots for USD 67.6 m. SES DTH do Brasil LTDA got 2 slots in the bid; Eutelsat and Hispasat got one slot each. Currently, Brazil is one of the most popular bandwidth markets; which is why Telesat, Inmarsat, and Yahsat also had tried to win Brazil's orbital slots bidding thru' their associates. Brazil has auctioned 4 of their slots. Subsequent auctions were not that successful.
- Major satellite operators such as Intelsat and SES Americom dominate the FSS listings. EchoStar and DirecTV have also purchased a large number slots on the DBS listings. With their large fleets, these companies resolve problems without any interruption in service. Since these major companies own a large number of orbital locations and frequencies, smaller companies have accused them of 'warehousing' the slots and frequencies. 'Warehousing' prevents their competitors from purchasing slots; FCC has been looking into the matter.
- The future of orbital slots will be greatly affected by technology, especially technology that allows satellites to operate more closely together.

Orbit - Spectrum– TRAI Studies on Auction of Satellite Spectrum?

The major companies have the resources to double the utilization of a slot with co-location. Co-location is when two satellites are located at the same orbital position but appear as one satellite. SES used this technique with its Astra satellites. One of the advantages of the co-location of method is that service goes uninterrupted if there is a failure in the current primary satellite. Having multiple satellites also increases the capacity at that orbital location. The owner of the set of co-located satellites coordinates the uplink transmissions to avoid interference problems.

The main challenge with licensing for orbital slots is that there are far more filings than could ever be implemented. There is the problem of warehousing but there is also the problem of dealing with slots assigned to satellites no longer in operation or to 'paper satellites' where an application was filed but the satellite was never built. It can be very difficult for private companies to overcome the obstacles created by 'paper satellites' and dead systems. The ITU has been working to improve orbital slot management especially when it comes to new filings.

As more companies enter the industry, it will be important for regulatory agencies to ensure that each orbital slot is utilized efficiently. Policy and procedures may need to be changed so that all companies have a chance to get the orbital slots and frequencies they require for their fleets of satellites.

Orbit - Spectrum – TRAI Studies on Auction of Satellite Spectrum?

In India, TRAI has issued a consultation paper in April 2023 soliciting comments of stakeholders on the issues related to assignment of spectrum for space-based communication services.

i.e. Whether to use or not the Auction method for Assignment of Satellite Spectrum?

Satellite Operators generally oppose Auctioning of Satellite Spectrum.

DOT insists on Auction. TRAI is in dilemma.

https://trai.gov.in/sites/default/files/CP_06042023.pdf

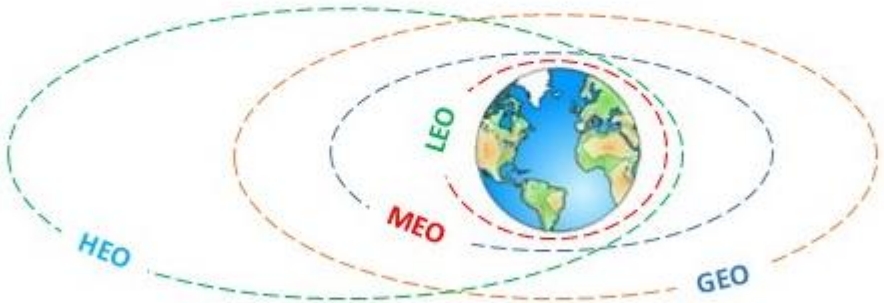
https://inc42.com/buzz/india-to-be-first-country-to-auction-satcom-spectrum-trai-chairman/

Types of Satellite Orbits

LEO 500-1500 KM, MEO 8000-18000 KM, HEO AROUND 23000 KM, GEO 35863 KM

There are 4 types of orbits, they are:

1. GEO (Geo-stationary earth orbit)
2. MEO (medium earth orbit)
3. LEO (Low earth orbit) and
4. HEO (Highly elliptical orbit)



TYPES OF SATELLITE ORBITS

RADIO FREQUENCY SPECTRUM (SPECTRUM)

RANGES FROM A FEW KHZ TO 3000 GHZ

A LIMITED NATURAL RESOURCE

SPECTRUM BELONGS TO THE ENTIRE HUMANITY

RADIO FREQUENCIES ARE USED FOR TERRESTRIAL AND SPACE RADIOCOMMUNICATIONS SERVICES (WIRELESS)

ITU RADIO REGULATIONS (ITU RR) PROVIDE INTERNATIONAL REGULATORY FRAMEWORK FOR USE OF RADIO FREQUENCY SPECTRUM BY ALL COUNTRIES

RADIO FREQUENCY SPECTRUM (SPECTRUM)

ORBIT-SPECTRUM RESOURCE:
SATELLITES OPERATIONS IN DIFFERENT **ORBITS** USING THE RADIO FREQUENCY **SPECTRUM** FOR PROVIDING SATELLITE BASED **SPACE RADIOCOMMUNICATION SERVICES.** THIS FORMS ORBIT-SPECTRUM RESOURCE

INTERNATIONAL MECHANISMS ARE DEVELOPED AND APPLIED TO PROVIDE INTERNATIONAL **REGULATORY FRAMEWORK** FOR USE OF ORBIT-SPECTRUM RESOURCES.

INTERNATIONAL TELECOMMUNICATION UNION (ITU) AS THE SPECIALIZED AGENCY OF UN IS RESPONSIBLE FOR MATTERS RELATING TO USE OF ORBIT-SPECTRUM RESOURCES BY COUNTRIES ALL OVER THE WORLD.

Satellite Communications

ITU Defined Radiocommunication Services for Satellite Communication Applications:

Refer: Volume 1 of ITU Radio Regulations (ITU RR) Edition 2020

- Fixed Satellite Service
- Mobile Satellite Service (Land, Sea and Air)
- Broadcasting Satellite Service
- Inter-Satellite Service
- Space Operation Service (TCR)

Definition of Services in ITU Radio Regulations

Definition of Services

***fixed-satellite service**; inter-satellite service; broadcasting satellite service;*

mobile-satellite service; space operation service

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*.

Definition of Services

fixed-satellite service*; inter-satellite service;* ***broadcasting satellite service****;*

mobile-satellite service; space operation service

(contd.)

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.*

In the broadcasting-satellite service, the term "direct reception" shall encompass both *individual reception and community reception.*

Definition of Services

***fixed-satellite service**; inter-satellite service; **broadcasting satellite service**;*

mobile-satellite service; space operation service

(contd.)

1.129

Individual reception (in the **broadcasting-satellite service**): The reception of *emissions* from a *space station* in the *broadcasting-satellite service* by simple domestic installations and in particular those possessing small antennas.

1.130

community reception (in the **broadcasting-satellite service**): The reception of *emissions* from a *space station* in the *broadcasting-satellite service* by receiving equipment, which in some cases may be complex and have antennas larger than those used for *individual reception*, and intended for use:

Definition of Services

fixed-satellite service; inter-satellite service; broadcasting satellite service; ***mobile-satellite service****; space operation service*

(contd.)

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.

Definition of Services

*fixed-satellite service; **inter-satellite service**; broadcasting satellite service; mobile-satellite service; space operation service*
(contd.)

1.22

inter-satellite service: A *radiocommunication service* providing links between artificial *satellites*.

Definition of Services

fixed-satellite service; inter-satellite service; broadcasting satellite service; mobile-satellite service; ***space operation service***
(contd.)

1.23

space operation service*:* A *radiocommunication service* concerned exclusively with the operation of *spacecraft*, in particular *space tracking*, *space telemetry* and *space telecommand*.

These functions will normally be provided within the service in which the *space station* is operating.

Definition of Services

fixed-satellite service; inter-satellite service; broadcasting satellite service; mobile-satellite service; ***space operation service***
(contd.)

1.133

space telemetry*:* The use of *telemetry* for the transmission from a *space station* of results of measurements made in a *spacecraft*, including those relating to the functioning of the *spacecraft*.

1.135

space telecommand*:* The use of *radiocommunication* for the transmission of signals to a *space station* to initiate, modify or terminate functions of equipment on an associated space object, including the *space station*.

Definition of Services

fixed-satellite service; inter-satellite service; broadcasting satellite service; mobile-satellite service; ***space operation service***

(contd.)

1.136

space tracking*:* Determination of the *orbit*, velocity or instantaneous position of an object in space by means of r*adiodetermination*, excluding *primary radar*, for the purpose of following the movement of the object.

Radio Frequency Spectrum
C, Ku, KA and Higher Frequency Bands

ITU Designations for Frequency Bands

Band number	Symbols	Frequency range (lower limit exclusive, upper limit inclusive)	Corresponding metric subdivision
4	VLF	3 to 30 kHz	Myriametric waves
5	LF	30 to 300 kHz	Kilometric waves
6	MF	300 to 3 000 kHz	Hectometric waves
7	HF	3 to 30 MHz	Decametric waves
8	VHF	30 to 300 MHz	Metric waves
9	UHF	300 to 3 000 MHz	Decimetric waves
10	SHF	3 to 30 GHz	Centimetric waves
11	EHF	30 to 300 GHz	Millimetric waves
12		300 to 3 000 GHz	Decimillimetric waves

NOTE 1: "Band N" (N = band number) extends from 0.3×10^N Hz to 3×10^N Hz.

NOTE 2: Prefix: k = kilo (10^3), M = mega (10^6), G = giga (10^9).

ITU designations of frequency Bands are more formal. But Telecommunication Industry uses the following designations

Frequency range	Wavelength	IEEE band
300KHz-3 MHz	1 km to 100 meters	MF
3-30 MHz	100 meters to 10 meters	HF
30-300 MHz	10 meters to 1 meter	VHF
300 MHz -3 GHz*	1 meter to 10 cm	UHF
1-2 GHz	30 cm to 15 cm	**L** band
2-4 GHz	15 cm to 5 cm	**S** band
4-8 GHz	5 cm to 3.75 cm	**C** band
8-12 GHz	3.75 cm to 2.5 cm	**X** band
12-18 GHz	2.5 cm to 1.6 cm	$\mathbf{K_u}$ band
18-26 GHz	1.6 cm to 1.2 cm	**K** band
26-40 GHz	1.6 cm to 750 mm	$\mathbf{K_a}$ band
40-75 GHz	750 mm to 40 mm	**V** band
75 to 111 GHz	40 mm to 28mm	**W** band
Above 111 GHz	"millimeter wave"	

Q band is also denoted for range of frequencies between 33 and 50 GHz but it may vary depending on the sources using the term

ITU TABLE OF FREQUENCY ALLOCATIONS

RADIO FREQUENCY SPECTRUM BELONGS TO HUMANITY.

ITU RADIO REGULATIONS (ITU RR) PROVIDE THE REGULATORY FRAMEWORK FOR EFFICIENT AND EQUITABLE USE OF THE SPECTRUM.

ITU RR HAS THE INTERNATIONAL TREATY STSTUS.

SPECTRUM IS DIVIDED INTO MANY SUB BANDS (UPTO 3000 GHz) AND ALLOCATED FOR DIFFERENT SERVICES.

(Refer: Volume 1 of ITU Radio Regulations (ITU RR) Edition 2020)

Important Satellite Services and Frequency Ranges

Band (code)	Frequency Range (ITU Band Designations)	Satellite Services
L Band	1 – 2 GHz (UHF)	**Mobile Satellite Service (MSS) Radionavigation Satellite Service**
S Band	2 - 4 GHz (UHF, SHF)	**MSS, Broadcasting Satellite Service (BSS) Space Operation, Space Research**
C Band	4 – 7 GHz (SHF)	**Fixed Satellite Service (FSS)**
X Band	7 – 10 GHz (SHF)	**Fixed Satellite Service (FSS) Earth Exploration Satellite Service**
Ku Band	10 – 15 GHz (SHF)	**FSS, BSS, Mobility Applications**
Ka Band	20 / 30 GHz (SHF, EHF)	**FSS, MSS**

ALSO NEED TO USE HIGHER FREQUENCY BANDS (Q, V & W) FOR MEETING THE GROWING REQUIREMENTS OF SATELLITE COMMUNICATIONS

V (37-50 GHz) AND W (70-86 GHz) FREQUENCY BANDS FOR SATELLITE COMMUNICATION NETWORKS

FSS FREQUENCY ALLOCATIONS IN V BANDS

ITU FREQUENCY ALLOCATIONS

SPACE-TO-EARTH DIRECTION

37.5-42.5 GHz FIXED-SATELLITE (space-to-Earth)

39.5-40.5 GHz MOBILE-SATELLITE (space-to Earth)

40.5-42.5 GHz BROADCASTING-SATELLITE

EARTH-TO-SPACE DIRECTION

47.2-50.2 GHz FIXED-SATELLITE (Earth-to-space)

50.4-51.4 GHz FIXED-SATELLITE (Earth-to-space)

OTHER ALLOCATIONS IN THE VBAND FREQUENCY RANGE

42.5-43-5 GHz FIXED-SATELLITE (Earth-to-space)

43.5-47 GHz MOBILE-SATELLITE

V (37-50 GHz) AND W (70-86 GHz) FREQUENCY BANDS FOR SATELLITE COMMUNICATION NETWORKS (contd.)

FSS FREQUENCY ALLOCATIONS IN W BANDS

ITU FREQUENCY ALLOCATIONS

SPACE-TO-EARTH DIRECTION

71-74 GHz FIXED-SATELLITE (space-to-Earth)

MOBILE-SATELLITE (space-to-Earth)

74-76 GHz FIXED-SATELLITE (space-to Earth)

BROADCASTING-SATELLITE

EARTH-TO-SPACE DIRECTION

81-84 GHz FIXED-SATELLITE (Earth-to-space)

MOBILE-SATELLITE (Earth-to-Earth)

84-86 GHz FIXED-SATELLITE (Earth-to-space)

INTER-SATELLITE SERVICE
FREQUENCY ALLOCATIONS
IN 20-30 GHZ AND 54-71 GHZ FREQUENCY RANGES

ITU FREQUENCY ALLOCATIONS IN GHZ

INTER-SATELLITE
FREQUENCY ALLOCATIONS IN 20 -30 GHZ FREQUENCY RANGE

22.55-23.15	**GHz**
23.15-23.55	**GHz**
24.45-24.65	**GHz**
24.65-24.75	**GHz**
25.25-25.5	**GHz**
25.5-27	**GHz**
27-27.5	**GHz**
32.3-33	**GHz**

INTER-SATELLITE
FREQUENCY ALLOCATIONS IN 54 -71 GHZ FREQUENCY RANGE

54.25-55.78	**GHz**
55.78-56.9	**GHz**
56.9-57	**GHz**
57-58.2	**GHz**
59-59.3	**GHz**
59.3-64	**GHz**
64-65	**GHz**
65-66	**GHz**
66-71	**GHz**

TYPES OF SATELLITE COVERAGES

National, Regional and Global Coverage as well as Spot Beam Coverage

Traditionally GSO Satellite Systems are used for Communications. Now increasing interest is being shown for launching NON GSO Satellite Constellations.

Therefore there are wide variations in the Commercial Communication Satellite Systems that are being launched and operated.

ITU Radio Regulatory Framework also becomes more complex to take into account such wide variations in the Satellite System Technical Characteristics.

C, Ku, KA and Higher Frequency Bands

C and Ku Bands

GSO Satellites:

C Band is normally used for Global Coverage Beams;

C and Ku Bands are normally used for National and Regional Coverage Beams

Ku, KA and Higher Bands

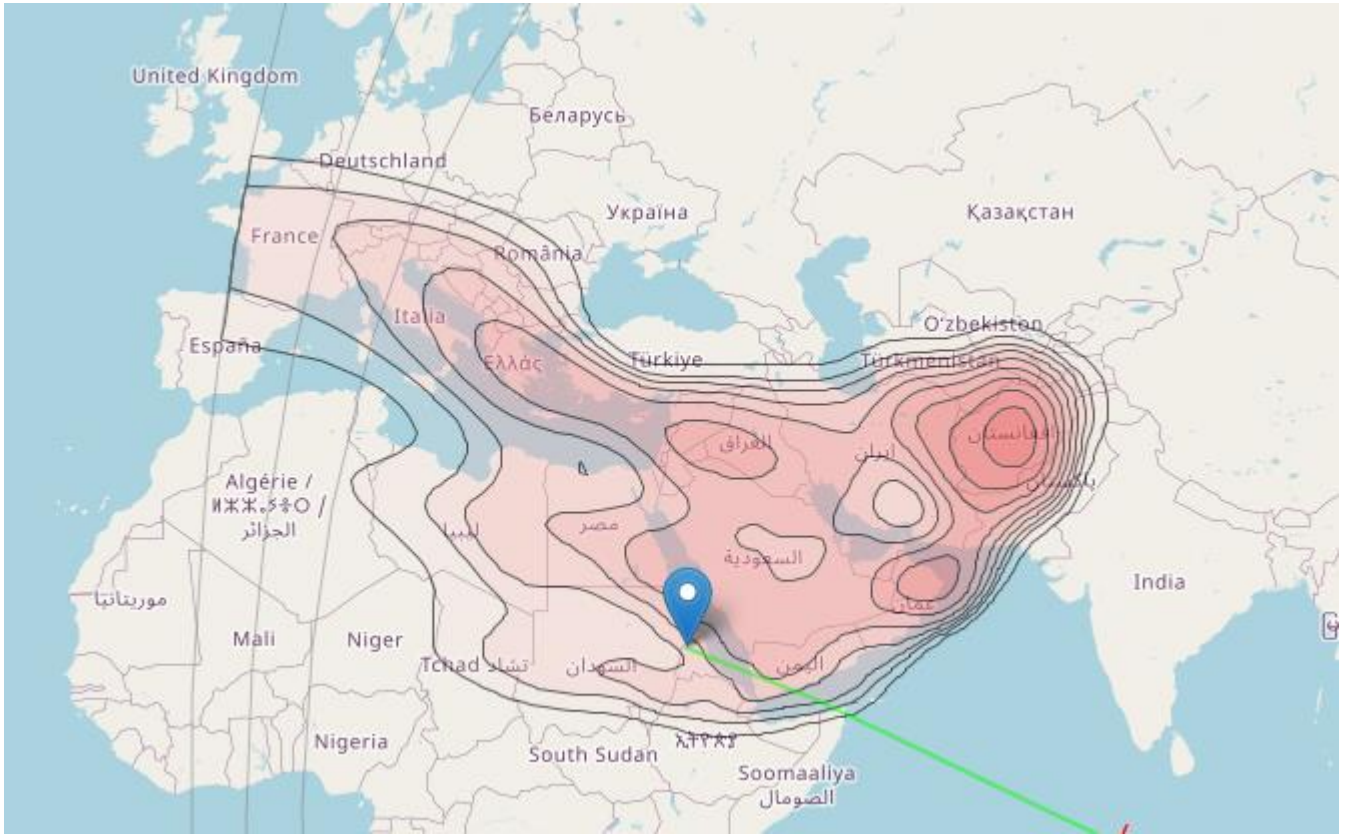
In these frequency Bands, Multiple Spot Beams are used in both GSO and Non GSO Satellites.

NATIONAL COVERAGE SATELLITE

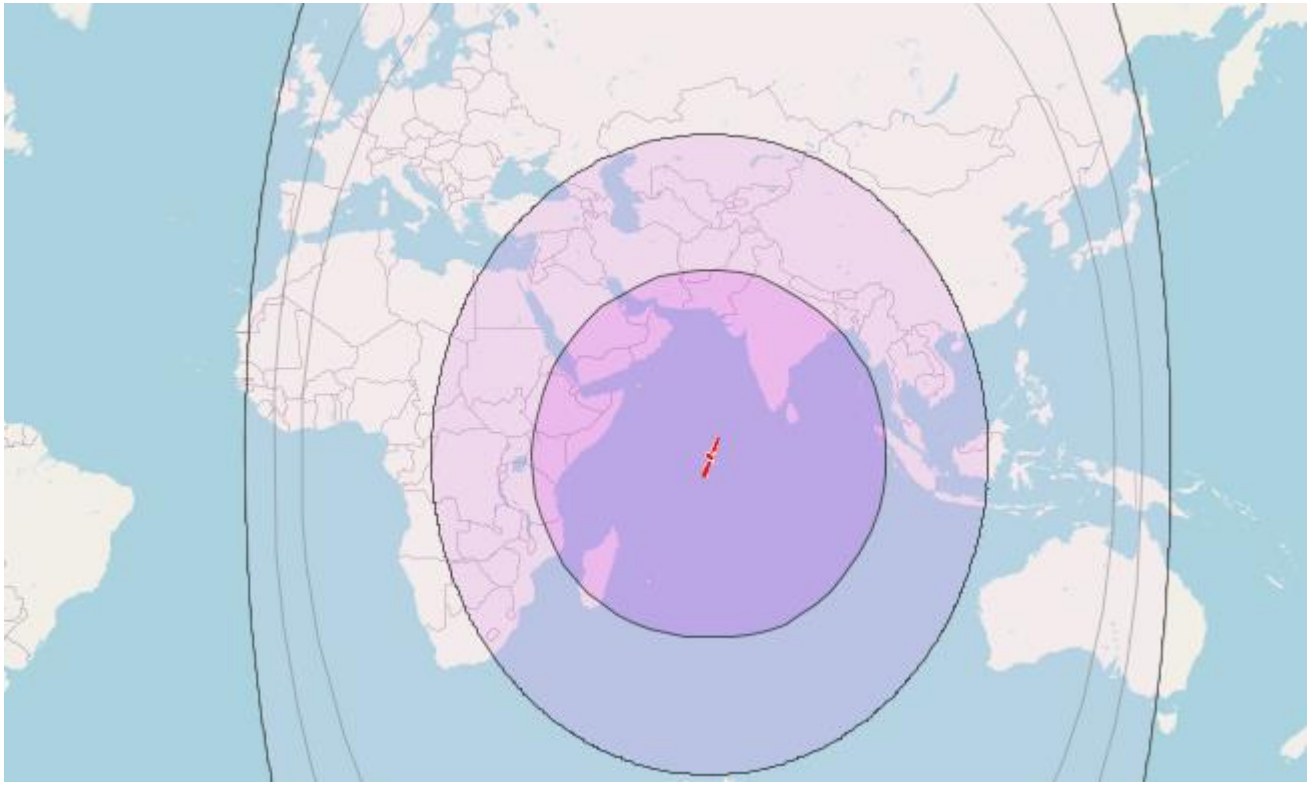
EXAMPLE INDIA

REGIONAL COVERAGE SATELLITE

EXAMPLE MIDDLE EAST AND NORTH AFRICA (MENA)



GLOBAL COVERAGE SATELLITE
EXAMPLE INDIAN OCEAN REGION (IOR)
From 66 E Orbital Slot in GSO
(Three GSO Satellites are required to cover almost the entire Globe)



Frequency Bands, Orbits and Coverage

C and Ku Bands

GSO Satellites:

C Band is normally used for Global Coverage Beams;

C and Ku Bands are normally used for National and Regional Coverage Beams

KA and Higher Bands

In these frequency Bands, Multiple Spot Beams are used in both GSO and Non GSO Satellites.

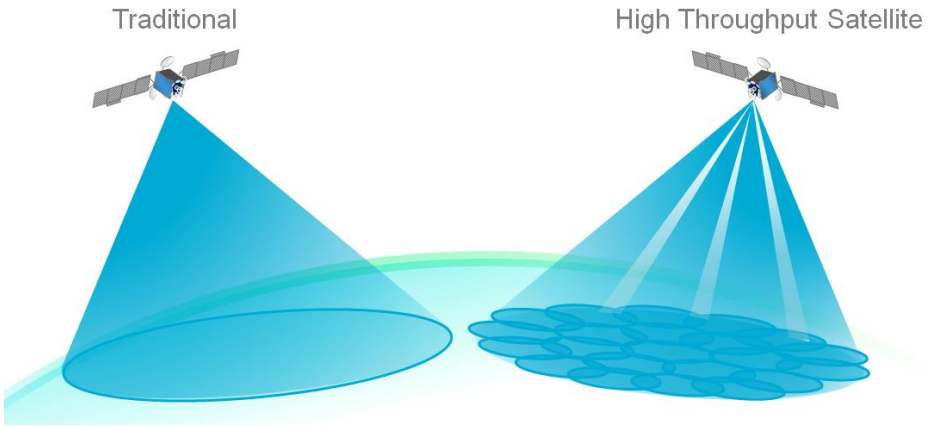
Typical Satellite Beam Foot Print Size

100 – 1000 Km for LEO and MEO Satellites

200 – 3500 Km for GSO Satellites

High Throughput Spot (HTS) Satellites - An Important Development

- High Throughput Spot (HTS) Satellites using hundreds of Spot Beams cover large geographical areas.
- Global coverage of such satellite constellations; geostationary and non-geostationary based infrastructure will transform the world into a “global village”.



Difference between Traditional Satellite Beam and HTS Spot Beams

Examples
High Throughput Satellite (HTS)

https://en.wikipedia.org/wiki/High-throughput_satellite

KA-SAT Spot Beam Coverage over Europe showing the frequency reuse

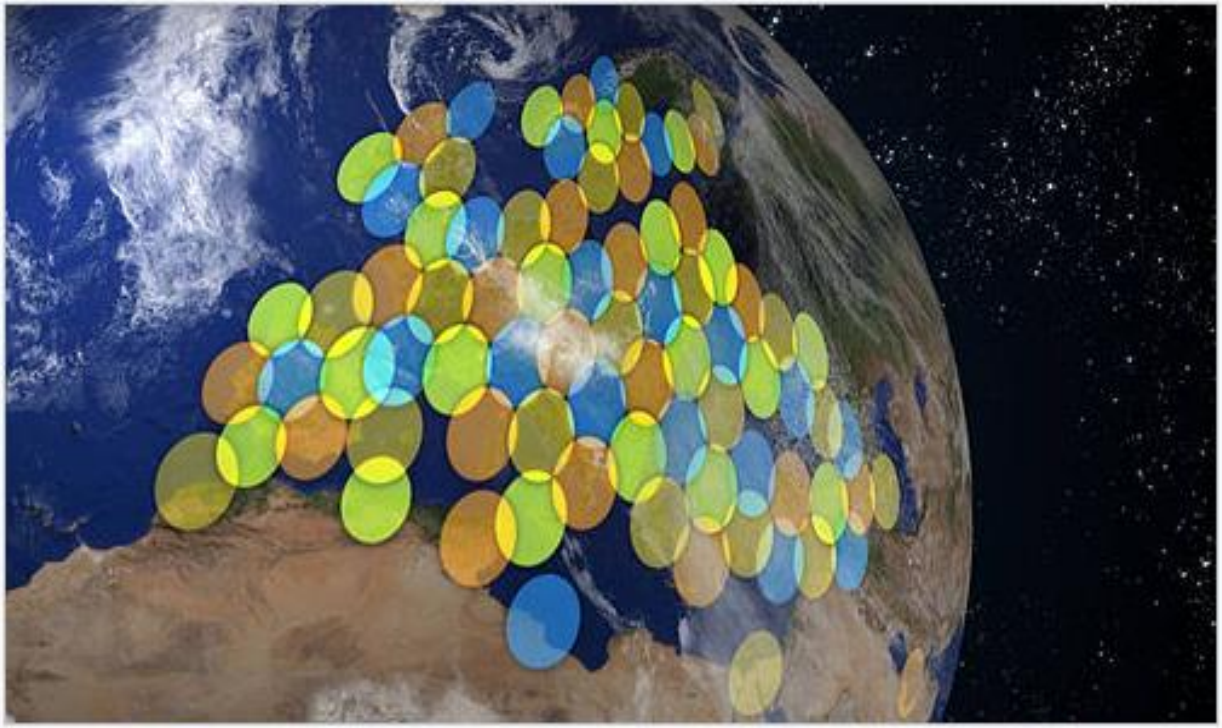
Similarly ISRO GSAT-20 has spot Beam Coverage over India

Examples for High Throughput Satellite (HTS)

https://en.wikipedia.org/wiki/High-throughput_satellite

KA-SAT Spot Beam Coverage over Europe showing the frequency reuse

Similarly ISRO GSAT 20 has spot Beam Coverage over India



KA-SAT coverage over Europe showing frequency reuse by different colors

Satellite Size – Traditionally 1000/2000/3000 Kg +
But now Small Satellites being introduced
In view of advances in technologies especially Electric Propulsion small satellites are also being built and launched.

Typical characteristics of small satellites

Denomination	Mass (kg)	Max. bus power (W)	Typical cost (USD)	Max. dimensions (m)	Development time (years)	Orbit	Mission duration (years)
Minisatellite	100-500	1 000	30-200 M	3-10	3-10	GEO MEO LEO HEO	5-10
Microsatellite	10-100	150	10-150 M	1-5	2-5	LEO (HEO)	2-6
Nanosatellite	1-10	20	100 k-10 M	0.1-1	1-3		1-3
Picosatellite	0.1- 1	5	50 k-2 M	0.05-0.1			
Femtosatellite	< 0.1	1	< 50 k	0.01-0.1	1		< 1

NON GSO SATELLITES

LIST OF SELECTED SATELLITES

ONEWEB Ku, KA, V Bands (Worldvu)

SPACEX Ku, KA, V Bands

TELESAT

Orbital Position	Satellite Name	Call Sign	Licensee or Grantee	Administration	Service	Frequency Range	Date In-orbit and Operating	Notes
NGSO	ONEWEB Ku-/Ka-BAND	S2963	WorldVu Satellites Limited, Debtor-in-Possession	United Kingdom	FSS	10.7-12.7 GHz (s-E) 14-14.5 GHz (E-s) 17.8-18.6 GHz (s-E) 18.8-19.3 GHz (s-E) 27.5-29.1 GHz (E-s) 29.5-30 GHz (E-s)	29-04-2019	720 satellites at an altitude of 1,200 km
NGSO	SPACEX Ku/Ka-BAND	S2983 / S3018	Space Exploration Holdings, LLC	U.S.A.	FSS	10.7-12.7 GHz (s-E) 12.75-13.25 GHz 13.85-14.5 GHz (E-s) 17.8-18.6 GHz (s-E) 18.8-19.3 GHz (s-E) 19.7-20.2 GHz (s-E) 27.5-29.1 GHz (E-s) 29.5-30 GHz (E-s)	12-06-2019	4,408 satellites at altitudes at or below 580 km

Orbital Position	Satellite Name	Call Sign	Licensee or Grantee	Administration	Service	Frequency Range	Date In-orbit and Operating	Notes
NGSO	TELESAT Ka-BAND	S2976	Telesat LEO Inc.	Canada	FSS	17.8-18.6 GHz (s-E) 18.8-19.3 GHz (s-E) 19.7-20.2 GHz (s-E) 27.5-29.1 GHz (E-s) 29.5-30 GHz (E-s)	12-01-2018	72 satellites at an approx. altitude of 1,000 km 45 satellites at an approx. altitude of 1,248 km

Satellite Systems are Highly Capital Intensive

Satellites are custom designed, built and launched.

Highly qualified engineers and scientists are involved in designing and building satellites.

Sophisticated technical facilities are required for building and testing satellite.

Satellite Launches are also expensive. Also need Insurances for Launch, Operations etc.

GSO Satellite System may cost around 500 M US $ or so.

NON GSO Satellite Constellation will also cost several billion US Dollars

Satellites are generally cost effective for broadcasting applications. A single GSO Satellite can easily provide service to 10 million or more DTH subscribers.

But Satellite based services for internet connectivity are more expensive as compared to terrestrial fibre networks.

Internet Connectivity Services Satellite vs. Terrestrial Systems

Optical Fibre based internet connectivity services are highly competitive in India.

India's Fastest Broadband Internet service providers 2021 are:

Airtel; Reliance Jio Fiber; Excitel Broadband; BSNL; Hathway's Broadband; ACT Fibernet Broadband; You Broadband

(https://freekaamaal.com/miscellaneous/best-internet-service-provider-in-india)

GSO and NON GSO Satellite Based Internet Access Services Example Tariffs

Provider	Best For	Price	Download speed	Details
Viasat	Fastest satellite internet speeds	$30.00–$150.00/mo.*	12–100 Mbps	12–300 GB
HughesNet	Budget-friendly low-end plans	$59.99–$149.99/mo.**	25 Mbps	10–50 GB

Non GSO Satellite Based Internet Access Services may bring down the price and the availability:

SpaceX / Starlink satellite internet price

Plan	Price	Downlink Speed	Data Cap
Starlink	$99/mo.	50–150 Mbps	Unlimited

Other Non GSO Systems like mO3b, OneWeb, etc are likely to offer similar highly competitive satellite based internet service services and prices.

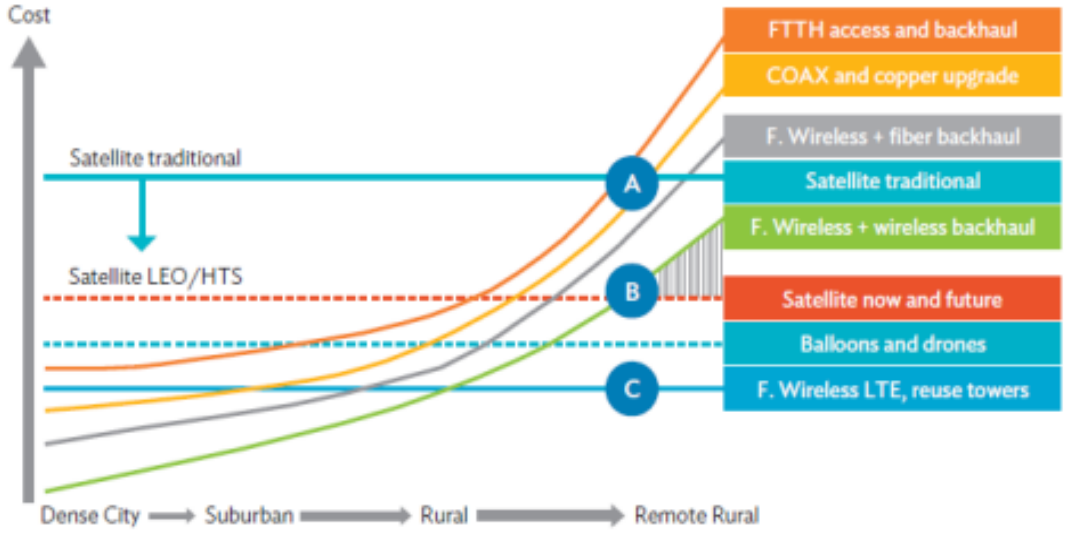
Satellite based internet services are expensive but Technology may bring down the price in future;

Whether it will be possible to bring the Space Segment Capex (US $) per Mbps per Month below say 10 US $?

[Extract From TRAI Consultation Report April 2023: https://trai.gov.in/sites/default/files/CP_06042023.pdf](https://trai.gov.in/sites/default/files/CP_06042023.pdf)

Technologies Compared by Costs and Population Density

(Adapted from World Bank 2019 Report)



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

Digital Divide and Satellite Communications

Digital Divide and Satellite Communications

The digital divide is a challenging situation in India, especially in remote and rural areas. As per TRAI data as of September 2022, no. of Internet subscribers per 100 populations in rural areas is around 30 or less in many states like:

State	Rural	Urban	Total
Assam	33.66	115.75	46.39
Bihar	28.56	88.88	37.93
Madhya Pradesh	29.30	103.74	50.47
UP	30.21	92.77	45.55

In response, terrestrial internet service providers (ISPs) like Reliance Jio Infocomm limited, Bharti Airtel Limited, etc. are working to expand their internet networks and implement new technologies such as fibre optic cables to deliver greater coverage and higher speeds to more communities.

However, terrestrial broadband faces geographic limitations, and individuals living in remote areas cannot easily access ground-based internet.

Digital Divide and Satellite Communications

Digital Divide and Satellite Communications (contd.)

Satellites have coverage advantage. So satellite ISPs are building constellations that will provide nearly global coverage. It remains to be seen if the markets for rural areas are robust enough to support satellite ISPs and whether satellite speeds are fast enough to compete with terrestrial ISPs.

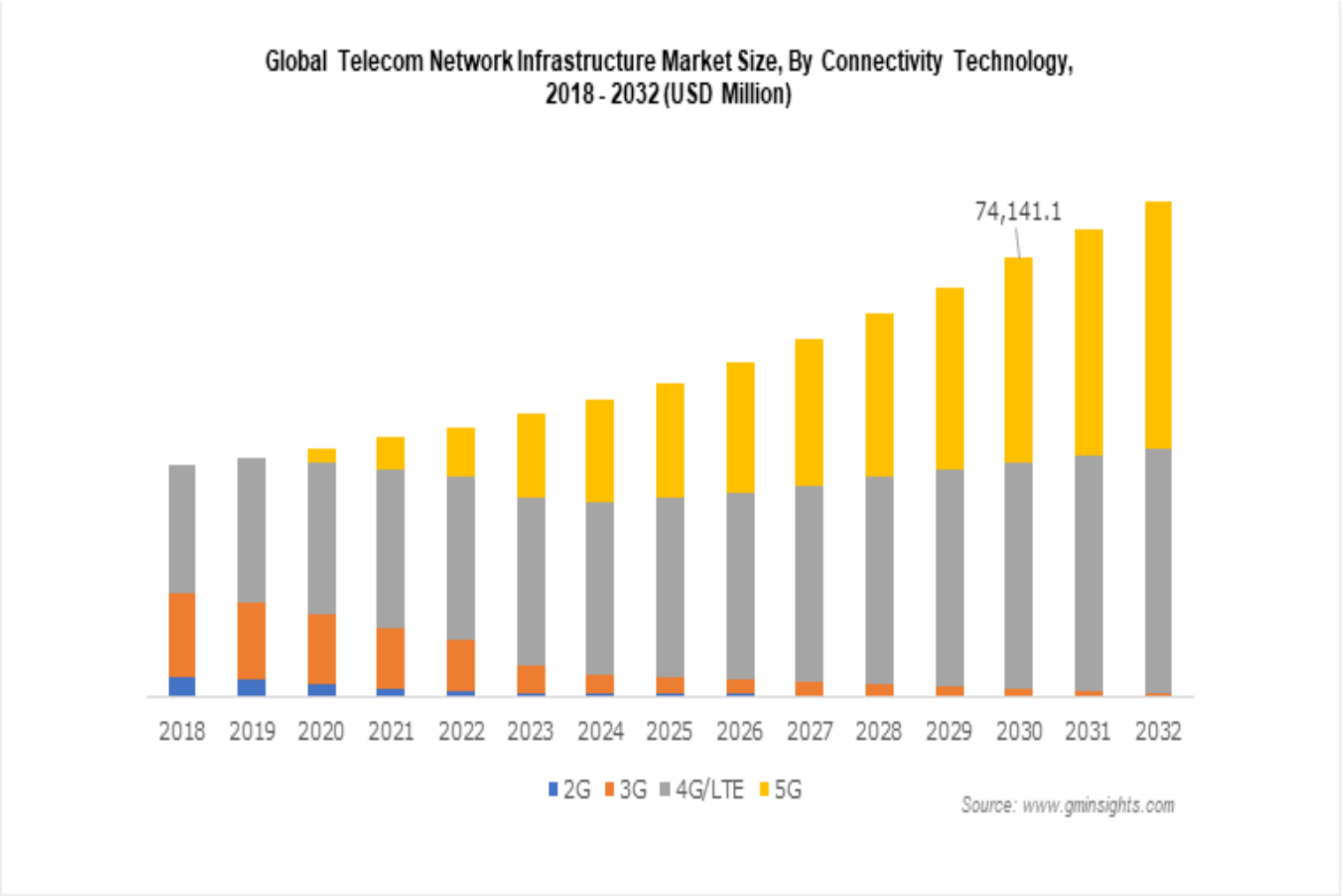
For example JIO in cooperation with SES (GEO and MEO satellite operator), AIRTEL along with OneWeb, Tata with Telesat and Star link / SpaceX are planning to provide satellite based services for internet connectivity in India.

SES's second-generation MEO communications system (O3b mPOWER) promises unrivalled performance, enabling customers' operations with high throughput, predictable low latency, and high availability.

In areas where populations tend to be clustered, integrated system i.e. Satellite + Terrestrial Cellular (LTE/4G/5G) Systems are expected to have an edge over stand alone satellite systems.

4G/LTE and 5G Terrestrial Services Will Dominate in the Future

Therefore Integrated Satellite Systems with 4G/LTE and 5G are being proposed



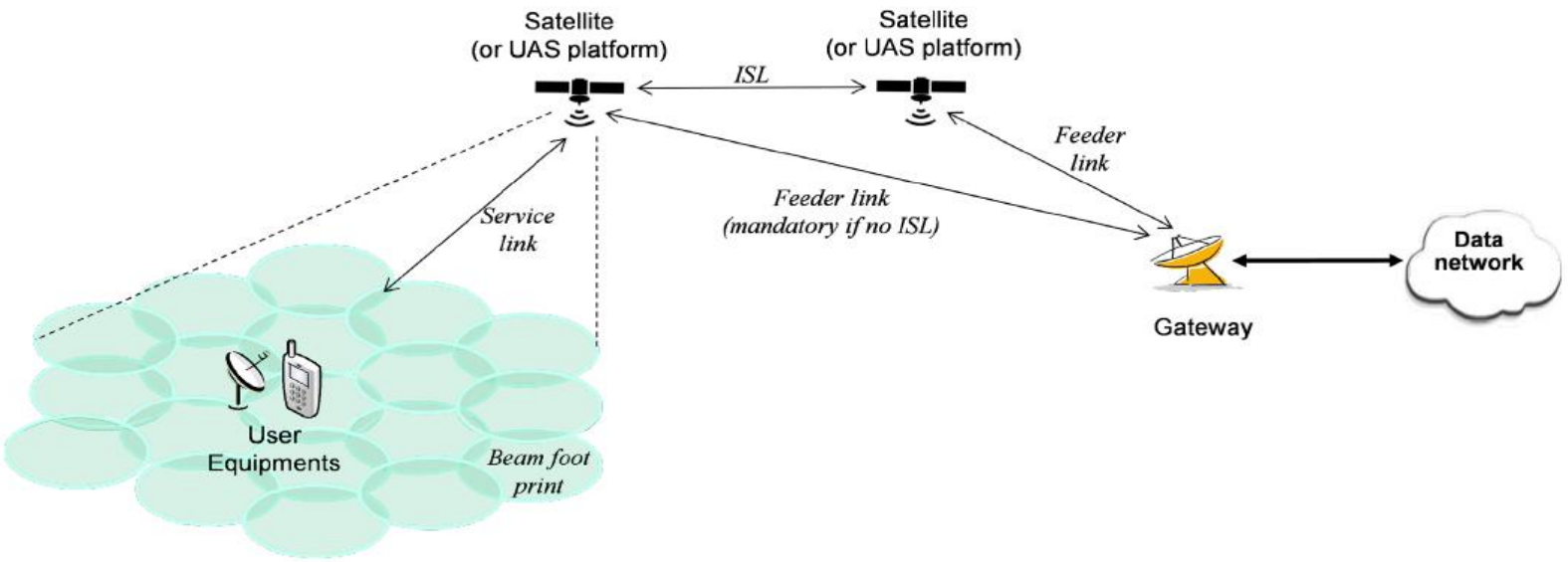
Traditionally Satellite Systems are Stand Alone Systems.

New Development
Integrated Satellite Systems are being proposed.

SATELLITE (HTS) – CONNECTED WITH TERRESTRIAL NETWORK

HTS Satellite Connected with Terrestrial Network (5G)
(source: 3GPP TR 38.821-g00)

Figure 4.1-3 Satellite-based NTN typical scenario based on regenerative payload (source: 3GPP TR 38.821-g00)



Digital Divide and Satellite Communications

Digital Divide and Satellite Communications

References:

TRAI – The Indian Telecom Services Performance Indicators July-Sep. 2022 www.trai.gov.in

Top 10 Best Internet Service Providers in India in 2023: https://www.inventiva.co.in/trends/top-10-best-internet-service-providers/

https://www.businesswireindia.com/marlink-to-drive-digital-transformation-across-french-guiana-leveraging-ses-s-multi-orbit-satellite-network-83153.html

https://www.spaceworks.aero/bridging-the-gap/https://ww

https://www.bcsatellite.net/blog/will-satellite-bandwidth-costs-continue-to-fall/

New Satellite Trends & Technologies

New Satellite Trends & Technologies

Small Satellites
Satellite IoT
In-Orbit Services
Advanced Ground Systems
Artificial Intelligence
Advanced Payload Systems
Spacecraft Propulsion
Very High Throughput Satellites (VHTS)
Flexible Launch Services
Additive Manufacturing

https://www.startus-insights.com/innovators-guide/satellite-trends-innovation/

Start Up Companies show interest in these New Satellite Trends & Technologies/Innovations.

These aspects need to be studied from the points of view of Technology, Applications, Business, Space Policy, and Regulations.

ITU RADIO REGULATIONS (ITU RR)

ITU RADIOCOMMUNICATION SECTOR (ITU-R) DEFINES AND MANAGES INTERNATIONAL REGULATORY FRAME WORK

ITU RADIO REGULATIONS (ITU RR) PROVIDE THE REGULATORY BASIS; ITU WORLD RADIO CONFERENCES (WRC) REVIEW AND REVISE ITU RR EVERY 3 OR 4 YEARS

ITU RADIO REGULATIONS HAVE THE FORCE OF INTERNATIONAL TREATY

ITU RADIO REGULATIONS (ITU RR) (Contd.)

ITU RADIO REGULATIONS INCLUDE TECHNICAL AND REGULATORY PROVISIONS

ITU TABLE OF FREQUENCY ALLOCATIONS

FORMS A MAJOR ARTICLE OF THE ITU RR
INCLUDES SIGNIFICANT REGULATIONS
HOW EACH FREQUENCY SUB BAND CAN BE PUT INTO USE

FREQUENCY ALLOCATION FOR SPACE SERVICES ARE ON **INTERNATIIONAL BASIS**

ITU RADIO REGULATIONS PROVIDE REGULATORY PROCEDURES FOR ACCESS TO ORBIT-SPECTRUM RESOURCES FOR IMPLEMENTATION OF SPACE SYSTEMS.

ITU RADIO REGULATIONS (ITU RR) (CONTD.)

PLAN AND COORDINATION APPROACHES

•ITU RADIO REGULATIONS (ITU RR) INCLUDE PLAN AND COORDINATION APPROACHES FOR ACCESS TO ORBIT-SPECTRUM

•**PLAN APPROACH**: ENABLES GUARANTEED ACCESS TO ORBITAL SLOT
PLAN INCLUDES A PRIORI IDENTIFICATION OF ORBITAL SLOT, FREQUENCIES, COVERAGE FOR EACH COUNTRY
PLANS EXIST ONLY IN 500 MHZ IN KU BAND FOR BSS AND
IN 800 MHZ IN C & KU BANDS FOR FSS

•**COORDINATION APPROACH**: FIRST COME FIRST SERVED BASIS
CAN TAKE INTO ACCOUNT THE ACTUAL REQUIREMENTS
SO CONSIDERED EFFICIENT
BUT OVER FILING MAKES COORDINATION UNCERTAIN AND DIFFICULT
OVER FILING CONTINUES IN SPITE OF DUE DILIGENCE REQUIREMENTS

ITU RADIO REGULATIONS (ITU RR) (CONTD.)

IMPORTANCE OF COORDINATION APPROACH

•PLAN ALOTTED PARAMETERS DO NOT NEED COORDINATION BUT PLAN MODIFICATIONS SHOULD GO THROUGH COORDINATION PROCEDURES

•PLAN MODIFICATIONS ARE INEVITABLE BECAUSE OF CHANGES IN REQUIREMNETS , TECHNOLOGY, ETC.

•PRACTICALLY COORDINATION APPROACH NEEDS TO BE APPLIED FOR BOTH PLAN AND NON PLANNED BANDS FOR IMPLEMENTATION OF SPACE SYSTEMS.

International Coordination Obligation

As per the regulatory procedures defined by the ITU RR, Technical Data of the proposed satellite networks are submitted to ITU BR (Radiocommunication Bureau) in the prescribed format known as Filings.

These ITU Filings have validity periods (7 or 8 years) i.e. Satellite networks need to internationally coordinated and brought into use within the validity period.

Since the Coordination Approach is generally based on “First Come First Served”, the Filing Dates (i.e. Seniority of Filings) form the criteria for International Coordination.

International Coordination Obligation (Contd.)

For a given Satellite Communication Network Successful Completion of International Coordination as per ITU RR provides International Recognition and International Protection.

Since Satellite Systems are capital intensive, successful completion of International coordination is an important requirement for interference free operations as well as Satellite Project Funding as well as licensing.

SATELLITE FILINGS (NETWORK) AND REGULATORY STATUS

https://www.unoosa.org/res/oosadoc/data/documents/2021/aac_105c_12021crp/aac_105c_12021crp_13_0_html/AC105_C1_2021_CRP13E.pdf

STATISTICS

TABLE 4.1: SATELLITE FILINGS (NETWORK) AND REGULATORY STATUS

(IN APPLICATION OF THE PROVISIONS OF ARTICLE 9 AND/OR ARTICLE 11 OF THE RADIO REGULATIONS)

(A = Network in API stage, C = Network in coordination stage,
N = Network in notification stage)

Year	Networks		A	C	N
2020	GSO	3404	19	2055	1330
	Non-GSO	1405	610	217	578
	TOTAL	**4809**	**629**	**2272**	**1908**
2019	GSO	3298	15	2038	1245
	Non-GSO	1144	479	147	518
	TOTAL	**4442**	**494**	**2185**	**1763**
2018	GSO	3371	N/A[1]	2152	1215
	Non-GSO	1066	448	132	486
	TOTAL	**4437**	**452**	**2284**	**1701**
2017	GSO	3292	N/A[1]	2148	1136
	Non-GSO	890	376	89	425
	TOTAL	**4182**	**384**	**2237**	**1561**

Over View of
Coordination and Notification Procedures
(Non-Planned Space Services)

Certain Aspects Only

REF: ITU SEMINAR DOCUMENT SP-0017
https://www.itu.int/dms_pub/itu-r/md/15/wrs18/sp/R15-WRS18-SP-0017!!PDF-E.pdf

Example
Orbital Arc of Interest to Indian Sub Continent
50 E – 110 E

Example: Good Coverage of India from GSO Orbital Slots in the Orbital Arc. 50 E – 110 E.

(Satellite Elevation Angle of about 30 Deg. or so is technically and operationally preferred)

Therefore Competition for Orbital Slots in this Orbital Arc

Coverage from 50 E GSO Orbital Position
(Eleveation Angle 30, 25 and 20 Deg; Inner to Outer)

Coverage from 110 E GSO Orbital Position
(Eleveation Angle 30, 25 and 20 Deg; Inner to Outer)

50 E – 110 E

Orbital Arc of Interest to Indian Sub Continent

ITU Filings in the Orbital Arc by:

China, France, India, UK, HOL, LUX, MLA, RUS IK, UAE, USA and other countries

International Satellite Operators like Intelsat, Inmarsat, SES/NSS, Eutelsat as well as

Regional Satellite Operators like MEASAT, ST, Asiasat, Yahsat (UAE) operate satellites.

International Coordination is involved among the above mentioned countries/operators.

50 E – 110 E
Orbital Arc of Interest to Indian Sub Continent (contd.)

Coordination Issue:

ITU Filings For Coordination of Orbital Slots with various Countries / Satellite Operators listed in the previous Slide.

This represent some sort of Non Cooperative Game Like Situation.

There is a need to overcome this Regulatory Obstacle through various Coordination measures and negotiations.

International Coordination Issue:

ITU Filings are increasing. That means More and more Claims for Orbit-Spectrum Resources.

The Issue becomes more acute as there is a preference for particular Orbital Slot / Orbital Arc for a given Country or Service Area .or Geographical Region.

In addition there is also preference for particular Frequency Band for a given application/service.

(L, S, C, X, Ku, KA, V, W Bands)

International Coordination Issue (Contd.)

There is a Competition for Securing particular portion of Spectrum and the Orbital Slot.

There is a need to complete successful International Coordination within the prescribed period by ITU RR for Launching the Satellite and occupying the Orbital Slot.

Regulatory Mechanism is also complex.

Satellite Systems are capital intensive.

Issues in Satellite Communications

(International Telecommunications laws)

Overview

Plan For Discussions

- UN Outer Space Treaty and related laws / procedures.
- ITU Radio Regulations (ITU RR).
- ITU RR regulatory framework and procedures for International Coordination for ensuring interference free operations.
- SPACE Activities Bill; New Spacecom Policy;

  IN-SPACe; Considerations for Auction of Satellite Spectrum
- Characteristics of Satellite Systems, Frequency Bands, GSO Orbital Slots, Capex, New Satellite Technology Trends, etc.
- Satellite vs. Terrestrial Systems - Internet Connectivity Services
- Integrated system i.e. Satellite + Terrestrial Cellular (LTE/4G/5G) Systems - Edge over Traditional Stand Alone satellite systems.

Issues in Satellite Communications
(International Telecommunications laws)
Overview/Summary

- Launching and Operations of Communication satellites are subject to UN Outer Space Treaty and related laws / procedures.
- Launching States i.e. countries / companies registered in the countries who own the satellites.
- Launching states control and operate their satellites without causing damage to all other countries.
- Communication satellites operate their services using the radio frequency spectrum and orbits need to Internationally Coordinate as per ITU Radio Regulations (ITU RR).
- ITU RR provides the regulatory framework and procedures for conducting International Coordination for ensuring interference free operations.

Issues in Satellite Communications
(International Telecommunications laws)
Overview (Contd.)

The following aspects relating to Satellite Communications in India are also discussed:

- **SPACE ACTIVITIES BILL OF INDIA**
  (To ensure compliance with UN Treaty Obligations & other Regulations)

- **The New Spacecom Policy**
  (Set to revolutionize Satellite Communications in India)

- **INDIAN NATIONAL SPACE PROMOTION AND AUTHORIZATION CENTER (IN-SPACe)**
  (Provides basis for Single Window Regulatory Clearances for Space matters)

- **Orbit - Spectrum – TRAI Studies on Auction of Satellite Spectrum?**
  (Procedures for Assignment of Satellite Spectrum)

The Discussions included Satellite vs. Terrestrial Systems related considerations for providing Internet Connectivity Services.

Issues in Satellite Communications
(International Telecommunications laws)
Overview/Summary (Contd.)

- There are wide variations in technical and operational characteristics of communication satellites launched and operated. Wide ranging parameters are: Frequency Bands, Orbits (GSO and non GSO), Coverage (National, Regional and Global), Conventional wide area coverage Beam or Use of multiple spot beams like High Throughput Satellites, Applications and Services (DTH, Internet Access, VSAT, SNG, etc.), Satellite Size (, Small, etc.) and other factors.

- Taking into account such wide variations ITU RR regulatory framework and procedures are reviewed and developed accordingly at ITU WRC Conferences held every four years and applied for Orbit and Frequency usage, International Coordination and other technical and regulatory aspects.

Issues in Satellite Communications
(International Telecommunications laws)
Overview/Summary (Contd.)

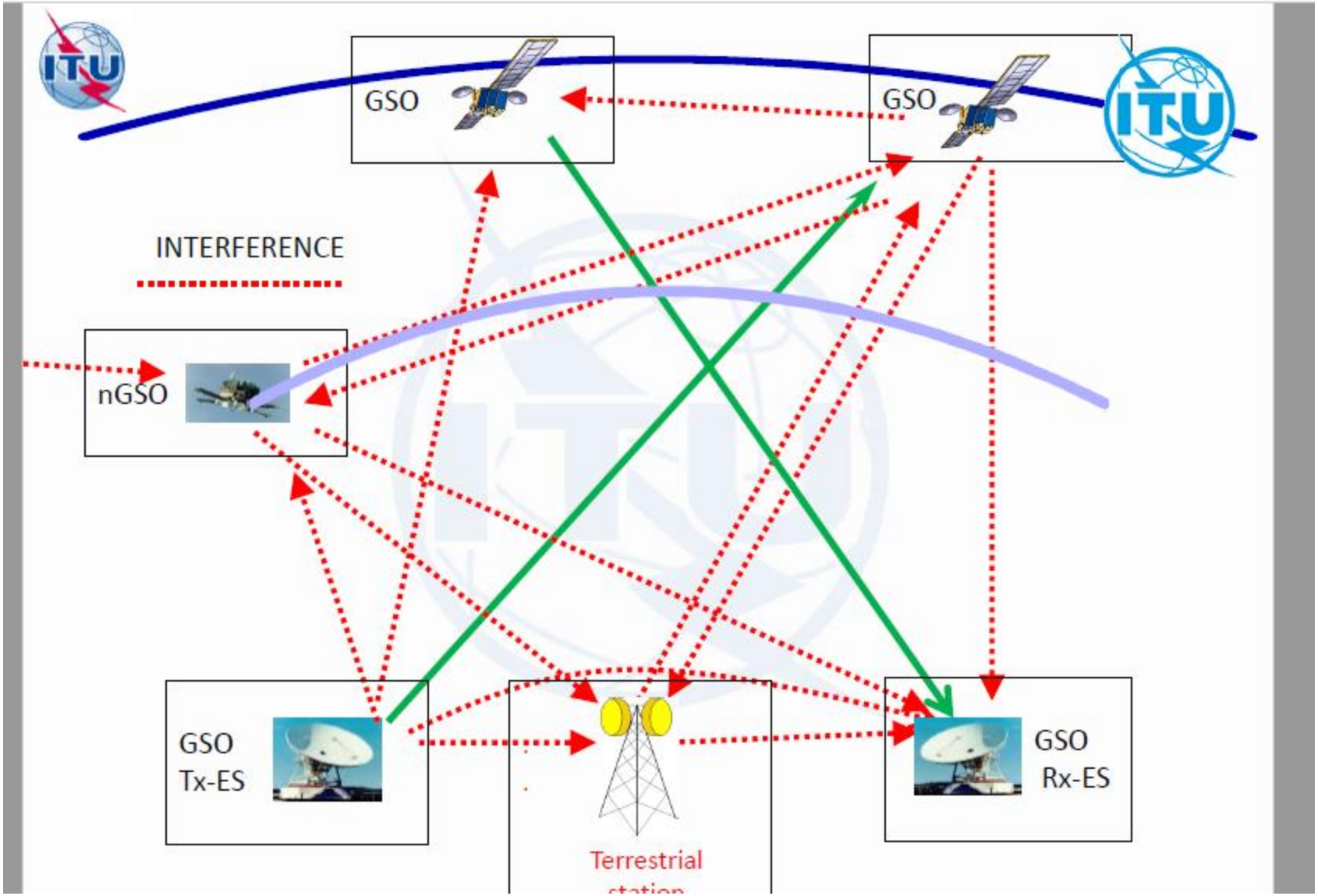
- Compliances with various ITU RR provisions and successful completion of International Coordination and Notification (i.e. Registration with ITU BR) of the intended Orbit=Spectrum parameters with ITU Radiocommunication Bureau (BR) are necessary for ensuring interference free operations.
- Only such Notified Communication Satellite Networks are internationally recognised and protected.
- Compliance with ITU RR provisions is normally a pre-requisite for funding, commercial operation of satellites and obtaining national licenses or landing rights.

Over View of
Coordination and Notification Procedures
(Non-Planned Space Services)

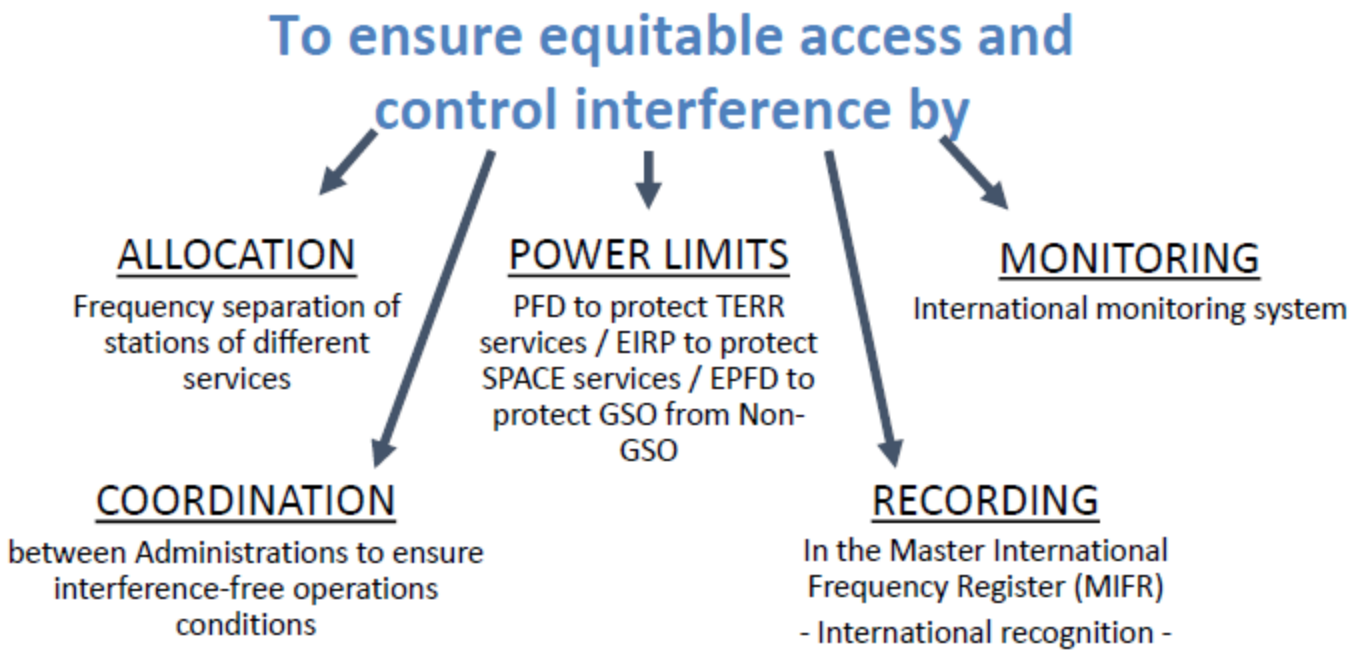
Certain Aspects Only

REF: ITU SEMINAR DOCUMENT SP-0017

https://www.itu.int/dms_pub/itu-r/md/15/wrs18/sp/R15-WRS18-SP-0017!!PDF-E.pdf


GSO
GSO
INTERFERENCE
nGSO
GSO
Tx-ES
Terrestrial
GSO
Rx-ES

Regulatory and technical solutions



Contents

Essence of coordination approach

Two stage procedure – A, N or C(A), N

Examination of Coordination Request

CR/C, CR/D and CR/E

earth station coordination

Recording in MIFR

Resolution 49 and Resolution 552

BR Actions at the end Regulatory Time Limit

One of the Main Purpose of RR is Interference-free operation

Mechanisms to achieve it

(Allocation, Limits, Licensing , Monitoring)

and

- Planned use
- Coordinated Use

→**First Come First Served (subject to some restrictions) and Obligatory Negotiations**

Elements of Coordination Approach

- Publish a planned use of satellite network
- Fulfil requirements mentioned in the RR
- Negotiate with concerned administrations and get agreements
- Record the coordinated assignments in the MIFR (Master International Frequency Register) to be taken into account by other administrations

Forms of Coordination

No.9.6:Before BiU or Notify in cases below shall effect coordination (No.9.27/AP 5 -Table 5-1)

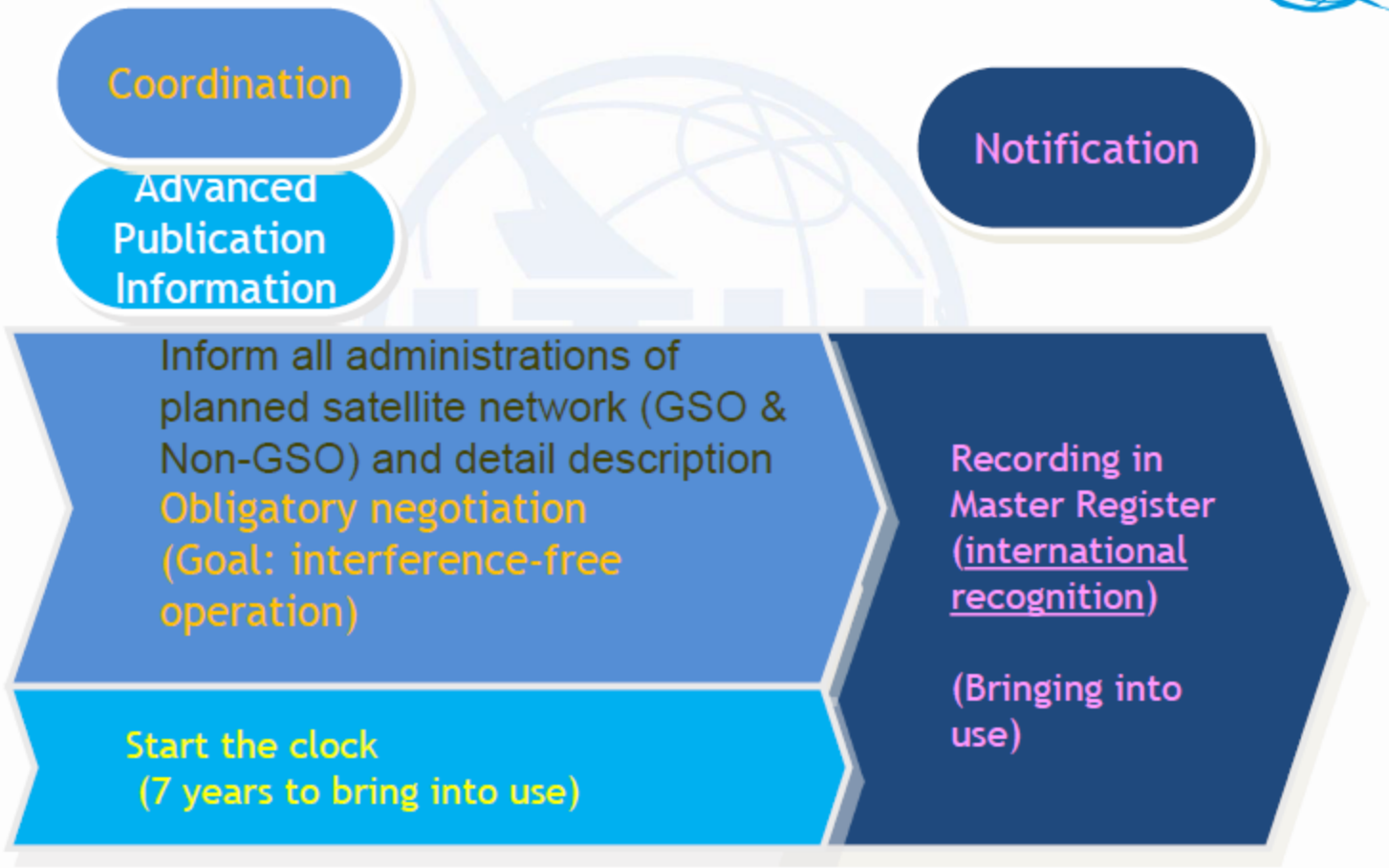
Cases	Provision
GSO to GSO	9.7, Art7 AP30/30A
Certain ES of GSO to NGSO	9.7A
NGSO to Certain ES of GSO	9.7B
BSS (GSO/NGSO) to Terrestrial Services	9.11, Res.539
NGSO to NGSO	9.11A/9.12
NGSO to GSO	9.11A/9.12A
GSO to NGSO	9.11A/9.13
NGSO/GSO to Terrestrial Services	9.11A/9.14
the requirement to seek the agreement of other administrations is included in a footnote to the Table of Allocation	9.21

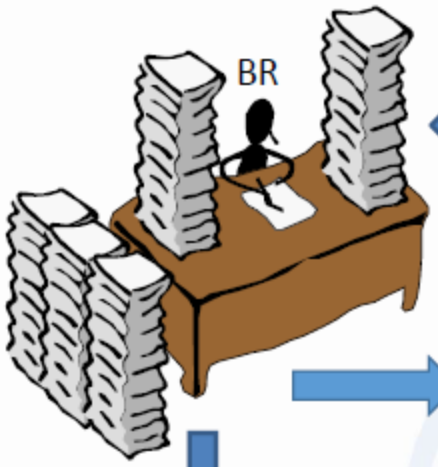
Elements of Coordination Approach

Elements	Relevant Provisions
Procedures	Articles 9 & 11
Submission format	Appendix 4
Technical & operational limits	Article 5, Articles 21&22 etc.
Criteria and methods to identify coordination requirements	Appendix 5 (Appendices 7 and 8)

Coordination Approach

Satellite networks Subject to Coordination Procedure





Request for coordination AP4 submission

API/C publication

CR/C publication
Technical & regulatory Exam
+
Coordination requirements

Set regulatory period

Findings (No.9.35)

Affected adm (No.9.36)

Set priority subject to Res.2 and No.9.53

Continue with the Presentation

Go Back To Page 72