NALSAR University of Law, Hyderabad, India.

M.A Space and Telecommunication Laws Classes

(Common session with advanced diploma GIS and remote sensing laws)

Issues in Satellite Communications

(International Telecommunication laws)

14/03/2022 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 Mr K Narayanan Former Director Satellite Communications Programme Office (SCPO) ISRO HQ Bangalore in the areas of Orbit-Spectrum, I take this opportunity to thank Mr K Narayanan.

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

- 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. Problems due to uncontrolled satellites / space debris.
- 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.)

- 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.)

- Compliance 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 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 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 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 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

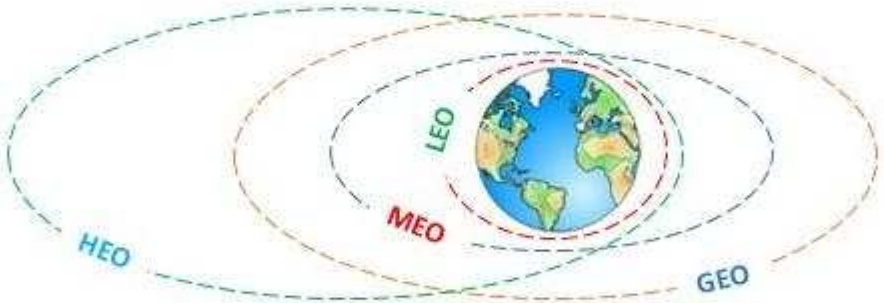
https://www.legalserviceindia.com/legal/article-3427-legal-regime-of-space-debris-and-legal-proposals-to-mitigate-the-negative-effects-of-space-debris.html

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 (37-45 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 (37-45 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

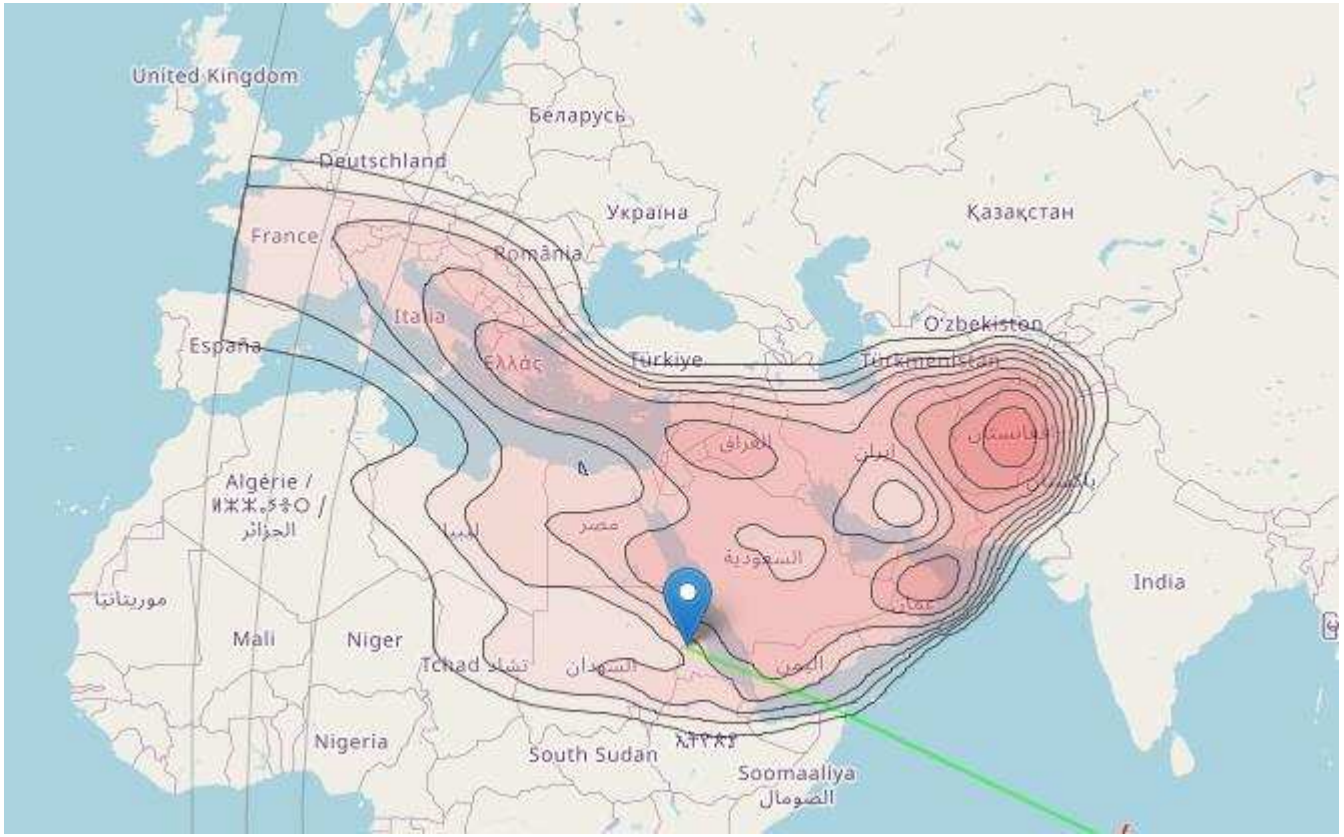
In these frequency Bands, Multiple Spot Beams are used in both GSO and Non GSO Satellites.

NATIONAL COVERAGE SATELLITE

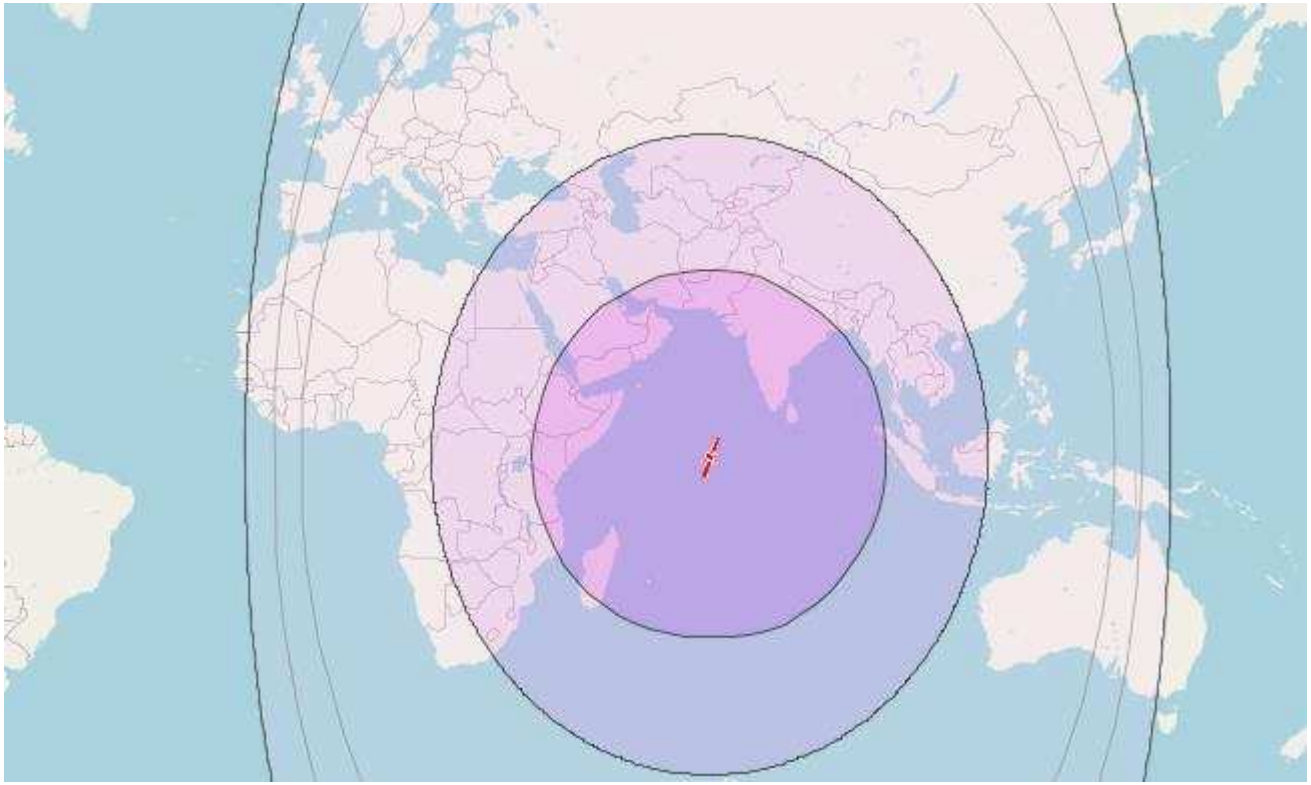
EXAMPLE INDIA

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.

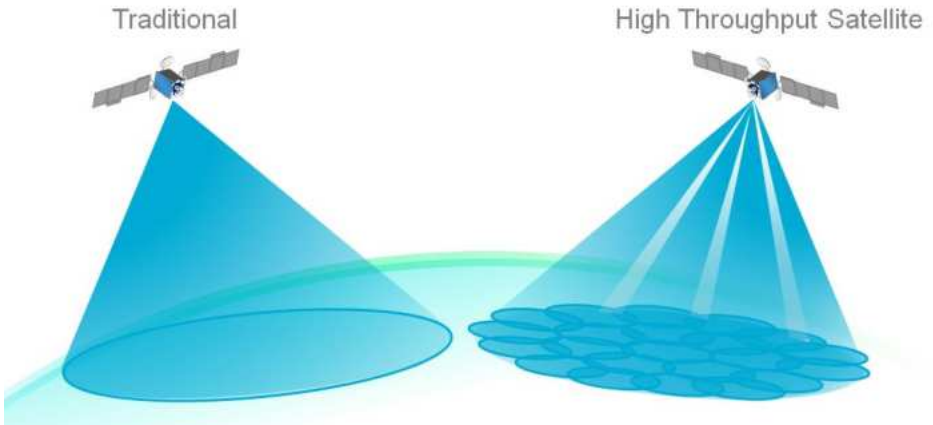
Typical Satellite Beam Foot Print Size

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

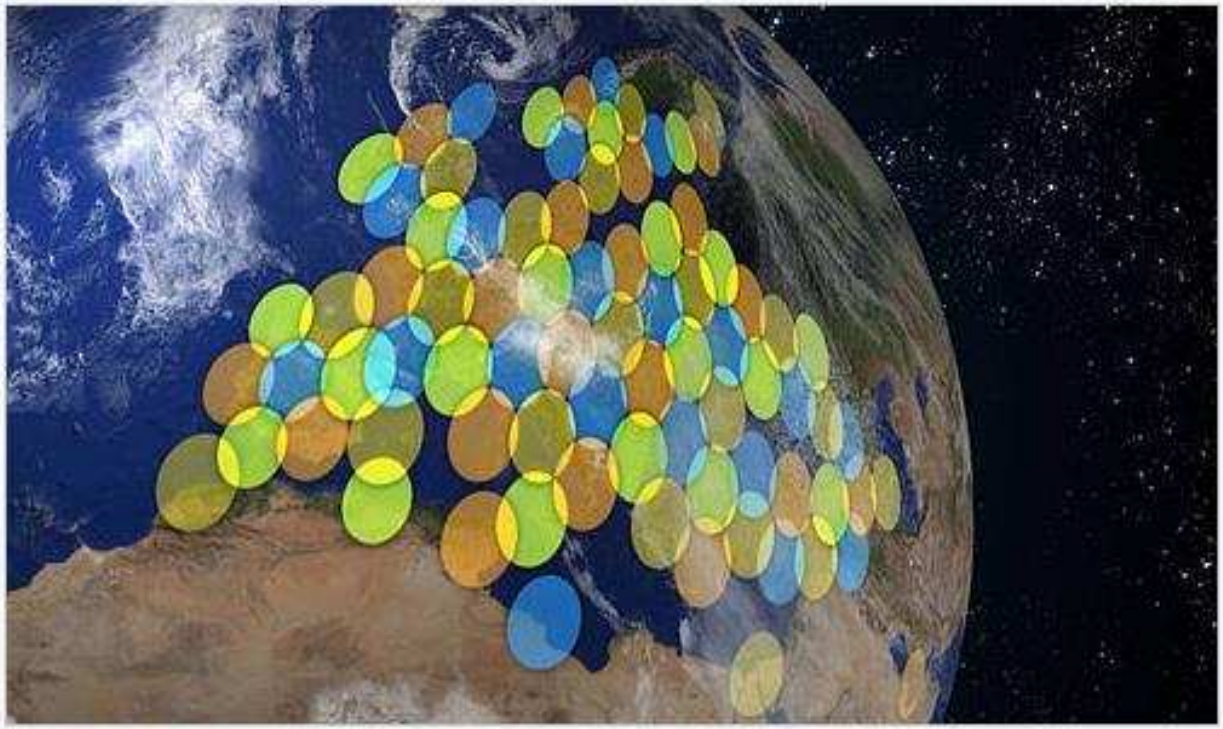
Similarly ISRO GSAT-20 has spot Beam Coverage over India

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

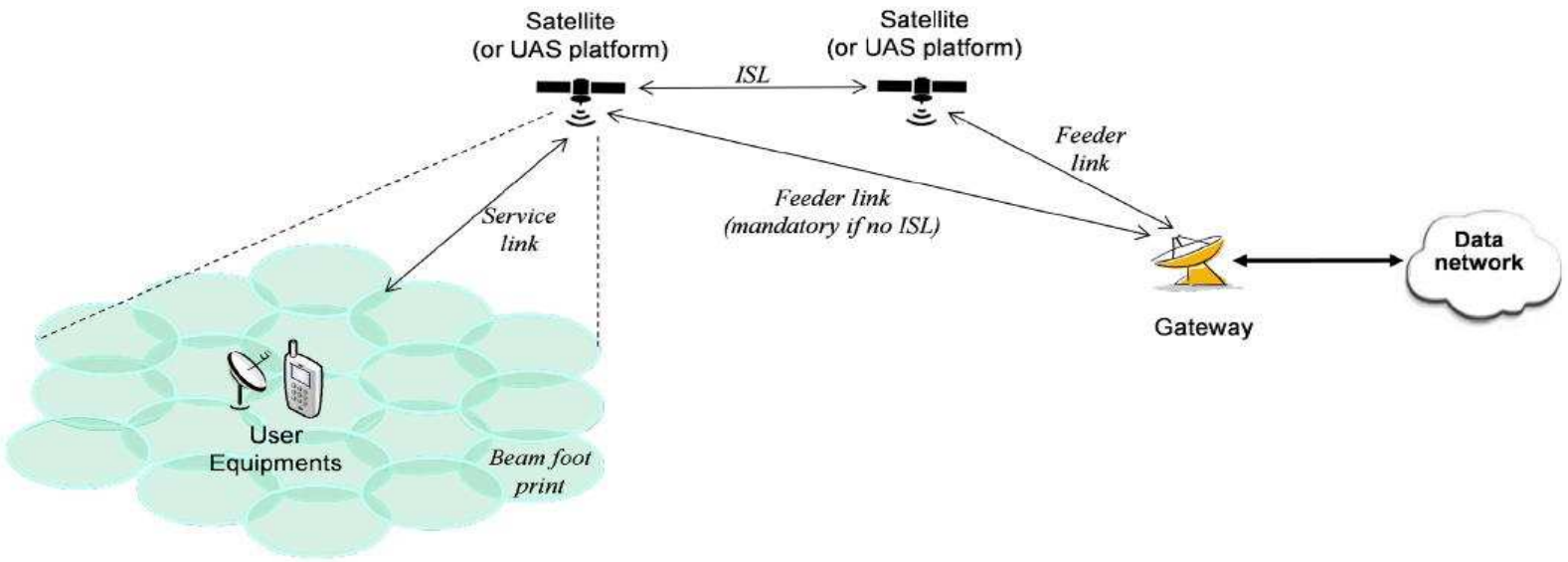
Traditionally Satellite Systems are Stand Alone Systems.

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)



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 service for internet connectivity services are more expensive as compared to terrestrial fibre networks.

Internet Connectivity Services

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)

Satellite based internet services are expensive

but Technology may bring down the price in future;

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:

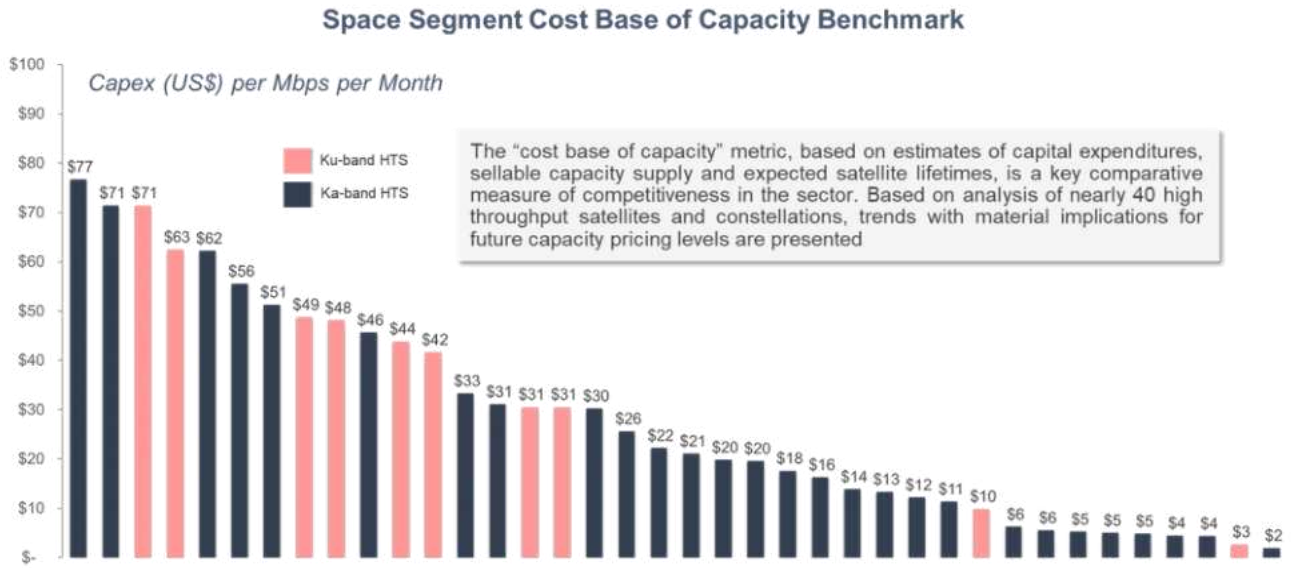
SpaceX / Starlink satellite internet price

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 capacity pricing declines slow, but price pressure expected to increase with new supply entering service in 2023

Seeing the on-going pricing disruption of successive generations of HTS,
With the scheduled 2021 launch of Viasat-3, it is estimated that the base cost will be just $5 per Mbps per month, when accounting for satellite, launch and ground segment CAPEX.
In comparison, Viasat-2, which launched in 2017, has a cost base roughly three times higher than Viasat-3.



Source: Euroconsult 2020 research "FSS Capacity Pricing Trends" https://www.geospatialworld.net/news/satellite-capacity-pricing-declines-slow-but-price-pressure-expected-to-increase-with-new-supply-entering-service-in-2023/

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

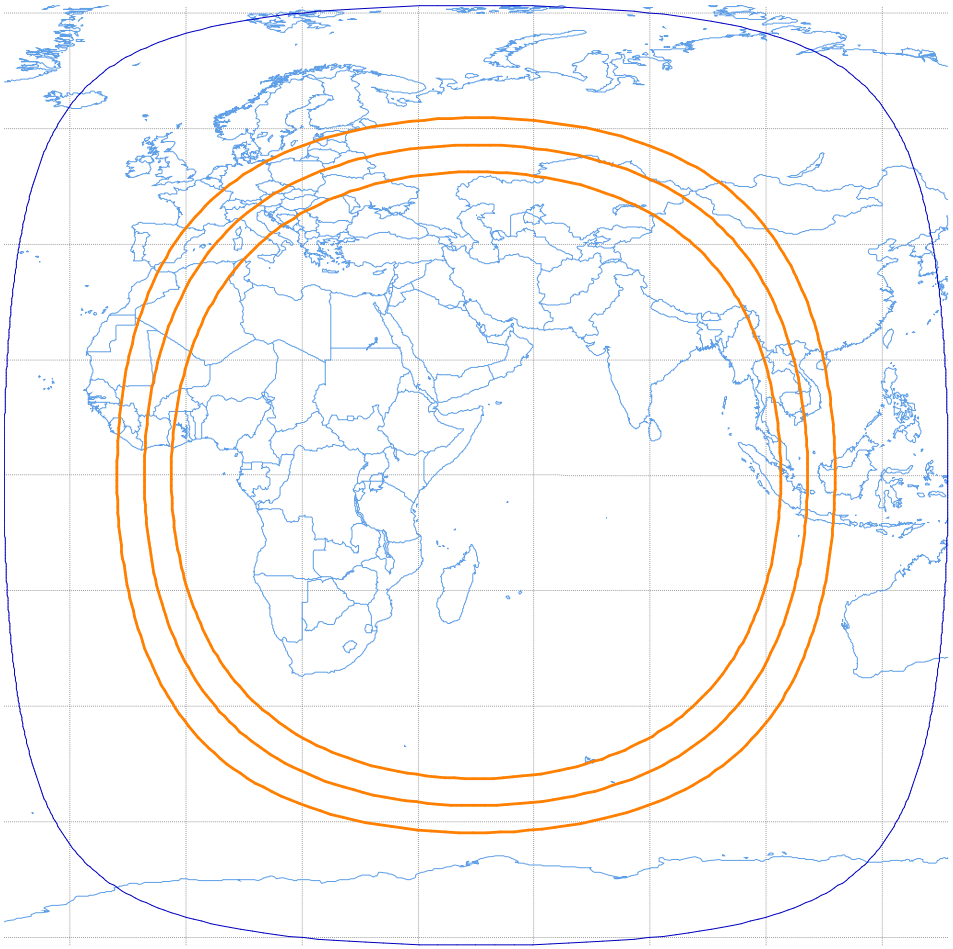
Example
Orbital Arc of Interest to Indian Sub Continent
50 E – 110 E

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

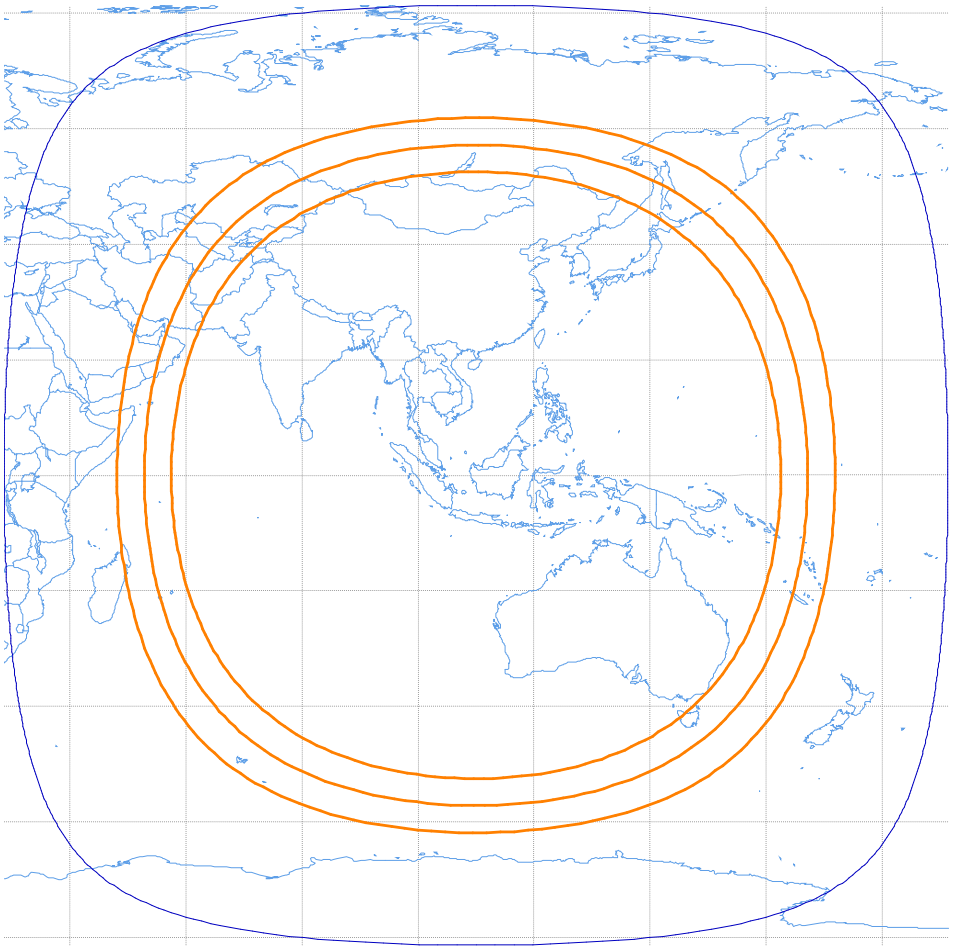
(Satellite Elevation Angle of about 30 Deg. or so is technically and operationally preferred)

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/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/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.)

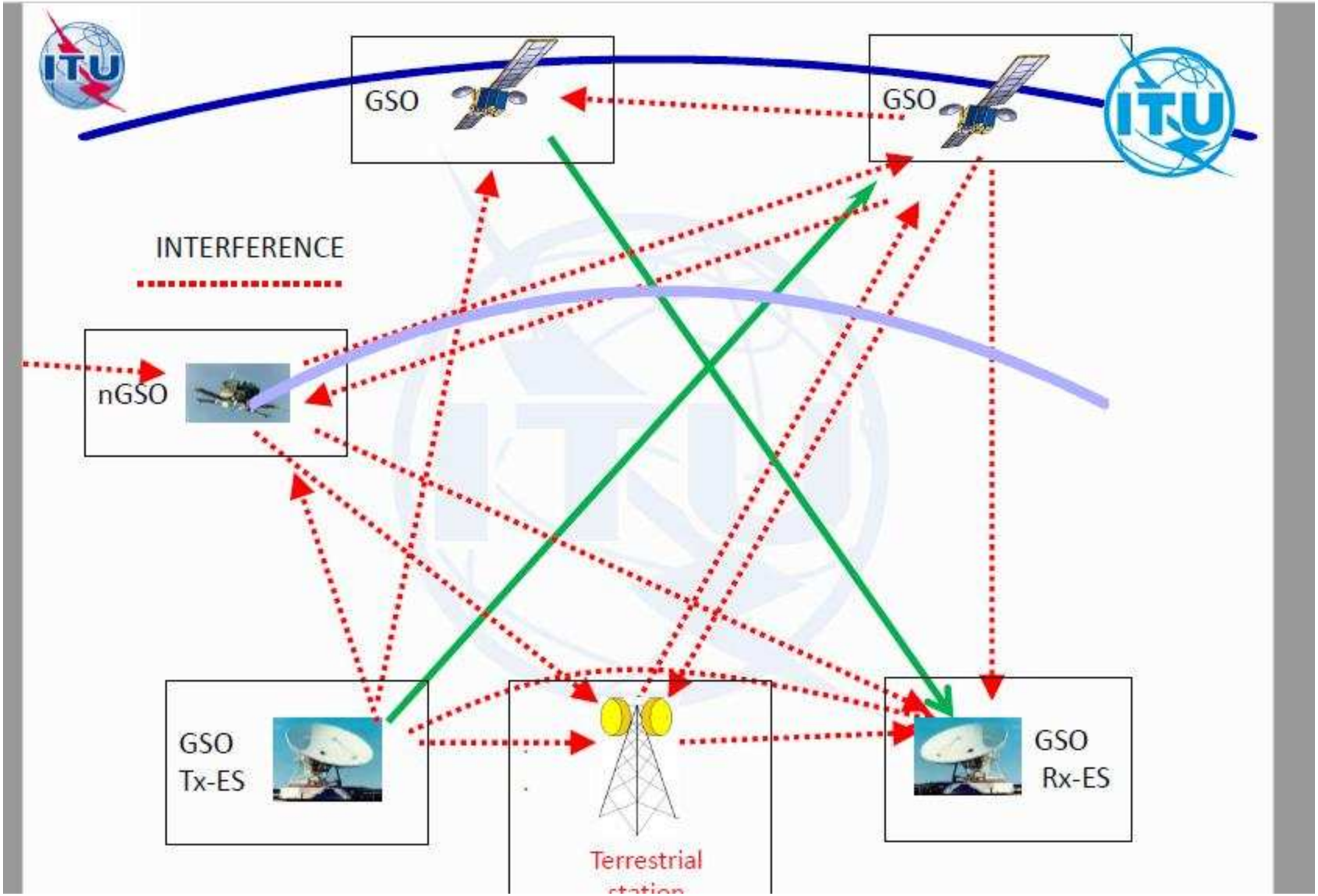
- Compliance with various ITU RR provisions and successful completion of International Coordination and Notification (i.e. Registration with ITU BR) of the intended Orbit=Spectrum parameters with ITU Radiocommunication Bureau (BR) are necessary for ensuring interference free operations.
- Only such Notified Communication Satellite Networks are internationally recognised and protected.
- Compliance with ITU RR provisions is normally 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)

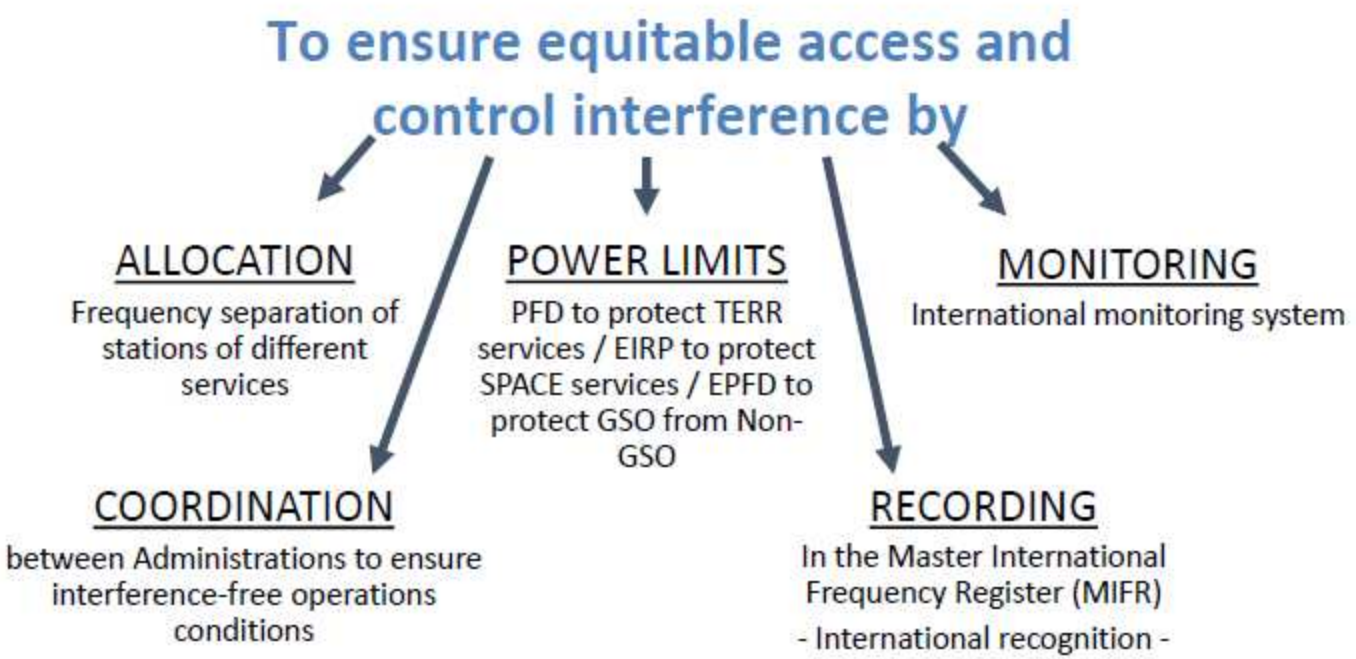
Certain Aspects Only

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)

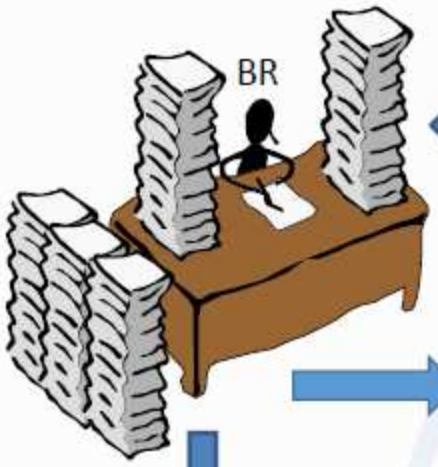
Cases	Provision
GSO to GSO	9.7, Art7 AP30/30A
Certain ES of GSO to NGSO	9.7A
NGSO to Certain ES of GSO	9.7B
BSS (GSO/NGSO) to Terrestrial Services	9.11, Res.539
NGSO to NGSO	9.11A/9.12
NGSO to GSO	9.11A/9.12A
GSO to NGSO	9.11A/9.13
NGSO/GSO to Terrestrial Services	9.11A/9.14
the requirement to seek the 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