



Satellite technology roadmap – 28GHz (27.5-29.5GHz) band

ITU-APT Foundation of India

The 26-28 GHz India 5G Spectrum Workshop

Delhi, 27-28 September 2018



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Inmarsat use of frequencies

Inmarsat use of Spectrum

L band

User terminals: 1626.5-1660.5 MHz ↑, 1525-1559 MHz ↓

Legacy spectrum used by current Inmarsat fleet

Extended L-band:

User terminals: 1668-1675 MHz ↑, **1518 MHz-1525 MHz** ↓

C band

Gateways for L-band satellites operate in the bands **3550 – 3700 MHz** and 6425 – 6575 MHz through more than 20 Land Earth Stations

Ka band

Gateway ↑ : 27.5 – 30.0 GHz

Gateway ↓ : 17.7 – 20.2 GHz

User terminals ↑ : 29.0 – 30.0 GHz

User terminals ↓ : 19.2 – 20.2 GHz

Used by Inmarsat Global Express satellites

Q/V band

37.5-42.5 GHz ↓

47.2-50.2 GHz + 50.4-51.4 GHz ↑

- Planned for future satellites to free up Ka-band for user terminals
- Developmental payload on Alphasat

S band

Gateway ↑ : 27.5 – 29.5 GHz

Gateway ↓ : 17.7 – 19.7 GHz

User link ↑ 1980-2010MHz

User link ↓ : 2170-2200MHz

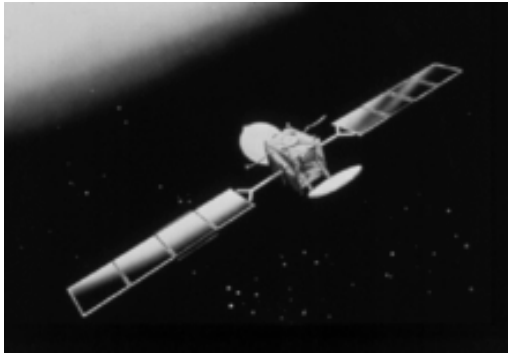
Used by Europasat



2

Satellite focus on 28 GHz band

HTS, NGSO, etc.



THE CONTINUED GROWTH OF SATELLITE INDUSTRY IN KA BAND

- Satellite systems (civil)
- Using Ka-band (27.5-30.0 GHz)

2015: 63 GSO & 2 NGSO

- Satellite systems (civil)
- Using Ka-band (27.5-30.0 GHz)

2020: >100 GSO & 4-5 NGSO

- A sustainable growth for both GSO & NGSO satellite systems

Future

ESSENTIAL TO MAINTAIN FSS ACCESS TO KA BAND

Importance of 28 GHz band for satellite

- Key uplink band for GEO and non-GEO satellite systems, including HTS systems
- 28 GHz band is defined as 27.5-29.5 GHz, globally allocated to the FSS (Fixed Satellite Service).
- Ka-band already used by many operational satellites: about 140 GSO satellites and two NGSO constellations.
- **Not included in WRC-19 Agenda Item 1.13**, and therefore is unlikely to be internationally harmonised
 - Europe is opposed to using this band for IMT
 - There is ample other spectrum being studied for 5G under WRC-19 Agenda Item 1.13
- WRC-19 **Agenda Item 1.5** is studying the use of the 28 GHz by Earth Stations in Motion (ESIM)

Satellites operating in Ka-band

| | |
|----|----------------|
| 1 | SES 15 |
| 2 | Galaxy 23 |
| 3 | Anik F3 |
| 4 | Spaceway 1 |
| 5 | ViaSat 1 |
| 6 | Anik F2 |
| 7 | Wildblue 1 |
| 8 | Echostar 17 |
| 9 | ACTS |
| 10 | AMC 15 |
| 11 | Spaceway 1 |
| 12 | Directv 15 |
| 13 | Directv 12 |
| 14 | Directv 10 |
| 15 | SDO |
| 16 | Directv 9S |
| 17 | Directv 8 |
| 18 | Directv 14 |
| 19 | Directv 11 |
| 20 | Spaceway 2 |
| 21 | Echostar 19 |
| 22 | Spaceway 3 |
| 23 | Echostar G1 |
| 24 | Galaxy 28 |
| 25 | Tupac Katari 1 |
| 26 | SES 2 |
| 27 | AMC 16 |
| 28 | Star One D1 |
| 29 | Nimiq 4 |
| 30 | Venesat 1 |

| | |
|----|--------------------|
| 31 | SGDC 1 |
| 32 | Viasat 2 |
| 33 | Astra 1H |
| 34 | Eutelsat 65 West A |
| 35 | Telstar 19V |
| 36 | Amazonas 3 |
| 37 | Amazonas 5 |
| 38 | Inmarsat-5F2 |
| 39 | Intelsat 29E |
| 40 | Intelsat 32e |
| 41 | Hispasat 36W-1 |
| 42 | Skynet 4F |
| 43 | Hylas 1 |
| 44 | Hylas 4 |
| 45 | Hispasat 1F |
| 46 | Hispasat 1E |
| 47 | XTAR-LANT |
| 48 | Nimiq 2 |
| 49 | AlComSat 1 |
| 50 | Al Yah 3 |
| 51 | Intelsat 37e |
| 52 | Telstar 12V |
| 53 | Cosmos 2473 |
| 54 | Nilesat 201 |
| 55 | Syracuse 3B |
| 56 | Amos 3 |
| 57 | Amos 7 |
| 58 | Skynet 4E |
| 59 | Thor 7 |
| 60 | Eutelsat 3B |

| | |
|----|--------------------|
| 61 | Astra 4A |
| 62 | Eutelsat 7A |
| 63 | Eutelsat 7B |
| 64 | Eutelsat KA-SAT 9A |
| 65 | Inmarsat 5F4 |
| 66 | Sicral 1B |
| 67 | Eutelsat 16A |
| 68 | Sicral 1A |
| 69 | Astra 1L |
| 70 | Arabsat 5C |
| 71 | GovSat-1 |
| 72 | SES 16 |
| 73 | Astra 3B |
| 74 | Eutelsat 25B B50 |
| 75 | Badr 5 |
| 76 | Badr 7 |
| 77 | Astra 2F |
| 78 | Astra 2E |
| 79 | Astra 2G |
| 80 | Hylas 2 |
| 81 | Astra 5B |
| 82 | Skynet 4C |
| 83 | Express AMU1 |
| 84 | Athena Fidus |
| 85 | HellasSat 3 |
| 86 | Turksat 4A |
| 87 | Nigcomsat 1R |
| 88 | Cosmos 2520 |
| 89 | Syracuse 3A |
| 90 | Yahsat 1B |

| | |
|-----|--------------|
| 91 | GSAT 19 B67 |
| 92 | Turksat 4B |
| 93 | Yahlive |
| 94 | Express AM6 |
| 95 | Intelsat 33e |
| 96 | Inmarsat-5F1 |
| 97 | Amos 4 |
| 98 | Intelsat 20 |
| 99 | UHF 10 |
| 100 | GSAT 14 |
| 101 | ABS-2 |
| 102 | DFH 76 |
| 103 | Cosmos 2520 |
| 104 | Chinasat 1C |
| 105 | TDRS 8 |
| 106 | NSS 6 |
| 107 | SES 8 |
| 108 | Luch 5V |
| 109 | Chinasat 2A |
| 110 | Chinasat 2C |
| 111 | Asiasat 7 |
| 112 | Gaofen 4 |
| 113 | DFH 165 |
| 114 | Chinasat 16 |
| 115 | Koreasat 5A |
| 116 | Koreasat 5 |
| 117 | Koreasat 7 |
| 118 | ABS-7 |
| 119 | Thaicom 4 |
| 120 | Asiasat 9 |

| | |
|-----|-------------------|
| 121 | QZSS 3 |
| 122 | Cosmos 2526 |
| 123 | COMS 1 |
| 124 | Chinasat 1A |
| 125 | APSTAR 6C |
| 126 | QZSS 1 |
| 127 | Express AM5 |
| 128 | NBN-Co 1A |
| 129 | Kizuna |
| 130 | NBN-Co 1B |
| 131 | Mtsat 2 |
| 132 | Jcsat 16 |
| 133 | DFH 139 |
| 134 | Optus C1 |
| 135 | Superbird B2+B111 |
| 136 | Superbird B3 |
| 137 | JCSat 16 |
| 138 | Inmarsat-5F3 |

Importance of 28 GHz band for satellite High Density Fixed Satellite Service use – i.e. ubiquitous VSATs

5.516B The following bands are identified for use by high-density applications in the fixed-satellite service:

17.3-17.7 GHz (space-to-Earth) in Region 1,

18.3-19.3 GHz (space-to-Earth) in Region 2,

.....

and

27.5-27.82 GHz (Earth-to-space) in Region 1,

28.35-28.45 GHz (Earth-to-space) in Region 2,

28.45-28.94 GHz (Earth-to-space) in all Regions,

28.94-29.1 GHz (Earth-to-space) in Region 2 and 3,

29.25-29.46 GHz (Earth-to-space) in Region 2,

29.46-30 GHz (Earth-to-space) in all Regions,

Importance of 28 GHz band for satellite FSS (Fixed Satellite Service) gateways

- The 27.5-29.5 GHz band is key for domestic gateways for (but not only) Fixed Satellite Systems with payloads in Ka-band
- Due to capacity requirements, the entire band is normally needed for gateway use.
- A domestic gateway is a regulatory requirement in India.
- **It is essential that FSS gateway operation in the 28GHz band will not be constrained by IMT deployment.**



3

WRC-19 A.I. 1.5 - ESIM in 27.5-29.5GHz

ESIMs (Earth Stations in Motion)

People want to use these..



anytime, anywhere!

ESIMs operate in Fixed-Satellite Service (FSS) networks

User Terminals with small directional antennas for the provision of broadband communication services.

May be mounted on aircraft, ships, land vehicles & platforms...



ESIMs expand the traditional FSS and MSS type applications providing truly broadband services to mobile platforms

ESIMs at WRC-19 – A.I. 1.5

(17.7-19.7 / 27.5-29.5GHz)

WRC-15 already adopted Resolution 156 for ESIM in 29.5-30.0GHz and 19.7-20.2GHz

A.I. 1.5 - Resolution 158 (WRC-15) resolves to invite ITU-R

1. to study the technical and operational characteristics and user requirements of ESIM (GSO FSS) in the frequency bands 17.7-19.7 GHz and **27.5-29.5 GHz** and **the requirement for flexible use of spectrum** to provide ESIM services
2. To study **sharing and compatibility** between ESIM and current and planned stations of existing services allocated in the bands;
3. To develop **technical conditions and regulatory provisions for ESIM operation.**

Studies within ITU-R heading toward a solution via a Resolution, **with regulations to address protection of terrestrial services**

WRC-19 Agenda Item 1.5 - Resolution 158 (WRC-15)

Resolves 1: flexible use of spectrum

- Maritime ESIM and Aeronautical ESIM that operate in accordance with agreed ITU constraints, e.g., minimum distance from shore for Maritime ESIM and a pfd mask for Aeronautical ESIM, should be able to operate anywhere in the spectrum as terrestrial services will be protected
- Land ESIM, as well as Maritime ESIM and Aeronautical ESIM wishing to operate beyond the agreed ITU constraints, will be subject to agreements with individual administrations, which may constrain ESIM operations to portions of the band (which may vary nationally or regionally)
- The WRC should provide for ESIM throughout Ka-band to afford flexibility and ensure that sufficient spectrum will be available for ESIM operations on a global basis
- *Further information in: Section 2.2 of WP4A preliminary draft new Report ITU-R S.[AGENDA ITEM 1.5]*

WRC-19 Agenda Item 1.5 - Resolution 158 (WRC-15)

Resolves 2: Sharing and compatibility studies in 27.5-29.5 GHz

Services to which the band is already allocated will be protected from transmitting ESIM in the 27.5-29.5GHz band.

- *Further information in: Section 4 of WP4A preliminary draft new Report ITU-R S.[AGENDA ITEM 1.5] as well as PDNRs S./M.[ESIM-MS], S./F.[ESIM-FS]*

| Service | Current Status in WP4A |
|---|---|
| Fixed and Mobile Service in 27.5-29.5GHz band | Aeronautical-ESIM: terrestrial systems, <u>including mobile</u>, can be protected if a Power Flux Density mask is met on the ground. PFD levels have been successfully used in CEPT since 2013. Similar solution for Aircraft Earth Station (AES) in Ku-band (REC ITU-R M.1643). |
| | Maritime-ESIM: terrestrial systems, <u>including mobile</u>, can be protected if a distance from the shore of any administration is respected. Similar solution in REC ITU-R SF.1650-1 and Res. 902 (WRC-13) for Earth Stations on Vessels (ESVs) in C and Ku-band. SF.1650-1 methodology indicate distances between 60-70 km for M-ESIM |
| | L(and)-ESIM: operation can be coordinated with neighbouring countries via bi- or multilateral negotiations. |

WRC-19 Agenda Item 1.5 - Resolution 158 (WRC-15)

Resolve 3: Technical and regulatory conditions for ESIM operation

- **Agreement in WP4A to solve AI 1.5 by way of a new Resolution at WRC-19**, which also utilises Resolution 156 (WRC-15) text on ESIM operation in 29.5-30 GHz and 19.7-20.2 GHz.
- Full text of the Example Resolution for WRC-19 is provided as an Attachment to Draft CPM text developed in WP4A



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Other bands under consideration for 5G in India

From the report of the 5G High Level Forum

Announce Tier - **3300-3600 MHz**: new gateway operation in part of the band should still be allowed on a coordinated basis (e.g. in remote areas)

Identify Tier:

- **1427-1518 MHz**: Protection would be required for incumbent Mobile Satellite Service Earth Stations receivers in the adjacent bands (1.518-1.559GHz), providing also essential safety and security services (i.e. GMDSS and GADSS – Global Marine/Aeronautical Distress Safety System). Poor potential for global 5G harmonisation as there are incumbent military systems in several countries.
- **29.5-30GHz** exclusive FSS primary allocation. Only secondary allocation to terrestrial in a few countries via RR No. 5.452. Heavily used for FSS, including ESIM, on global basis.
- **30-31GHz**: Military use in several countries. Also harmonised NATO band.
- **37.5-40.5GHz**: Very much needed for future expansion by the satellite industry. Inmarsat advises against identification for IMT. It is also noted that 40-40.5 GHz are the only 500 MHz in the range globally identified for HDFSS.



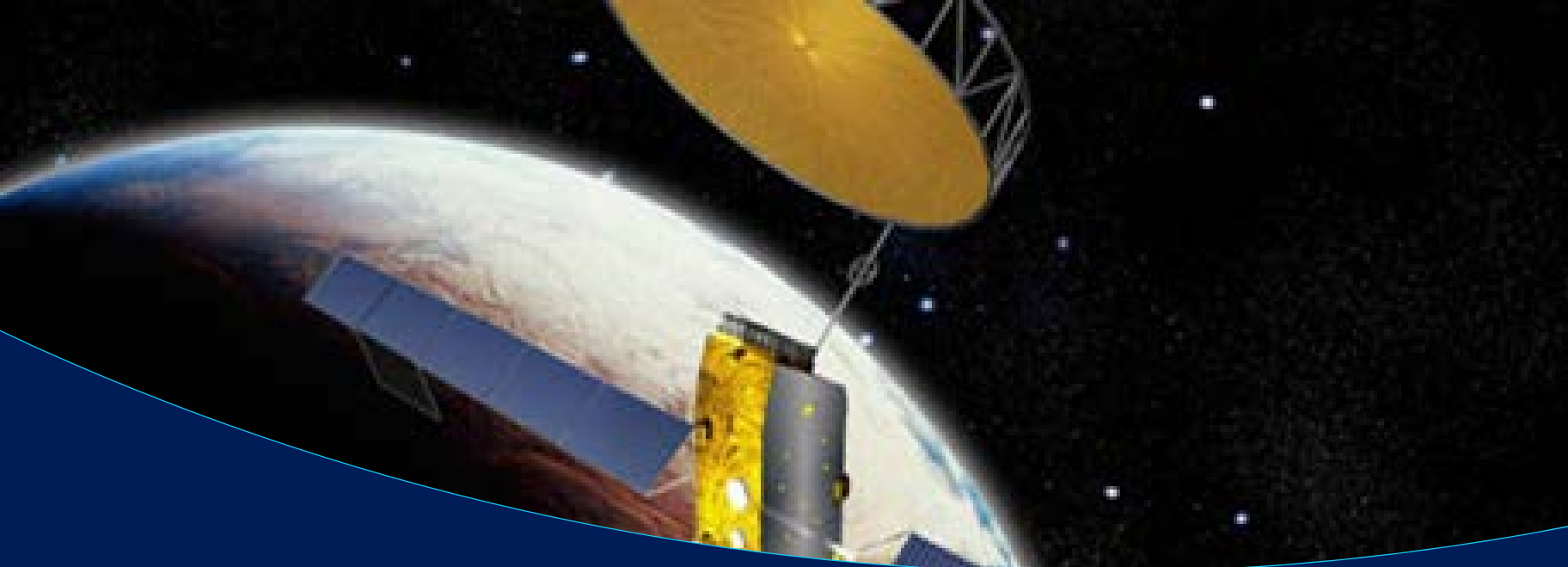
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Summary

Summary

With full appreciation for India 5G vision and relevance, the interested stakeholders are respectfully invited to consider the following

- **Satellite use of the 28 GHz band continue to grow:** many satellites, both GEO and non-GEO already operational in the band and more planned for the near future
- **Fixed Satellite Service gateway operation in the 28GHz band not to be constrained**
- In addition to the wide variety of conventional fixed uses of the band, the use of Earth Stations in Motion (ESIM) is growing rapidly (WRC-19 A.I. 1.5). **ESIM operation will protect terrestrial systems in the 28GHz band.**
- All of this helps to explain why the 28 GHz band was not identified for possible use by IMT under WRC-19 Agenda item 1.13
- **Overall, the 28GHz band is a poor candidate for global harmonisation/economy of scale. Use by 5G on a national basis will disrupt global harmonisation for satellite use.**
- **The 26GHz (24.25-27.5 GHz) band is an excellent alternative to the 28 GHz one, with much better chances of global harmonisation.**



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