

1.0 INTRODUCTION & SCOPE

- 1.1 This document contains the Mandatory Technical Requirements and Operational Requirements for all Non-Geostationary satellite orbit (NGSO) based communication networks providing Fixed Satellite Services (FSS) [or Broadcast Satellite Services (BSS)] in Ku and Ka band. The mandatory Interface Requirements contained in this document are technical requirements only; while the regulatory & legal requirements are specified in the License conditions. Necessary clearances shall have to be taken from Government of India, including DoT, TEC, DoS, WPC, NOCC, DGCA before commencing operations.
- 1.2 The document also contains the satellite technical parameters for link calculations and the link budget format.
- 1.3 Satellite networks are expected to be used for Telecommunication and Broadcasting services including but not limited to two-way multimedia applications, Intermediate Data Rate (IDR) channels, digital MCPC, closed user group (CUG) digital voice telephony, digital SCPC, video conferencing, Digital Satellite News Gathering (DSNG) with acknowledgement, Direct-To-Home (DTH) television with/without return channel, digital cinema, Digital Video Broadcast (DVB) with RCS, HD TV, 3D TV, satellite radio, digital audio broadcast, Tele-education, Tele-medicine, Tele-agriculture etc. The technical requirements are necessary for meeting international regulatory requirements and optimizing the network resources.

[Editor's Note: Stakeholders to provide input if NGSO systems are to be used for BSS services too. If yes, relevant inputs may be provided in subsequent sections of the document for BSS

IAFI COMMENTS – WE DO NOT EXPECT THAT NGSO WILL BE USED FOR BSS

2.0 APPLICABLE DOCUMENTS

2.1 ITU Radio Regulations

- 2.1.1 ITU-R Radio Regulations- Article 21 “Terrestrial and space services sharing frequency bands above 1 GHz”
- 2.1.2 ITU-R Radio Regulations- Article 22 “Space Services”

2.2 ITU Recommendations and Reports

- 2.2.1 ITU-R Recommendation S.1503 (Functional description to be used in developing software tools for determining conformity of non-geostationary-

satellite orbit fixed-satellite service systems or networks with limits contained in Article 22 of the Radio Regulations).

2.2.2 ITU-R Recommendation S.672-4 (Satellite antenna radiation pattern for use as a design objective in the fixed-satellite service employing geostationary satellites)

(IAFI Comment – Please add Report ITU-R S.2261)

2.2.3 ITU-R Report S.2261 (Technical and operational requirements for earth stations on mobile platforms operating in non-GSO FSS systems in the frequency bands from 17.3 to 19.3, 19.7 to 20.2, 27 to 29.1 and from 29.5 to 30.0 GHz)

2.3 Other Standards

2.3.1 (Draft) ETSI EN 303 980 “Satellite Earth Stations and Systems (SES); Fixed and in-motion Earth Stations communicating with non-geostationary satellite systems (NEST) in the 11 GHz to 14 GHz frequency bands; Harmonised Standard for access to radio spectrum”

2.3.2 ETSI EN 303 979 “Satellite Earth Stations and Systems (SES); Harmonised Standard for Earth Stations on Mobile Platforms (ESOMP) transmitting towards satellites in non-geostationary orbit, operating in the 27,5 GHz to 29,1 GHz and 29,5 GHz to 30,0 GHz frequency bands covering the essential requirements of article 3.2 of the Directive 2014/53/EU”

2.3.3 ETSI EN 303 699 “Satellite Earth Stations and Systems (SES); Fixed earth stations communicating with non-geostationary satellite systems in the 20 GHz and 30 GHz FSS bands; Harmonised Standard for access to radio spectrum”

Comments: This is now a published standard (i.e. not a draft)

https://www.etsi.org/deliver/etsi_en/303600_303699/303699/01.01.01_60/en_303699_v010101p.pdf

3.0 Definitions

- i. **Earth Station in Motion (ESIM):** Earth Station designed to operate for both in-motion and stationary operations. ESIM operates in-motion on various platforms such as trains, maritime vessels, aircraft and other vehicles. (IAFI Comments: This is not a part of the ESIM definition. Furthermore, any wireless link may be subject to occasional disturbance and interruption)
- ii. **EIRP_{Aggregate}:** sum of the EIRP (Watts) within the nominated bandwidth of the ESOMP network.
- iii. **EIRP_{max}:** maximum EIRP capability of the earth station as declared by the manufacturer/operator.
- iv. **equivalent power flux density:** The sum of the power flux densities produced at a geostationary-orbit receive earth or space station on the Earth’s surface or in the geostationary orbit, as appropriate, by all the transmit stations within a non-geostationary-orbit Fixed-Satellite Service system, taking into account the off-axis discrimination of a reference receiving antenna assumed to be pointing in its nominal direction.
- v. **Network Control and Monitoring Center (NCMC):** NCMC is a facility that has the capability to remotely control earth stations and/or space stations operating as part of a satellite network or system.

4.0 TYPES of NETWORKS

Satellite Network considered in this standard are broadly classified into telecom networks and broadcasting networks. The mandatory technical requirements specified in the subsequent sections mainly include frequency of operation, epfd values, spurious emission limits and other parameters relevant to network link engineering. IAFI Comments: Reference to Broadcasting from this section could be deleted as broadcasting is not relevant for NGSO

4.1 TELECOM NETWORK

A network which employs two-way communication and may also include one-way communication is a telecom network. Telecom networks are further classified into CUG networks, transmission networks and access networks.

4.1.1 CUG VSAT NETWORKS

The CUG VSAT networks are used to provide data connectivity between various sites scattered within territorial boundary of India using VSATs. The users of the service should belong to a Closed User Group (CUG). However, the VSAT licensee after obtaining ISP license may use same Hub station and VSAT (remote station) to provide Internet service directly to the subscribers, and in this case VSAT (remote station) may be used as a distribution point to provide Internet service to multiple independent subscribers or IoT/M2M devices. This network can operate in Star, Mesh, or Hybrid configurations.

4.1.1.1 STAR CONFIGURATION

In star type satellite network configuration, earth stations (VSAT) communicate via Hub station or central station..(IAFI Comment: Why this restriction? It limits the configuration to star only which should not be mandatory)

- a. For Remote VSATs (Static terminals): - Multiple carriers will be allowed for transmission from remote VSAT terminal (i.e. inbound data at Hub).
- b. For ESIM terminals (“Communication On the Move” and “Communication On the Pause”): - Only one carrier will be allowed for transmission from remote VSAT terminal (i.e. inbound data to Hub).
- c. For Hub Station: - Multiple carriers will be allowed for transmission from Hub station (i.e. outbound data from hub).

IAFI Comments: Limitations proposed in this section are not required and should not be mandatory)

4.1.1.2 MESH CONFIGURATION

Mesh type is called point-to-point configurations. In this mesh type network configuration, earth stations communicate directly via satellite. Multiple carriers will be allowed for transmission between VSATs.

4.1.1.3 HYBRID CONFIGURATION

The Hybrid Configuration is a combination of star and Mesh configuration. The requirements for mesh configuration shall be applicable for VSATs having mesh connectivity and star configuration for star connectivity. For the terminals having both configurations, requirement of mesh connectivity shall be applicable.

4.1.2 TRANSMISSION NETWORK

This network basically consists of connectivity between two nodes of a telecom service provider with no end-user connectivity.

4.1.3 ACCESS NETWORK

This network shall provide access only to end user.

IAFI Note: Section 4.2 could be deleted as it is confirmed that broadcasting is not relevant for NGSO

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5.0 MANDATORY TECHNICAL REQUIREMENTS

5.1 FREQUENCY BANDS OF OPERATION

The equipment shall operate in the following sets of frequency bands. Specific frequency band(s) may be indicated in the License agreement.

Table I: Frequency Bands permitted for NGSO systems

Frequency band	Space to Earth (GHz)	Earth to Space (GHz)	Service
Ku band	10.7-12.75	12.75-13.25	FSS
		13.75-14.0	
		14.0-14.5	
		14.5-14.8	
		17.3-18.1	
Ka Band	17.7-21.2	27-31	FSS

NOTE: - All the frequency bands mentioned in the table above, along with their associated services/application, shall be as per the extant National Frequency Allocation Plan.

[Editor's Note: Stakeholders to provide inputs on the frequency bands (clause 5.1) to be utilized for NGSO systems]

5.2 EPFD LIMITS- For protection of Geostationary Orbit Systems

5.2.1 An NGSO system operator must not cause unacceptable interference to, or claim protection from, a GSO FSS or GSO BSS network. Accordingly, it must comply with the relevant epfd limits specified in Article 22 of the Radio Regulations (reproduced below).

A) EPFD limits applicable to NGSO systems' Earth Stations- for protection of GSO space stations

5.2.2 The equivalent power flux density, $epfd_{\uparrow}$, produced at any point in the geostationary orbit by emissions from all the earth stations in an NGSO system, shall be determined by the Network Control and Management

Centre (NCCM) to ensure compliance with the epfd \uparrow limit, as specified in No. 22.5D of ITU Radio Regulations Article 22.

5.2.3 The applicable epfd \uparrow limits are produced below in Table II for information:

Table II: Limits to the epfd \uparrow radiated by non-geostationary-satellite systems

Frequency Band	epfd \uparrow (dB(W/m ²))	Percentage of time epfd \uparrow level may not be exceeded	Reference bandwidth (kHz)	Reference antenna beamwidth and reference radiation pattern
12.5-12.75 GHz 12.75-13.25 GHz 13.75-14.5 GHz	-160	100	40	4° Recommendation ITU-R S.672-4, Ls= -20
17.3-18.1 GHz	-160	100	40	4° Recommendation ITU-R S.672-4, Ls = -20
27.5-28.6 GHz	-162	100	40	1.55° Recommendation ITU-R S.672-4, Ls = -10
29.5-30 GHz	-162	100	40	1.55° Recommendation ITU-R S.672-4, Ls = -10

5.2.4 The epfd \uparrow limits, specified above, relate to equivalent power flux density, for all conditions and all modulations, which would be obtained under free-space propagation conditions, into a reference antenna and in reference bandwidth, as specified in Table II, for all pointing directions towards the Earth's surface visible from any given location in the geostationary satellite orbit.

5.2.5 The NGSO system operator shall declare the method and accuracy of uplink power control, if any, and demonstrate the capability of Network Control and Management Centre (NCCM) to ensure compliance with the epfd \uparrow limits specified above.

B) i. EPFD limits applicable to NGSO Space Stations- for protection of GSO space stations

5.2.6 The equivalent power flux density, epfd_{is}, produced at any point in the geostationary orbit by emissions from all space stations in an NGSO system, including emissions from a reflecting satellite, for all conditions and for all

modulation methods of modulation, shall comply with $epfd_{is}$ limits, as specified No. 22.5F of ITU Radio Regulations Article 22.

5.2.7 The applicable $epfd_{is}$ limits are produced below in Table II for information:

Table II : Limits to the $epfd_{is}$ radiated by non-geostationary-satellite systems

Frequency Band	$epfd_{is}$ (dB(W/m ²))	Percentage of time $epfd_{is}$ level may not be exceeded	Reference bandwidth (kHz)	Reference antenna beamwidth and reference radiation pattern
17.8-18.4	-160	100	40	4° Recommendation ITU-R S.672-4, Ls= -20
...

[Editor's Note: Stakeholders to provide inputs on the $epfd$ limits applicable across all frequency bands to be utilized for NGSO systems (as specified in clause 5.1)]

B) ii. EPFD limits applicable to NGSO Space Stations- for protection of GSO Earth stations

5.2.8 The equivalent power flux-density, $epfd_{\downarrow}$, at any point on the Earth's surface visible from the geostationary-satellite orbit, produced by emissions from all the space stations of a non-geostationary-satellite system in the fixed-satellite service shall not exceed the limits specified in No. 22.5C of ITU Radio Regulations Article 22.

5.2.9 The $epfd_{\downarrow}$ specified above relate to emissions from all space stations, including emissions from a reflecting satellite, for all conditions and for all methods of modulation.

5.3 Protection of fixed or mobile services

5.3.1 The power flux density (pfd) of the Earth's surface produced by emissions from a space station, including emissions from a reflecting satellite, for all conditions and for all methods of modulation, shall not exceed the limits specified in Section V of ITU Radio Regulations Article 21.

5.3.2 The pfd limits, specified above, relate to the pfd which would be obtained under assumed free-space propagation conditions and apply to emissions by a space station of FSS service where frequency bands are shared with equal rights with the fixed or mobile service as per NFAP.

5.4 POLARIZATION

Transmit and receive polarization of the satellite are linear/ circular over entire coverage. The earth station polarization angle should match the spacecraft polarization angle under clear sky conditions. Transmit and receive polarization sense of earth station shall be linear or circular for Ku and Ka bands.

IAFI Comment: Requirements for the hub should be removed. Gateway design varies with the satellite system and there are typically no applicable standards. License application for any hub will in any case be evaluated on a case-by-case basis, together with the technical characteristics and interference potential. As such, there is no need to impose some values a priori which may unnecessarily exclude some designs.

5.5

5.6 EARTH STATION REQUIREMENTS

5.6.1 Transmit cross polar discrimination : Better than 30 dB on-axis (IAFI Comment: **This limit is too stringent for some of the more compact user terminals and should be relaxed**)

5.6.2 **(IAFI Comment: No specific limit should apply in reception as operators will deploy a variety of user terminals to meet target throughput levels. Possible reduced performances in reception are a product/marketing/operational decision.**

5.7 Transmit Spurious Limits (in any 100 KHz Band outside the operating frequency band)

5.7.1 Transmit On-axis and Off- axis spurious radiation Limits:

i. Static Earth Stations

- a) Ku Band: As per ETSI EN 303 980
- b) Ka Band: As per ETSI EN 303 699

ii. ESIMs

- a) Ku Band: As per ETSI EN 303 980
- b) Ka Band: As per ETSI EN 303 979

5.8 Declaration of maximum EIRP:

- a) The NGSO system operator must declare the maximum EIRP capability of the earth stations and the gain of the antenna.
- b) The NGSO system operator shall declare if the design and operation of the satellite network permits more than one earth station to transmit simultaneously on a given carrier frequency, from a signal location. In such a case, the manufacturer shall also declare the maximum number N of such earth stations

that may transmit simultaneously on a given carrier frequency, and the aggregate EIRP from the earth stations.

[Editor's Note: Stakeholders to provide inputs on the extent of definition of 'signal location' to be considered in aforementioned clause. Inputs must be supported with international standards or global best practices]

5.9 Declaration of EPFD limits:

- a) The NGSO system operator must use ITU validation software to assess the compliance of ITU Radio Regulations epfd limits, as mentioned earlier in this document.
- b) Prior to initiation of service, the operator must declare the ITU findings and the input data files used for ITU review of epfd demonstrations.

5.10 Pointing Error:

- a) The NGSO operator shall declare the maximum antenna beam pointing error $\delta\theta_{\max}$ for earth stations.
- b) The NGSO network shall have the means to detect antenna beam pointing errors specified above. This detection shall be performed over the range of azimuth and elevation angles for the intended purposes.
- c) The Earth stations must cease transmissions when pointing error exceeds $\delta\theta_{\max}$ and shall not resume transmissions until the pointing error is within $\delta\theta_{\max}$.

5.11 EIRP Stability : ± 0.5 dB/24 hrs

(IAFI Comment: The 24 hrs reference is not relevant for NGSO systems.

EIRP will be varied over each pass, equal to or less than the maximum rated terminal linear EIRP, dependent on path loss. A possible suggestion is ± 1.3 dB of the target EIRP level, for 95% of the pass

5.12 Transmit IM Products: **23 dB below two equal carriers at 6 dB output**

5.13 Transmit harmonics : Better than -40 dBc upto second harmonic

5.14 Frequency Stability : Better than 1 ppm over the temperature range of -5°C to + 60°C

5.15 Long term frequency stability: Better than 0.1 ppm over a day

6.0 NUMBERING PLAN (for user terminals):

VSAT as well as DSNG networks shall follow the unique ID for each terminal specified or approved by the Department of Telecom.

7.0 OTHER TECHNICAL REQUIREMENTS

7.3 SATELLITE PARAMETERS

To be mentioned: The salient parameters of NGSO network to be declared for the purpose of link budgeting.

- 7.4** The NGSO operator must declare orbital information, or ephemeris data in a standard format and update it at the event of any change in the constellation.

[Editor's Note: Stakeholders to provide inputs on the content, format and mode of sharing ephemeris data for facilitating coordination among NGSO operators. Inputs must be supported with global best practices or examples].

7.5 LINK BUDGET FORMAT

To be mentioned: Sample format for link calculation to be submitted prior to initiation of service.

[Editor's Note: Stakeholders to provide inputs for sample format of link budget calculations that may be applicable to NGSO systems. Inputs must be supported with relevant ITU Recommendations, international standards and global best practices].

8.0 Additional Mandatory Requirements applicable to Earth Stations in Motion (ESIM):

- A) Control and Monitoring Functions : Network Control and Monitoring Centre (NCCM)**

- 8.1** The NGSO network shall operate under the control of a Network Control and Monitoring Centre. ESIM are subject to permanent monitoring and control by a Network Control and Monitoring Centre (NCCMC) or equivalent facility.
- 8.2** ESIM should be capable of receiving and acting upon at least “enable transmission” and “disable transmission” commands from the NCCMC or equivalent facility.
- 8.3** It shall be possible to shut down transmissions from an ESIM terminal through the Network Control Centre if the operation of the ESIM terminal is found to cause harmful interference to any other satellite network or terminal.
- 8.4** ESIM must transmit their geolocation (latitude and longitude) to NCCMC in real time, whenever communicating with the network, at least every 1 minute, for tracking purpose(s).
- 8.5** It shall be possible to define the service area contour through the NCCMC. The ESIM shall operate only in the specified service area contour in accordance with the service area requirements as defined in the license conditions. NCCMC should have capability to allow or cease transmission from ESIM based on geofencing. The Gateway in India may be used to provide services within India or outside India, subject to compliance with any applicable international and national law at the location of the ESIM.

(IAFI Alternative suggestion proposed to allow for the gateway to be potentially used also on a regional/sub-regional basis.)

- 8.6** The NCCMC shall facilitate the LIM/LIS requirements as per the license conditions along with the following:
 - a. The Law Enforcement Agency (LEA) should get intercepted content in en-clair form along with meta-data (including geolocation, session details, IPDR/CDR etc) for any type of communication through ESIM terminal.
 - b. The NCCMC should have facility to monitor all ESIM terminals in the network.
 - c. The details of the devices connected through in-built WiFi hotspot in ESIM terminal should be retrievable/viewable at NCCMC.
 - d. The ESIM network should have a proper authentication mechanism to uniquely identify each user. Moreover, the NGSO network should have technical capability to facilitate retrieval of any information in respect of LIM and Lawful Access to information.
 - e. Immediate cessation of service to some or all ESIM terminals in a geographical area as per directive of Government of India should be feasible at NCCMC.

B) General Requirements

- 8.7** For each ESIM terminal (whenever the terminal is online or communicating with the network) a record of its location (latitude, longitude; and altitude in case of aircraft based ESIM), transmit frequency, bandwidth, satellite used and on-axis EIRP shall be time annotated and maintained for a period of not less than one year. Records shall be recorded at time intervals no greater

than 1 minute while the ESIM terminal is transmitting. ESIM shall have a means of determining its geographic location at a resolution compatible with the radio navigation system being used (e.g. GPS, NAVIC). (IAFI Comment: For ESIM, it is not possible to define tracking based on a specific distance since the speed can be different.

- 8.8** The ESIM terminal on entering the Indian territory shall set-up communication link only through the Hub/Gateway station in the Indian territory.
- 8.9** On entering and while in the Indian territory, the ESIM shall use the regional IP addresses as allocated to Indian service providers.
- 8.10** The Wi-Fi access provided on board the vehicle shall be as per the relevant regulatory conditions of India like the frequency bands of operation (which shall be as per the prevalent National Frequency Allocation Plan (NFAP), EIRP etc.

ANNEXURES
(To be specified)