Overview of DoS Sharing Studies between incumbent and Future users of 6 GHz Band

Dr. S. C. Bera
Group Director, SNSICG/SNPA,
Space Applications Centre, Ahmedabad

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Present/Planned Satellite Services in 6 GHz Spectrum

Summary of ISRO'S C-Band Satellites

Frequency Band (MHz)	Satellite (Operational/Planned)	No. of Transponders
5925 -6425*	GSAT-7/GSAT-10/GSAT-16 GSAT-17/GSAT-18/GSAT-30/ GSAT-7R/GSAT-7AR	111 (101+10)
6425- 6725	GSAT-7/GSAT-7R/ GSAT-17/GAGAN/IRNSS	23 (21+2)
6725- 7025	GSAT-12R/GSAT-14/GSAT-16/ GSAT-17/GSAT-18/GSAT-7B	61 (54+7)

* Commanding & Ranging for all satellites

Summary of Frequency Band for Co-existence Study

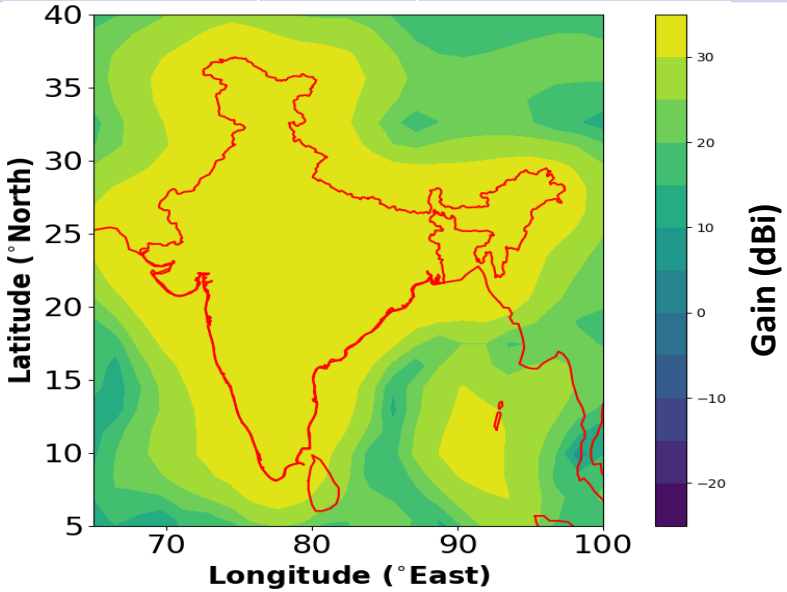
System	Interferer/Affected	Operating Frequency range
Terrestrial	Interference source	6.425 GHz-7.025 GHz (Uplink/Downlink)
Satellite	Affected system	6.425 GHz-7.025 GHz (Uplink)

Co-existence Between FSS & IMT

Simulation Parameters: FSS

Summary of Satellite Parameters

Sr. No.	Parameter	Unit	Value/Range
1	Interference scenario	---	Co-frequency, co-coverage (Indian Mainland)
2	Peak Antenna Gain	dBi	32
3	Satellite System Noise Temperature	K	650
4	Coverage/Service Area (Shaped)	-	Indian Mainland
5	Protection Criterion (ΔT/T)	dB	-12.2 (6%)
6	Orbital Location	°E	55, 83, and 129
7	WP-4A Liaison Statement Reference	#	Uplink Carrier 8



Representative Antenna Pattern

Peak Gain: 32 dBi

Summary of IMT Parameters

Sr. No.	Parameter	Assumptions/Data Source	Remarks
Estimating Number of Macro Base Stations			IMT Characteristics 5D/716 (Annex 4.4)-E
1	Ra and Rb Model	Different options as per WP-5D	
2	Base Station Density	Urban: 10 BSs/km^2 Suburban: 2.4 BSs/km^2 Rural: 0.006 BSs/km^2	
Base Stations Parameters			
3	Signal Bandwidth	100 MHz	
4	Loading Factor for BS	20 %	
5	Mode of operation	TDD [75% BS & 25% UE]	
6	Antenna Height	18m Urban, 20m Suburban	
7	Cell radius	0.3 km Urban, 0.6 km Suburban	
8	Antenna Type	Advanced Antenna System (AAS)	
9	Element Gain	5.5 dBi Urban, 6.4 dBi Suburban	
10	3 dB Beam-width	Urban: 90º for H, 90º for V, Suburban: 90º for H, 65º for V,	
11	Antenna Elements	16 x 8	
12	Simulation of antenna pattern	Average antenna pattern over azimuth for 1000 Monte-Carlo run (generation of beam towards users located randomly within the BS coverage)	
13	Peak EIRP	Urban: 67.6 dBm, Suburban: 68.5 dBm, [single element power: 22 dBm, output loss: 2 dB]	
14	Antenna Down-tilt	Urban 10° and Suburban 6°	

Simulation Parameters: IMT

Summary of IMT Parameters

Sr. No.	Parameter	Assumptions/Data Source	Remarks
UE Parameters			**IMT Characteristics 5D/716 (Annex 4.4)-E**
15	EIRP	Peak: 23 dBm, Average EIRP: 2 dBm (as per ITU-R M.2292)	
16	Polarization	Linear ±45º	
17	Antenna Gain	-4 dBi	
18	UE Height	1.5m	
Channel Parameters			
19	Path Loss Model	ITU-R P.619-5 (Gas + Cloud + Scintillation + Rain + Clutter loss)	

Summary of Ra/Rb Parameters – As per ITU WP-5D

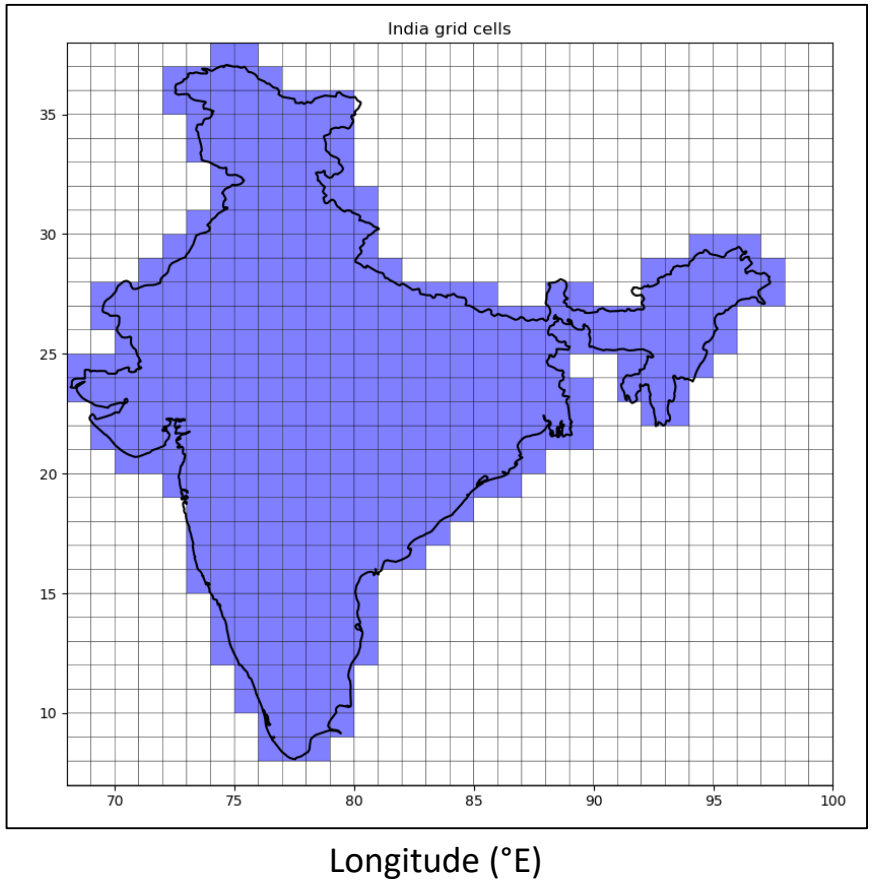
Options	Values of Ra and Rb (Urban)	Values of Ra and Rb (Suburban)
Case 1: (Ra1/Rb1)	Ra: 10% (area > 200 000 km^2) Rb: 1% (area > 1 000 000 km^2)	Ra: 5% (area > 200 000 km^2) Rb: 1% (area > 1 000 000 km2)
Case 2: (Ra1/Rb2)	Ra: 10% (area > 200 000 km^2) Rb: 5% (area < 3 500 000 km^2)	Ra: 5% (area > 200 000 km^2) Rb: 5% (area < 3 500 000 km^2)
Case 3: (Ra2/Rb1)	Ra: 45% Rb: 1% (area > 1 000 000 km^2)	Ra: 20% Rb: 1% (area > 1 000 000 km^2)
Case 4: (Ra2/Rb2)	Ra: 45% Rb: 5% (area < 3 500 000 km^2)	Ra: 20% Rb: 5% (area < 3 500 000 km^2)

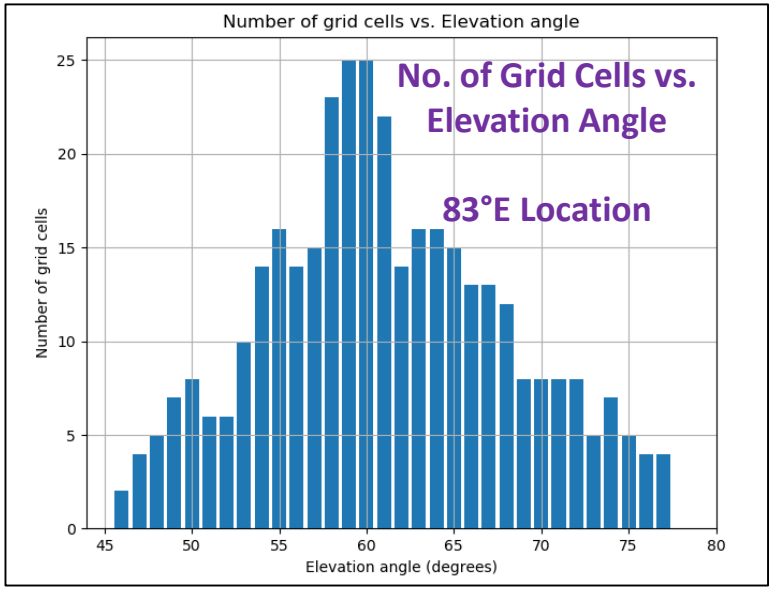
Simulation Parameters: Discussion Points

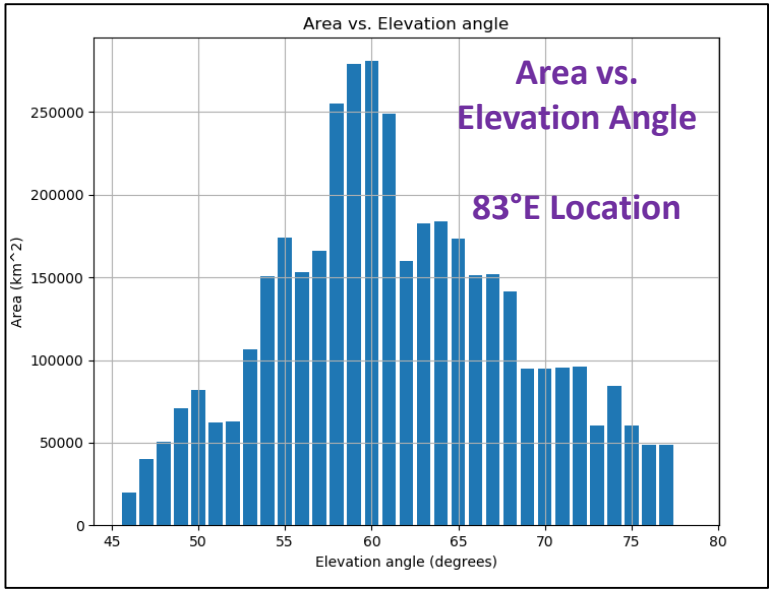
- *Ra, Rb combination for Indian IMT deployment*
- *Spatial distribution of IMT BS within India & Globally*
- *Modelling IMT BS gain towards FSS receiver*
- *FSS Uplink Protection Criteria and Apportionment Factor*
- *Deployment of IMT BS Outside India*
- *Interference from User Equipment*

Simulation Results

India Grid Cells – Aggregate Interference

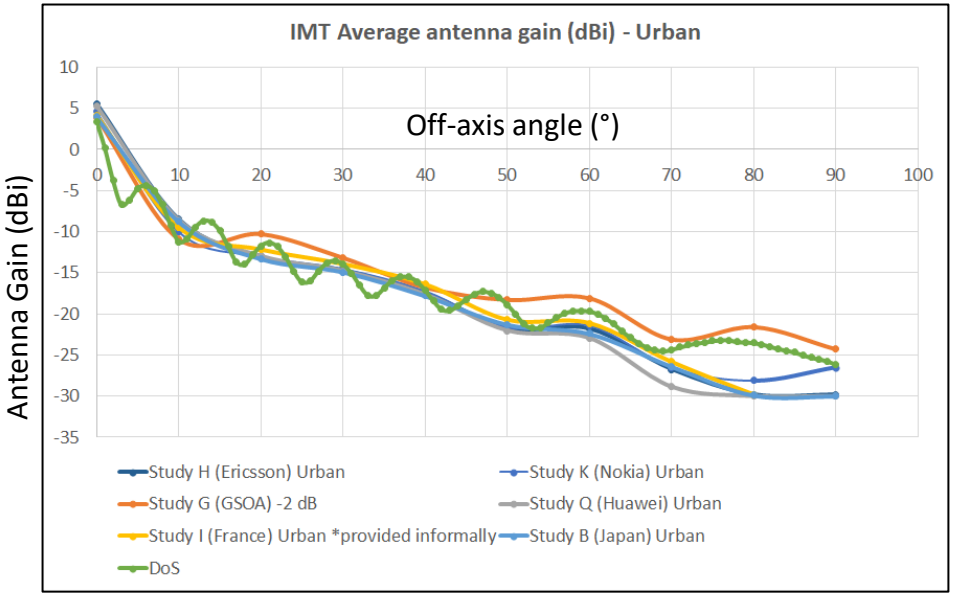




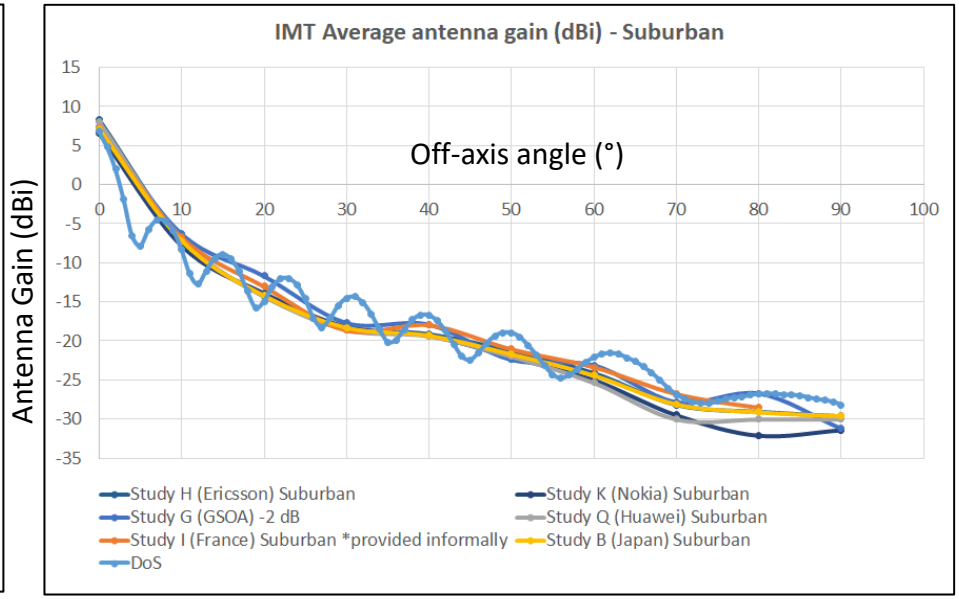


Simulation Results: IMT Average Antenna Pattern

Monte-Carlo Simulation Results – IMT BS Average Antenna Pattern



Simulated IMT BS averaged antenna pattern of Urban



Simulated IMT BS averaged antenna pattern of Suburban

Interference Analysis Summary

I/N values considering BS only for Ra/Rb Cases – Deployment in India

Satellite Location (°E)	Case Type	Urban (I/N) (dB)	Sub-urban (I/N) (dB)	Total I/N (dB)
55	Ra1/Rb1	-22.4	-33.0	-22.0
	Ra1/Rb2	-15.4	-26.0	-15.0
	Ra2/Rb1	-15.9	-26.5	-15.5
	Ra2/Rb2	**-8.9**	-20.0	**-8.6**
83	Ra1/Rb1	-23.8	-34.5	-23.4
	Ra1/Rb2	-16.8	-27.5	-16.4
	Ra2/Rb1	-17.3	-28.0	-16.9
	Ra2/Rb2	**-10.3**	-21.5	**-10.0**
129	Ra1/Rb1	-21.8	-31.3	-21.3
	Ra1/Rb2	-14.8	-24.3	-14.3
	Ra2/Rb1	-15.3	-24.8	-14.8
	Ra2/Rb2	**-8.3**	-18.3	**-7.9**

Protection Criteria: -12.2 dB (without apportionment factor)

DoS Views

Parameter	DoS Views
Ra & Rb Parameters for Country-Specific Study	• Considering the number of base stations for Ra-1 and Rb-1 (around 40000) and the base station density as defined by WP-5D, the area of India covered is < 0.05% (~1500 sq. km of 3.3 million sq. km). • DoS is of the opinion that present scenario may not be an accurate representation of future deployments of high capacity base stations. • Recent news articles show that in a span of less than a year, more than 80000 base stations were set-up just in one part of the country. This exceeds the total number of base stations as per Ra1/Rb1. • Considering Indian scenario, It is to be noted that the Rb2 values are actually very close to the actual built-up area of India as per contribution of DoS to WP-5D.

DoS Views ….

Parameter	DoS Views
IMT BS Distribution	• Emphasizing that this band will be used only for high density deployments, thus not considering the population distribution is not appropriate. • While initial studies have been carried out without any population distribution, actual interference scenario will be as per population only.
Protection Criteria	• In Ra1/Rb2 and Ra2/Rb1 case, there is very less margin with respect to the I/N criteria even without considering any apportionment factor or deployment outside of India (in Region-1 and Region-3). • In Ra2/Rb2 case, actually realistic representation of the Indian scenario, there is clear case of exceedance of the I/N criterion.

Based on the DoS study, IMT may impact 6GHz satellite services within India. However, co-existence studies between 6 GHz 5G IMT & Satellite services in India are still under progress.

Co-existence Between FSS & WLAN

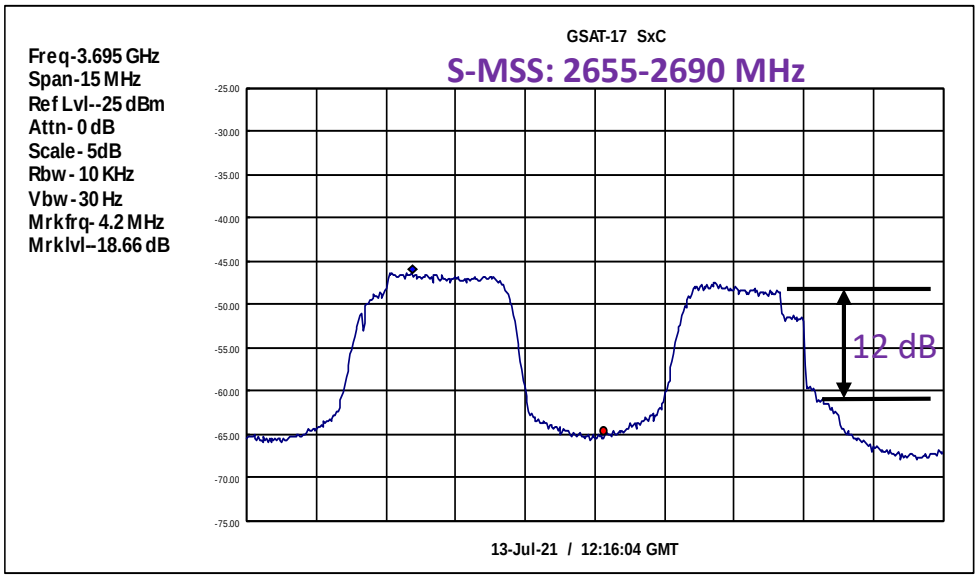
DoS Views on Co-existence between C-Band WLAN and Satellite Services in India

- Simulation parameters of WLAN services in India are under discussion to carry out co-existence study:
  - ✓ Population using WLAN services
  - ✓ Multiple devices per person
  - ✓ Link speed for high activity & low activity devices
  - ✓ Instantaneous number of devices in 6 GHz WLAN
  - ✓ Uplink / Downlink ratio
  - ✓ Percentage ratio of Indoor and Outdoor units
  - ✓ Constraints on Outdoor units
- It was agreed to carry out co-existence studies for Indoor WLAN units only as there is no control on Outdoor WLAN units.
- Co-existence study between 6 GHz WLAN & Satellite services in India are under progress.

Examples of Interference from Terrestrial Services to ISRO's Satellite Services

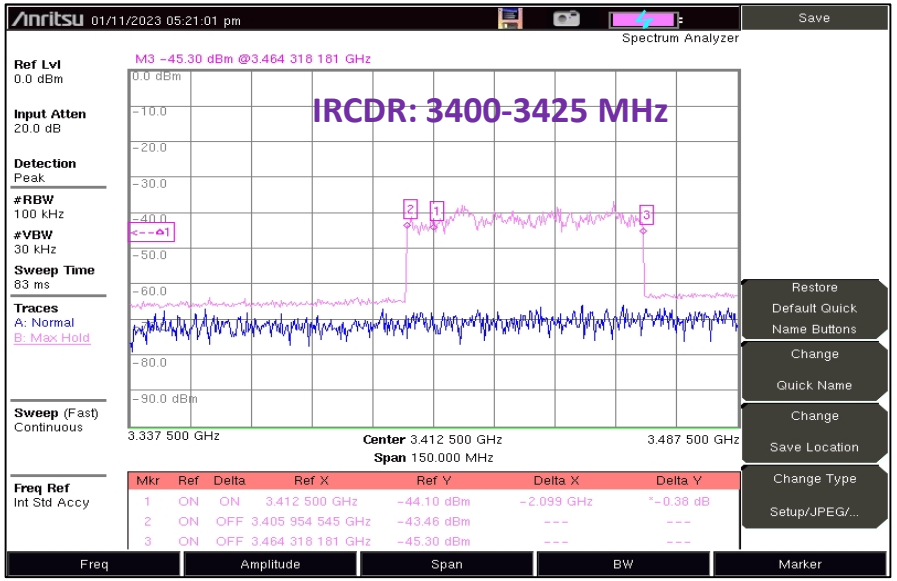
Examples of Interference in ISRO's Satellites

S-MSS Return Link interference from 4G-LTE



- ~12dB rise in the noise floor makes the transponder unusable.
- With certain mitigation measures to avoid interference from IMT outside India, ISRO will be able to provide satellite services with Spot beam configuration.

5G interference to IRCDR (Shillong)



- In-spite of recommendations based on coexistence study, significant interference observed.
- It is required to ensure compliance to the recommendation.

Currently, FSS services are predominantly used by Government Agencies and Broadcast users. Hence, it is prudent that enough caution be exercised in introduction of new services in 6 GHz which may significantly affect the incumbent satellite services.

Thank You