# LEOSAT NON-GEOSTATIONARY SATELLITE SYSTEM

## ATTACHMENT A

## Technical Annex to Supplement Schedule S

## *TABLE OF CONTENTS*

## 1. SCOPE AND PURPOSE

This attachment contains the information required by 47 C.F.R. § 25.114(d) and other Part 25 rules that cannot be captured by the Schedule S software.

## 2. GENERAL DESCRIPTION OF OVERALL SYSTEM FACILITIES, OPERATIONS AND SERVICES AND EXPLANATION OF HOW UPLINK FREQUENCY BANDS ARE CONNECTED TO DOWNLINK FREQUENCY BANDS (§ 25.114(d)(1))

### 2.1 Overview

The LeoSat non-geostationary satellite orbit ("NGSO") system (the "LeoSat system") consists of a constellation of approximately 78[1] high-throughput Ka-band satellites in low earth orbit ("LEO"), plus six in-orbit spare satellites, all operating in polar circular orbits at an altitude of approximately 1,400 km, as well as associated ground control facilities, gateways and user terminals. The LeoSat system will provide extremely high speed (up to 1.2 Gbps in both directions), low-latency and highly secure data connections between two or more user terminals (*e.g.,* for leased line service) or between a user terminal and a gateway (*e.g.,* for Internet access) to support the operations of commercial and government organizations, both small and large.

The high-throughput satellites form a mesh network interconnected through laser intersatellite links, creating an optical backbone in the sky. Using polar orbits, steerable spot beams and optical intersatellite links ("OISLs"), the satellites can serve gateways and user terminals located anywhere on the Earth, thus providing a true global service. Orbiting at an altitude five times closer to Earth than satellites in medium earth orbit ("MEO") and 25 times closer than GSO satellites, this space-based backbone delivers a round trip time faster than terrestrial fiber backbones, especially for medium and long distance connections.

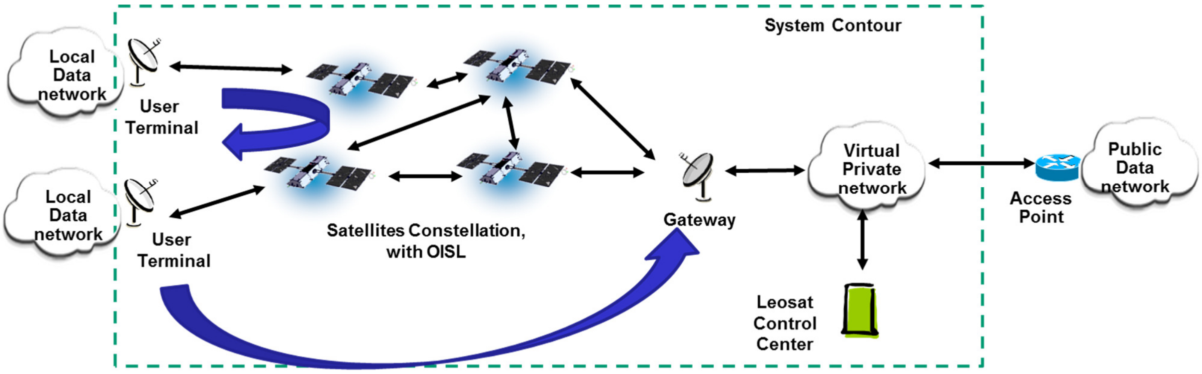
User terminals utilize 1.2 m aperture or larger antennas, depending on their location and the associated propagation characteristics and service requirements. User terminals in the United States initially will consist of small and large fixed user terminals that will be authorized under separate FCC earth station licenses.

Typically collocated with public data network access points, gateways will be deployed progressively to accommodate growing traffic demand. Due to the networking capability of the LeoSat constellation created by its use of OISLs, a single gateway would be able to serve users around the world. Hence, the system can provide global service with a single gateway. Gateways utilize 2.4 m or larger antennas, depending on their location and the associated propagation characteristics and service requirements. At least one gateway earth station site is

[1] The LeoSat satellite system is designed such that more satellites can be added to the constellation to increase capacity while still ensuring interference protection of geostationary satellite orbit ("GSO") and NGSO networks. A total of 108 operational satellites in the constellation is envisioned for the longer term, but the requested FCC authorization is limited to an initial constellation of approximately 78 operational satellites.

expected to be deployed in Arizona or Alaska, and there may be additional U.S. sites. Exact gateway locations have yet to be determined.

A ground-based virtual private network ("VPN") will interconnect the gateways with the public data network's access points as well as the nominal and redundant control centers.
The logical architecture of the LeoSat system is illustrated in the figure below.




The LeoSat satellite constellation will operate under International Telecommunication Union ("ITU") filings submitted by France for the MCSAT-2 LEO-2 network. Further details regarding these filings are provided in Section 7 below.

The frequency ranges used by the LeoSat system are summarized in the Table below, and the detailed channelized frequency plan is given in the associated Schedule S.

| Type of Link and Transmission Direction | Frequency Ranges |
|---|---|
| Earth station-to-satellite<br>(service and gateway uplinks) | 27.5 — 28.35 GHz<br>28.35 — 28.6 GHz<br>28.6 — 29.1 GHz<br>29.5 — 30.0 GHz |
| Satellite-to-earth station<br>(service and gateway downlinks) | 17.8 — 18.6 GHz<br>18.8 — 19.3 GHz<br>19.3 — 19.7 GHz<br>19.7 — 20.2 GHz |

LeoSat will operate at least two separate satellite control centers, each providing full redundancy for the other. The centers may be located in Virginia and Arizona, though the exact locations have yet to be determined. Connectivity between these control centers and gateway earth stations will be implemented using terrestrial leased circuits and secure VPNs.

Each satellite is able to generate up to 12 independent steerable Ka-band circular spot beams of various widths. The system allows the transmission of one or more channels of up to 500 MHz bandwidth per beam in both earth-to-space and space-to-earth directions.

The Ka-band uplink channels received by a satellite from one of the steerable beams are demodulated and decoded. Data packets are retrieved in the binary flow and are individually routed towards either one of the steerable beams or one of the OISLs according to the data packet header and configurable on-board routing tables. This ensures full connectivity between the uplink and downlink beams in each LeoSat satellite at the granularity of a single packet.

In the same way, OISL inputs are demodulated and decoded. Data packets from OISLs are processed in the same way as data packets from Ka-band uplink channels.

In order to ensure satellite monitoring and control, the system design includes dedicated control and monitoring packets that are routed through the constellation in the same way as the telecommunication packets.

The constellation enables the service continuity of a connection established between two earth stations (*e.g.*, user terminal and gateway). Each connection is mapped over a route path consisting of at least two radio links and, if needed, one or more OISLs, as follows:

- a first radio link between the originating earth station and a serving satellite;
- a second radio link between the terminating earth station and the same or another serving satellite;
- if the two serving satellites are distinct, a succession of OISLs through the space-based backbone is needed to complete the route path.

Each radio link is independently handed over from the serving satellite to an incoming satellite following a "make-before-break" procedure. This is possible with dual beam capable earth stations, which allow them to simultaneously establish a radio link with an incoming satellite while maintaining the radio link with the serving satellite. When a radio link is handed over from the serving satellite to an incoming satellite, the route path through the space-based backbone is re-routed.

The control center is responsible for the planning of the allocation of radio resources (*e.g.,* satellite, beam, carriers, and polarizations) to the targeted earth stations and the planning of the routing through the space-based backbone.

The air interface is nominally based on the digital video broadcasting satellite second generation ("DVB-S2") air interface for both earth-to-satellite and satellite-to-earth links. However, other air interfaces, such as DVB-S2x or proprietary solutions, could be selected. On the user downlink, the multiple access mode is time division multiplexing ("TDM"), wherein all frames are multiplexed on the same wide carrier. Each earth station in the beam receives and demodulates this carrier and extracts only the data that is destined for it, which is determined by the data headers. On the user uplink, bandwidth will be partitioned in as many carriers as there are user terminals, in a single channel per carrier ("SCPC") mode: nominally from 50 MHz to 250 MHz (in multiples of 50 MHz). However, other granularity and bandwidth could be selected.

One user terminal can use a bandwidth of up to 500 MHz both on the uplink and on the downlink, allowing to transmit and receive up to 1.2 Gbps. A gateway is able to process up to four channels totaling as much as 500 MHz each both on the uplink and on the downlink in contiguous or non-contiguous spectrum segments and on both polarizations.

Adaptive coding and modulation ("ACM") combined with power control is used to ensure the optimum data throughput of the user terminals and gateways as a function of the link margin available at the time, which varies as a function of rain fade as well as the time varying geometry of the radio link due to the movement of the LeoSat satellite. ACM functionality allows different modulation formats and error correction levels (*i.e.*, coding rates) to be used and changed on a frame-by-frame basis. The data rate is negotiated end to end by the earth stations to cope with the radio link that has to face to the worst conditions.

The radio resource management software allocates the frequency bandwidth to beams in order to ensure that the interference level is compliant with the link budget requirements. The radio resource management software also implements the power and bandwidth adjustments to ensure system compliance with all regulatory requirements.

### 2.2 Earth Stations

There are two broad categories of earth stations in the LeoSat system — gateway stations and user terminals.[2] Gateways~~,~~ typically will use 2.4 m. (in diameter) or larger antennas, including multiple active tracking antennas and associated electronics. Those gateways performing telemetry, tracking, and command ("TT&C") functions will be located at high latitudes in order to communicate with multiple satellites operating in multiple orbital planes at the same time.

User terminals will employ two antennas, typically 1.2 m. to 4.2 m. in equivalent antenna aperture diameter, and will include fixed and transportable (for fast deployment) user terminals. User terminals will employ mechanically steerable parabolic reflector antennas, electronically steerable phased array antennas or other beam-steering technology.

To compensate for satellite motion and ensure seamless service continuity, a make-before-break hand-over scheme is enabled by equipping user terminals with a dual steerable beam antenna system and dual transmission chain.

### 2.3 Payload architecture

Each satellite will be equipped with two high capacity beams and 10 regular beams. For each beam, Ka-band signals are received and transmitted through a steerable antenna. Each high capacity beam antenna is able to receive and transmit simultaneously in both RHCP and LHCP polarizations. Each high capacity beam provides up to four channels of up to 500 MHz per channel. The high capacity beams may communicate with gateway or user earth stations, while regular beams communicate exclusively with user earth stations. Each regular beam antenna is

[2] LeoSat will separately seek appropriate FCC authorization for any U.S. earth stations.

able to receive and transmit in a selectable polarization, RHCP or LHCP. Each regular beam provides one channel of up to 500 MHz.

Depending on their aperture, the 10 regular beams may be either (i) “narrow” beams with an aperture of approximately 4.1°; or (ii) “wide” beams with an aperture of approximately 5°. The number of narrow and wide beams comprising the 10 regular beams is yet to be determined.

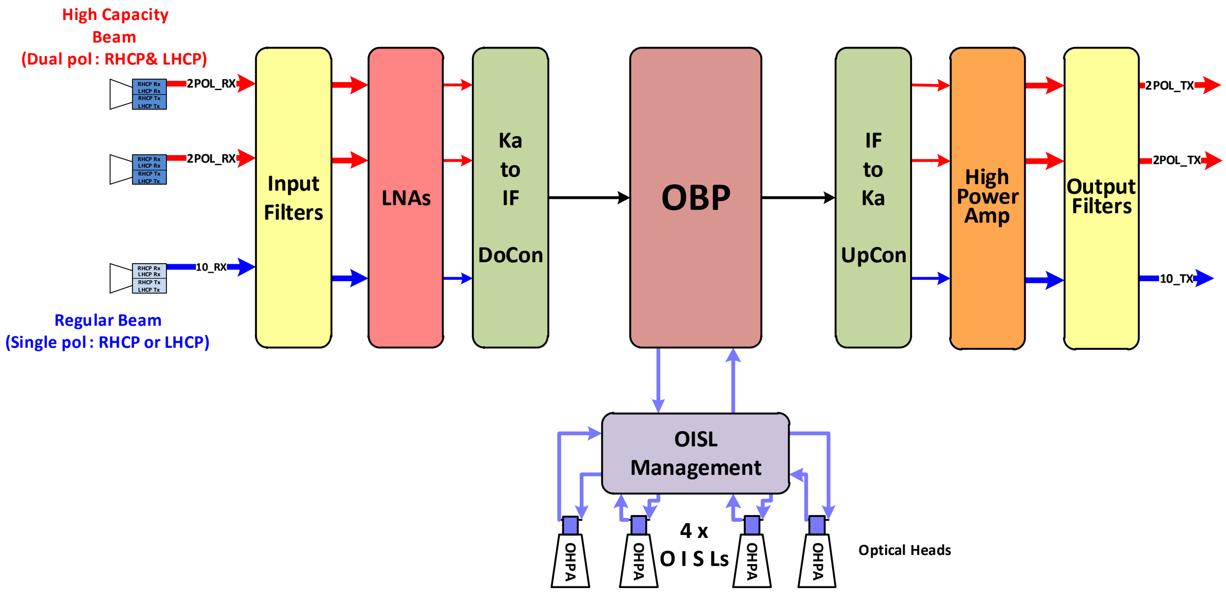
The mapping of the beam names with the identifiers used in the Schedule S is provided in the table below:

| | High capacity beam | | Regular beams | | | |
|---|---|---|---|---|---|---|
| | | | Narrow beam | | Wide beam | |
| | Receive | Transmit | Receive | Transmit | Receive | Transmit |
| RHCP | HRU | HRD | NRU | NRD | WRU | WRD |
| LHCP | HLU | HLD | NLU | NLD | WLU | WLD |

The Ka-band RF signals received by each beam antenna from an earth station are amplified by a low noise amplifier, filtered, and then down-converted to an intermediate frequency (“IF”) before being demodulated and processed by an on-board processor (“OBP”). This processing includes the data packets’ retrieval from the binary flow and the routing of each individual packet toward either one of the steerable beams or one of the OISLs according to their packet header and configurable on-board routing tables. After OBP processing and modulation, IF signals are frequency up-converted in the Ka-band, filtered, and then amplified by a high-power amplifier before transmission through each beam antenna.

The 4 OISLs point towards adjacent satellites (located north, south, east, and west), with the optical heads of each OISL controlled by means of the pointing acquisition and tracking system. Each OISL provides full duplex transmission, using different wavelengths.

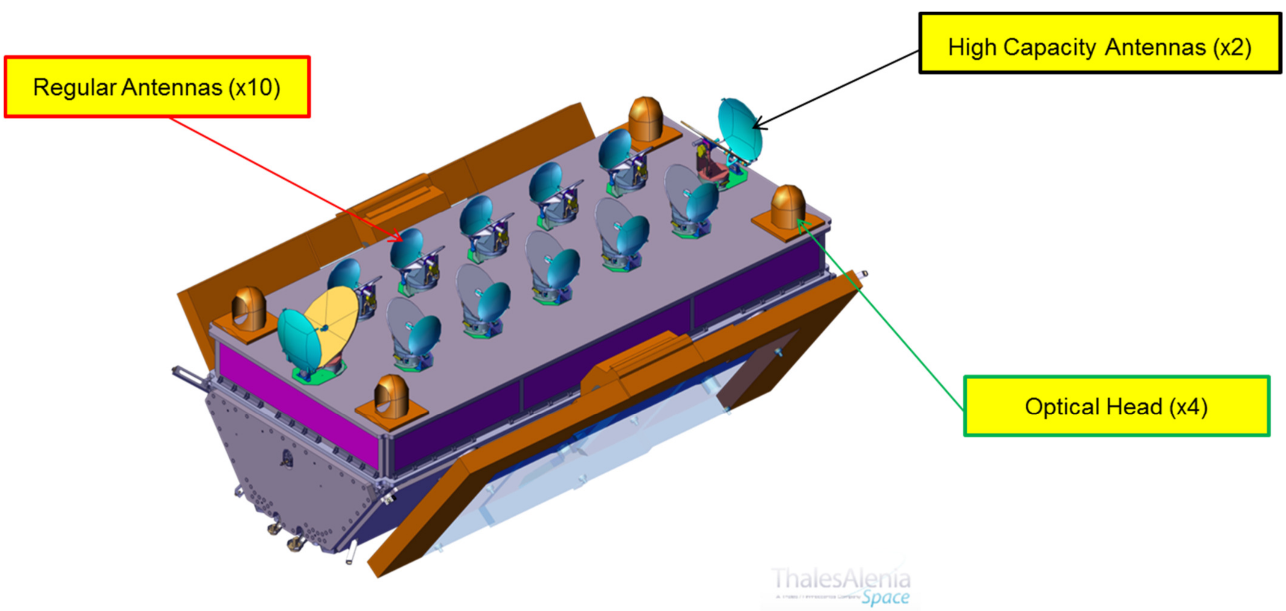
A principle diagram of the payload is shown below:



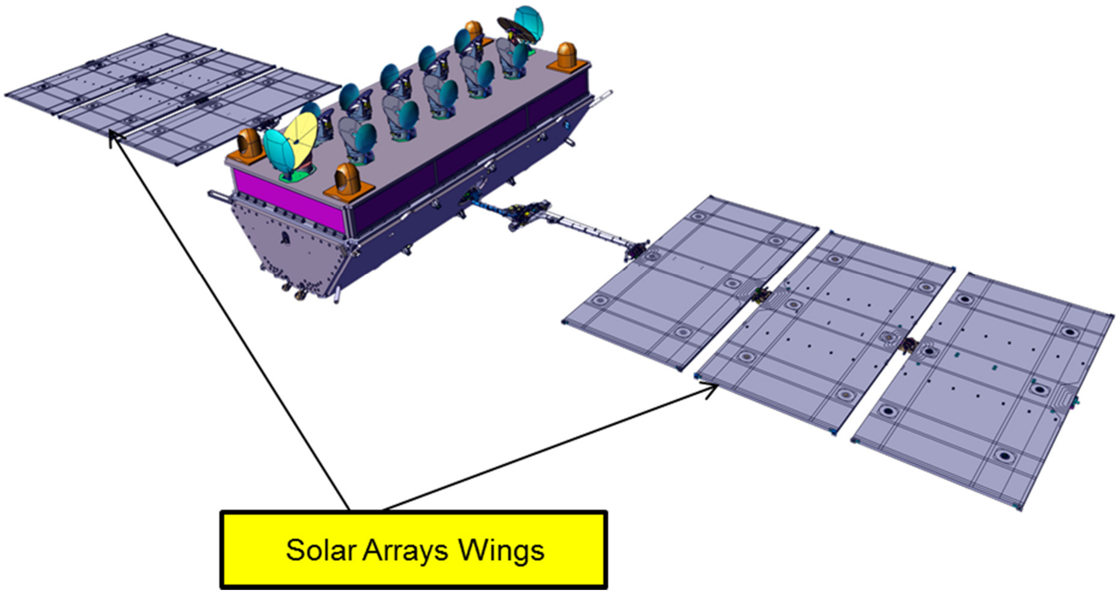

## 2.4 Satellites

Each satellite will use the ELITEBUS™ 2000 platform, an evolution of the qualified ELITEBUS™ 1000 platform, which is used in several existing and planned constellations, including Globalstar (second generation), O3b (blocks 1, 2, and 3) and Iridium NEXT.

Below are illustrations of the anticipated LeoSat satellite configurations:




Stowed configuration




Deployed configuration

The ELITEBUS™ 2000 platform consists of the following:

(1) power subsystem with solar arrays and batteries;

(2) avionics subsystem with

- the power and avionics centralized electronics, including a GPS receiver,
- its attitude and orbit control subsystem ("AOCS") with sensors and actuators, and
- its software;

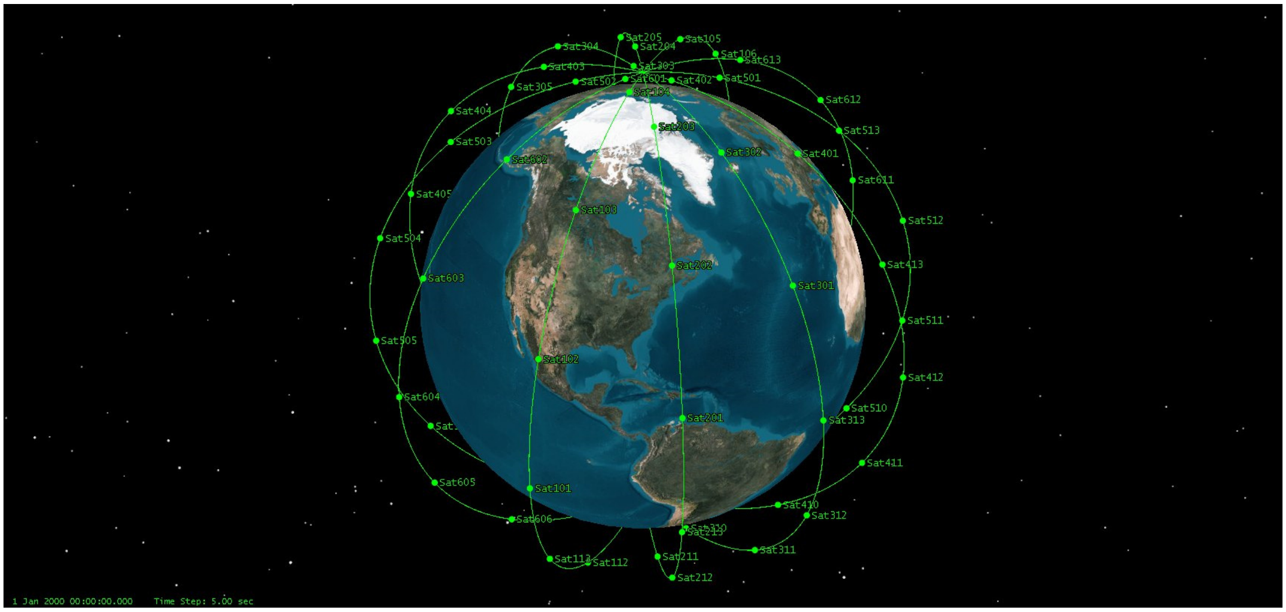
(3) propulsion subsystem, including hall effect thrusters;

(4) structure subsystem, with earth box to accommodate payload units; and

(5) thermal sub-system.

### 2.5 Satellite constellation and deployment principles

The LeoSat constellation consists of approximately 78 satellites (6 planes with 13 satellites per plane) at an altitude of approximately 1,400 km. The figure below is a representation of the planned constellation.




Detailed constellation parameters are specified in Schedule S.

Constellation deployment will follow a step-by-step approach:

- First, two satellites will be deployed to provide early service. It is anticipated that no U.S. earth stations will be required at this stage.
- Second, 13 active satellites in each of the six planes will be deployed, for a total of 78 active satellites. This configuration will also include six in-orbit spare satellites (nominally one per orbital plane) to ensure system availability.
- The constellation may then be expanded to up to 18 satellites per plane to provide increased capacity, for a total of 108 active satellites.[3]

[3] LeoSat is not seeking U.S. market access for the larger 108-satellite constellation at this time, and may later seek additional FCC authorization for the larger constellation, as appropriate.

## 3. TT&C FUNCTIONS (§ 25.202(g))

The monitoring and control system controls and monitors all aspects of each satellite necessary for onboard equipment configuration, safe operations and health monitoring. It also controls mission aspects such as routing configuration, earth stations locations, and related matters.

Two distinct monitoring and control channels may be used to manage each satellite:

- launch and early orbit phase ("LEOP")/emergency TT&C system channel; and
- nominal monitoring and control channel through the constellation.

(i) The LeoSat TT&C system provides for robust and low data rate communications during launch, transfer orbit and during spacecraft emergencies. Consistent with 47 C.F.R. § 25.202(g), the TT&C system operates at the edges of the Ka-band frequency allocations for service uplinks and downlinks to minimize interference into other satellite networks. On-board telecommand ("TC") receivers are active during all phases of the mission. On-board telemetry ("TM") transmitters are activated on request. Both use nominally low-gain near-omnidirectional antennas to allow communications between satellite and earth, regardless of the satellite attitude. TT&C communications between the ground and a satellite are performed when the satellite is visible to a TT&C gateway. When not visible, the satellite acts autonomously, executing time-tagged commands and storing telemetry data for later download.

The table below provides a summary of the TT&C and payload control subsystem characteristics:

| | |
|---|---|
| Uplink – TC signal modulation: | BPSK - PM |
| Uplink – TC frequencies: | 28.60-28.61 GHz |
| Downlink – TC signal modulation: | BPSK - PM |
| Downlink – TM frequencies: | 18.80-18.81 GHz |
| Polarization of receiving and transmitting omnidirectional antennas | Receiving: LHCP and RHCP<br>Transmitting: LHCP and RHCP |

(ii) The nominal monitoring and control channel provides for regular and high data rate communications during nominal operations (*i.e.*, as soon as the satellites' OISLs are connected, forming a network in the sky). This system relies on the network to ensure the transport of commands from the satellite control center to each target satellite and relay of monitoring data from each satellite to the satellite control center. Control and monitoring data use the same frequencies, polarizations, modulations, coding and packet format as data communications traffic. Therefore, during nominal operations, the monitoring and control system will not require the use of dedicated TT&C channels.

TT&C earth stations will be nominally located in the high latitudes where maximum simultaneous visibility of multiple satellites is possible. These high-latitude TT&C earth stations ensure control through both LEOP/emergency TT&C and nominal monitoring and control systems.

## 4. PREDICTED SATELLITE ANTENNA GAIN CONTOURS (§ 25.114(c)(4)(vi)(B))

Each satellite has nominally 12 Ka-band steerable beams for transmit and receive. Each spot beam can be steered to a half cone of 55° with respect to the nadir satellite direction. RF radiating patterns for LeoSat satellites are invariant versus scanning.

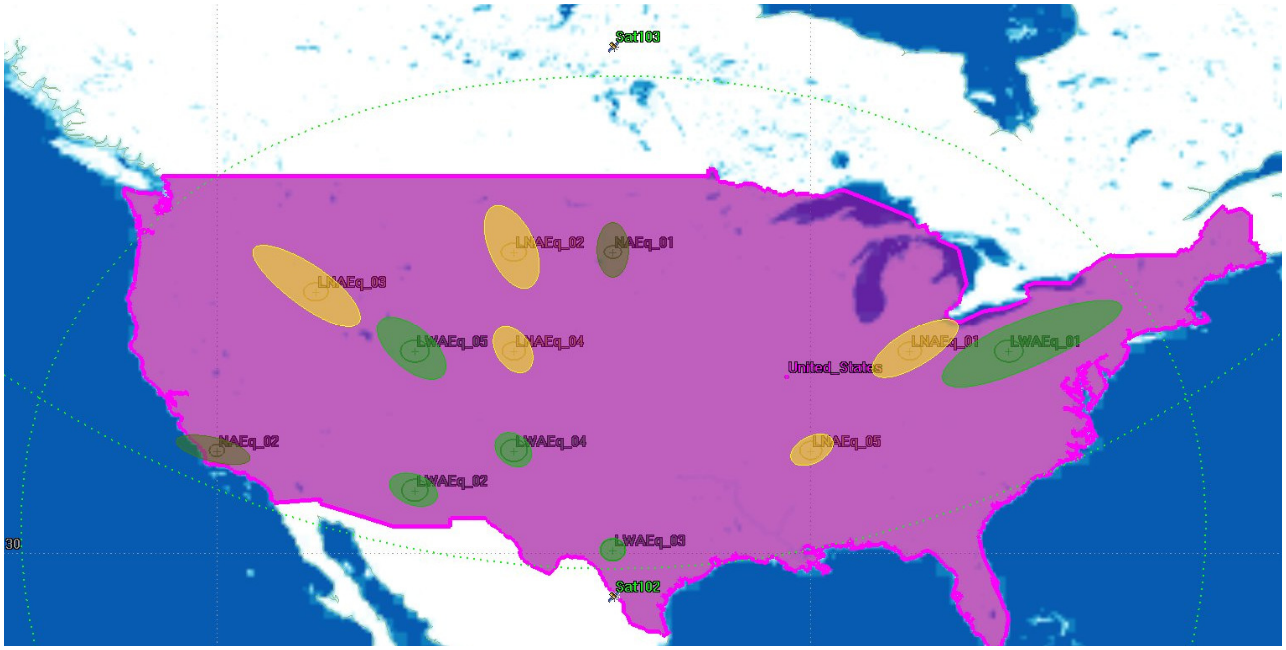
Each LeoSat satellite nominally provides three kinds of dual band and dual circularly polarized spot beams:

- 2 high capacity beams, which may be used for gateways and user terminals; and
- 10 narrow and wide beams dedicated to user terminals.

Furthermore, each satellite includes two quasi-omnidirectional antennas for LEOP and emergency TT&C purposes.

The antenna plots are provided in Schedule S.

The figure below is an illustration of the steerable beams' footprint over the U.S. from one satellite generated at a given time: the sub-satellite point corresponding to the selected satellite is located at the border between Mexico and Texas. Brown, green, and yellow footprints represent high capacity beams, narrow beams, and wide beams, respectively. The two wide dotted circles surrounding the entire country are the visibility limit circles (from earth) corresponding to each satellite, at a 10° minimum elevation angle.



Sat103
LNAEq_02
NAEq_01
LNAEq_03
LWAEq_05
LNAEq_04
LNAEq_01
LWAEq_01
United_States
NAEq_02
LWAEq_04
LNAEq_05
LWAEq_02
30
LWAEq_03
Sat102

## 5. GEOGRAPHIC COVERAGE (§ 25.145(c))

Under the Commission's geographic coverage requirements set forth in § 25.145(c), NGSO FSS systems must be capable of providing FSS as follows:

(1) to all locations as far north as 70° North Latitude and as far south as 55° South Latitude for at least 75 percent of every 24-hour period; and

(2) on a continuous basis throughout the 50 states, Puerto Rico, and the U.S. Virgin Islands.

The 78-satellite constellation will operate in polar circular orbits, thus ensuring coverage capability for continuous service to any part of the Earth's surface located above 15° latitude, north or south, taking into account the GSO protection measures described in Section 6.1 below and providing a minimum elevation angle of 10° or greater. Accordingly, this continuous coverage capability surpasses § 25.145(c)(2)'s U.S. coverage requirement.

Moreover, the 78-satellite constellation ensures service coverage of the equatorial area (*i.e.,* from 0° to 15° latitude, north or south) at least 90 percent of the time on a daily basis (in addition to continuous coverage of all other areas of the Earth), thus surpassing § 25.145(c)(1)'s global coverage requirement.

## 6. INTERFERENCE ANALYSES

### 6.1 Interference Protection for GSO Satellite Networks

The LeoSat system is designed to protect GSO satellite networks, as required under ITU Radio Regulations ("RR"), including (i) equivalent power flux density ("EPFD") limits on NGSO downlink, uplink and intersatellite transmissions on certain Ka-band frequencies; and (ii) procedures for coordination with GSO operations on other Ka-band frequencies not subject to EPFD limits.

The LeoSat system will protect GSO satellite networks in the 17.8-18.6 GHz and 19.7-20.2 GHz frequency bands, as required under ITU RR Article 22. Compliance with EPFD limits specified in ITU RR Article 22 for the Ka-band is demonstrated below and in the attached Annexes 1 through 3.

Specifically, ITU RR Nos. 22.5C, 22.5D and 22.5F establish EPFD limits to ensure interference protection of GSO satellite networks from LeoSat's NGSO operations in the following Ka-band spectrum:

- 27.5-28.6 GHz and 29.5-30 GHz: $EPFD_{up}$
- 17.8-18.6 GHz and 19.7-20.2 GHz: $EPFD_{down}$
- 17.8-18.4 GHz: $EPFD_{is}$

#### *6.1.1 Compliance with EPFD limits*

(i) $EPFD_{up}$

To ensure compliance with ITU $EPFD_{up}$ limits, LeoSat relies upon both a minimum avoidance angle of seven (7) degrees viewed from an earth station, between a LeoSat satellite and the GSO arc. This GSO avoidance angle is the cornerstone of the method employed to ensure EPFD compliance, as demonstrated in the attached Annex 1. The technical access methodology, or access scheme, used for the Earth-to-space link is SCPC mode; therefore the number of earth stations transmitting simultaneously co-frequency will be limited to one per LeoSat beam. All these different technical parameters contribute to a situation where the protection of GSO earth stations can be ensured without significant constraints on LeoSat operations.

(ii) $EPFD_{down}$

To ensure compliance with ITU $EPFD_{down}$ limits, the LeoSat system will implement the GSO arc avoidance approach (*i.e.,* minimum avoidance angle of seven degrees) to ensure GSO earth station protection, as demonstrated in the attached Annex 2.

NGSO constellations using steerable beams and dynamic power adjustment capability, like LeoSat, provide a high degree of flexibility to ensure protection of GSO earth stations, which is not accounted for in Recommendation ITU-R S.1503-2.

Indeed, the ITU Bureau Director's report to the World Radiocommunication Conference ("WRC") 2015 raised certain elements related to Recommendation ITU-R S.1503-2. The conclusion of the WRC was that the algorithm and ensuing software may not be able to adequately model certain NGSO networks, specifically NGSO constellation using steerable beams, and the WRC recognized that improvements to the algorithm in Recommendation ITU-R S.1503-2 may be required. All the results described in the attached Annex 2 consider the new approach described at ITU Working Party 4A ("WP4A/196/Annex21"). This approach introduces new technical parameters, including the non-GSO earth station minimum tracking duration that contribute to a situation where the protection of the GSO satellite networks is ensured without significant constraints on the LeoSat operations.

(iii) $EPFD_{is}$

The 17.8-18.4 GHz band is allocated bi-directionally to FSS. The ITU $EPFD_{is}$ limits protect GSO space station uplink receivers in this band from interference due to LeoSat space station transmissions through spot beam sidelobes in the direction of the GSO arc. LeoSat will comply with the $EPFD_{is}$ limit specified in ITU RR Article 22, as demonstrated in the attached Annex 3.

### *6.1.2 Ka-band Frequencies with No EPFD Limits*

LeoSat's proposed operations in the 18.8-19.3 GHz downlink and 28.6-29.1 GHz uplink bands are not subject to ITU EPFD limits, and are consistent with the FCC's Ka-band plan, which permits NGSO operations on an exclusive primary basis (with GSO operations on a non-conforming basis at 18.8-19.3 GHz and secondary basis at 28.6-29.1 GHz). Moreover, operations in these frequency bands are subject to ITU Radio Regulations requiring coordination between NGSO and GSO operations, based upon ITU date priority of the associated ITU filings. LeoSat expects to coordinate with GSO operators and their licensing administrations, as required under ITU RR, and will consider appropriate GSO interference avoidance mechanisms to achieve successful coordination.

### 6.2 Interference with Respect to Other NGSO Satellite Systems

LeoSat's operations on all of its proposed Ka-band frequencies, except 19.3-19.7 GHz, are subject to procedures set out in ITU RR Nos. 9.12 and 9.11A requiring coordination with other NGSO FSS networks, based upon ITU date priority of the associated ITU filings. LeoSat expects to coordinate with other NGSO operators and their licensing administrations, as required under the ITU RR.

Interference and coordination with certain existing and future authorized NGSO satellite systems are described in more detail in the subsections below.

#### *6.2.1 Interference with Respect to O3B*

To date, the O3B system is the only Ka-band NGSO FSS system authorized by the Commission. O3B operates in an equatorial MEO at an altitude of 8,062 km.

The figure below shows the percentage of time during which the angular separation between the O3B and LeoSat systems is higher than 2° over the United States. This estimation is a worst-case assumption in that at each given time and at each test point location, the selected angle is the smallest one between all available LeoSat satellites and all available O3B satellites. Under actual operating conditions, when an O3B satellite and a LEOSAT satellite serve the same location, these two satellites may not be the ones that have the smallest separation angle. Therefore, the operational in-line events will occur less frequently than shown on the figure below.

The results demonstrate that in-line interference events will occur rarely. The determination of relevant avoidance parameters will be subject to coordination discussions with O3B, but in principle LeoSat can protect O3B operations with negligible impact on LeoSat system performance.

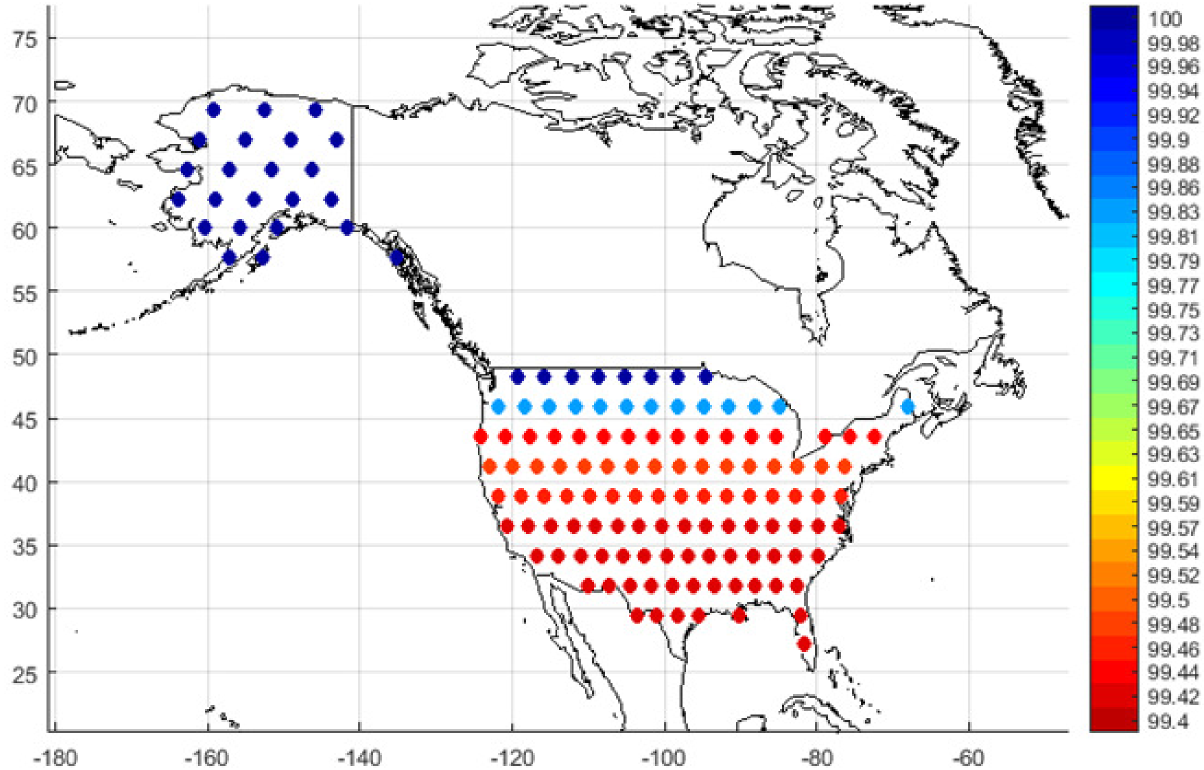



Figure: Worst case Angular separation over the US territory.

### *6.2.2 Interference with Respect to NGSO MSS Feeder Links in the 19.3-19.7 GHz Band*

LeoSat seeks to operate in the 19.3-19.7 GHz band for both user terminal and gateway receivers in the U.S. on a non-conforming basis.

The ITU RR footnote 5.523D mandates that the use of the 19.3-19.7 GHz band for NGSO FSS systems other than those providing NGSO MSS feeder links *"is not subject to the provisions of 9.11A and shall continue to be subject to Article 9 (except 9.11A) and 11 procedures, and to the provisions of No 22.2".* The Radio Regulations therefore allow the notification of NGSO FSS assignments that are used for other purposes than MSS feeder links on an international basis.

Allowing NGSO FSS operations in the 19.3-19.7 GHz band will offer substantial public interest benefits, including (i) fostering increased use of spectrum; (ii) expanding the range of services provided in the U.S.; and (iii) facilitating Ka-band sharing with other NGSO FSS systems by increasing the spectrum available to support measures to avoid in-line interference.

Despite the inapplicability of ITU coordination procedures to the 19.3-19.7 GHz band, LeoSat is prepared to discuss sharing solutions with Iridium, the sole FCC licensee of NGSO MSS feeder links in the 19.4-19.6 GHz downlink band. LeoSat expects that authorized NGSO MSS feeder link stations can be protected through any or a combination of the following:

- Angular separation: NGSO MSS feeder link stations are generally highly directive and are not susceptible to harmful interference when the potentially interfering NGSO satellites are located at angles far from the feeder earth station antenna's main lobe.
- Satellite diversity: A given LeoSat earth station may be served by several LeoSat satellites. The system can elect satellites that provide a sufficient angular separation to protect specific NGSO MSS feeder links.
- Geographical separation: The LeoSat satellites generate steerable spot beams to serve customers or system gateways. The LeoSat system could avoid using bands authorized for NGSO MSS feeder stations within LeoSat satellite beams when those beams are pointing towards those ground locations in the vicinity of the considered NGSO MSS feeder link stations.
- Frequency avoidance: The LeoSat will be able to avoid using the spectrum licensed for NGSO MSS feeder links on a short term basis in case angular and geographical separation measures are deemed insufficient. LeoSat, however, believes that the use of the above mitigation techniques should permit its use of the band 19.3-19.7 GHz band at all times.

LeoSat's on-board processing capacity and flexible frequency resource allocation capability allow for the implementation of the above measures.

#### *6.2.3 Coordination with Other Planned NGSO FSS Systems*

LeoSat will coordinate its operations internationally with other planned NGSO FSS systems on a first-come, first-served basis under ITU RR §§ 9.11A or 9.12.[4] Based upon the LeoSat system's ITU date priority, LeoSat expects to coordinate successfully with later ITU filings for other planned NGSO FSS systems.

Additionally, the Commission has adopted rules under 47 C.F.R. § 25.261 to permit sharing among multiple NGSO systems in the 28.6-29.1 GHz (uplink) and 18.8-19.3 GHz (downlink) bands. These rules include procedures for avoiding in-line interference and sharing the spectrum resources among various NGSO systems, in the absence of specific coordination agreement among parties. LeoSat expects to complete such coordination agreements based on angular separation and satellite diversity (and possibly frequency avoidance, but only if necessary). LeoSat believes that similar arrangements will also enable NGSO FSS sharing of other Ka-band spectrum proposed for the LeoSat system (*i.e.,* 27.5-28.6 GHz, 29.5-30 GHz, 17.8-18.6 GHz and 19.7-20.2 GHz bands).

Moreover, LeoSat will work with other NGSO FSS operators to ensure compliance with applicable aggregate $EPFD_{down}$ limits specified in ITU RR Resolution 76.

[4] Coordination under ITU RR § 9.11A does not apply to NGSO FSS operations in the 19.3-19.7 GHz band, except with respect to NGSO MSS feeder links.

### 6.3 Coordination with Federal Government Satellite Networks

LeoSat will coordinate with federal government GSO and NGSO FSS systems in the 17.8-20.2 GHz downlink band, as required under Footnote US334 to the U.S. Table of Frequency Allocations.

### 6.4 Interference with respect to Terrestrial Networks in the 17.8-18.6 GHz and 19.3-19.7 GHz Bands, and Compliance with PFD Limits (§ 25.208)

LeoSat seeks non-conforming use of the 17.8-18.6 GHz and 19.3-19.7 GHz bands for both user terminals and gateway receivers in the U.S. Both bands are allocated on a primary basis to terrestrial fixed service ("FS") systems, which are individually, site-based licensed under Parts 74F (TV broadcast auxiliary), 78 (cable TV relay) and 101 (fixed microwave) of the Commission's rules.

The analysis below addresses the two relevant interference paths in these frequency bands: i) interference from FS transmitters into LeoSat receive earth station sidelobes; and ii) interference from LeoSat space stations into FS receivers.

i) Interference from FS transmitters into LeoSat earth station receivers.

LeoSat will accept interference from FS transmitters and will take the necessary measures to minimize the impact on its U.S. earth station operations. In most cases, interference will be sufficiently reduced by terrain attenuation along the interference path and by limited earth station sidelobe gain in the direction of the FS interference source. Additional mitigation measures will be applied on a case-by-case basis and include frequency avoidance, site shielding, and earth station elevation restrictions for the relevant azimuth directions.

ii) Interference from LeoSat space stations into FS receivers.

LeoSat satellites will comply with both FCC and ITU power flux density ("PFD") limits designed to ensure sufficient interference protection of FS systems.

Specifically, the table below summarizes the FCC and ITU PFD for the various portions of the Ka-band in which LeoSat will operate.

| | Power flux density limits | |
|---|---|---|
| | FCC (47 C.F.R. Part 25) | ITU (RR Article 21 Table 21-4) |
| 17.8-18.3 GHz | None | Same limit as 25.208(e) |
| 18.3-18.6 GHz | 25.208(c) | Same limit as 25.208(e) |
| 18.8-19.3 GHz | 25.208(e) | Same limit as 25.208(e) |
| 19.3-19.7 GHz | 25.208(c) | Same limit as 25.208(c) |
| 19.7-20.2 GHz | None | None |

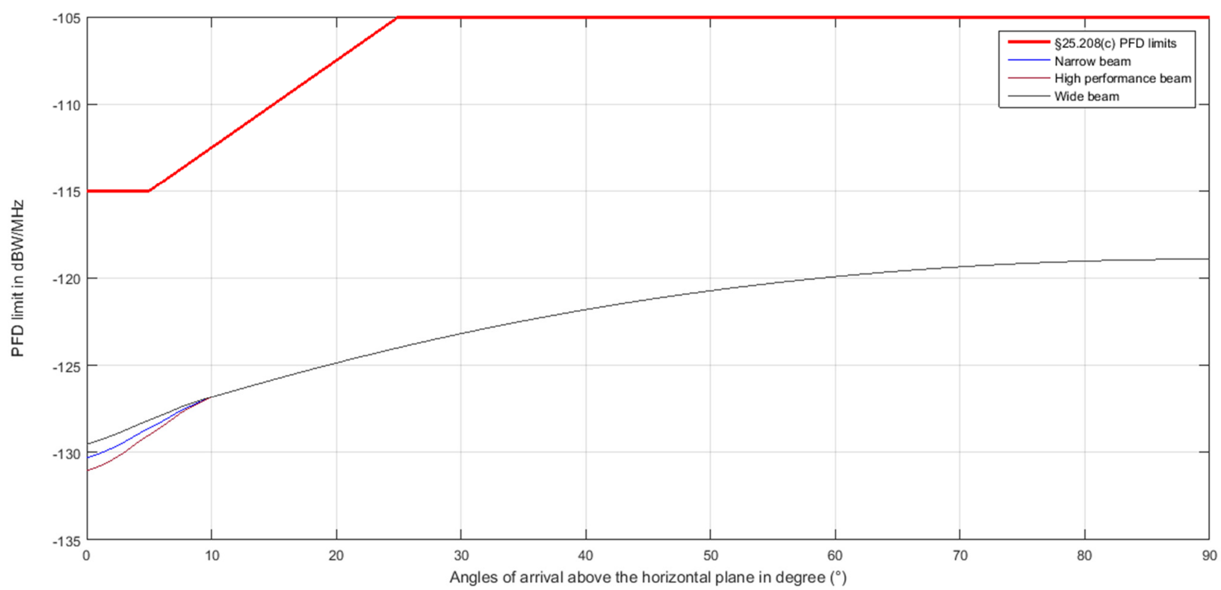
As shown in the table above, the ITU PFD limits for the 19.3-19.7 GHz band are identical to the FCC PFD limits under § 25.208(c) for the band. Additionally, the ITU PFD limits for the 17.8-

19.3 GHz band are identical to the FCC PFD limits under § 25.208(e), and are specified as a function of the number of satellites in an NGSO constellation.  Given the number of satellites in the LeoSat constellation, the PFD limits under § 25.208(e) and under ITU RR Art. 21 (for 17.8-19.3 GHz) are more stringent than those under § 25.208(c).

The LeoSat system is designed to comply with the ITU PFD limits for the 17.8-19.7 GHz band on a global basis.  Consequently, LeoSat also meets the PFD requirements of § 25.208 by complying with equivalent or more stringent ITU PFD limits.[5]

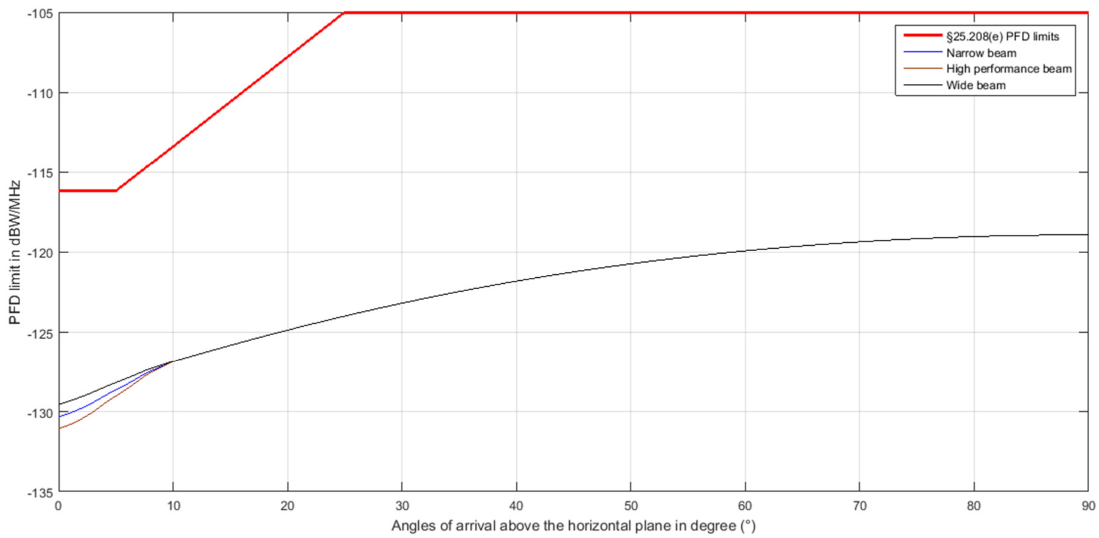
The following graphs show system compliance with the PFD limits for all operational pointing directions.  The maximum downlink e.i.r.p. density for LeoSat satellite is 15 dBW/MHz as indicated in the attached Schedule S.

- 18.3-18.6 GHz and 19.3-19.7 GHz frequency bands (§ 25.208(c)).




- 18.8-19.3 GHz frequency band (§ 25.208(e)). The number of non-GSO satellites considered is 78 for determination of PFD mask defined in § 25.208(e).

[5] Although § 25.208 does not specify any PFD limit for the 17.8-18.3 GHz band, LeoSat nonetheless will comply with the PFD limits under ITU RR Art. 21 for the band and under § 25.208(e), thereby ensuring additional interference protection of FS systems.




Compliance with the most restrictive PFD limit is achieved with a minimum margin of 11.9 dB at 5 degree elevation.

### 6.5 Interference with Respect to Terrestrial Networks in the 27.5-28.35 GHz Band

LeoSat will comply with FCC rules requiring interference protection and coordination with terrestrial operations in the 27.5-28.35 GHz uplink band, to the extent that it seeks future FCC licensing of any U.S. user terminals or gateways in the band on a secondary basis.[6]

## 7. ITU FILINGS

The LeoSat satellite system is registered with the ITU under filings by France for the MCSAT-2 LEO-2 satellite network. The relevant French ITU filings for the MCSAT-2 LEO-2 satellite network are listed in the table below:

| Publication Reference | Date of Receipt | IFIC number | IFIC Date |
|---|---|---|---|
| API/A/9837 | 29.01.2014 | 2790 | 17.03.2015 |
| CR/C/3723 | 25.11.2014 | 2797 | 23.06.2015 |
| API/A/9837 MOD-1 | 01.06.2015 | 2798 | 07.07.2015 |
| CR/C/3723 MOD-1 | 25.11.2014 | 2808 | 24.11.2015 |
| CR/C/3723 MOD-2 | 14.12.2015 | 2824 | 19.07.2016 |
| CR/D/2967 | 14.12.2015 | 2825 | 02.08.2016 |

[6] *Use of Spectrum Bands Above 24 GHz for Mobile Radio Services,* Report and Order and Further Notice of Proposed Rulemaking, 31 FCC Rcd 8014, 8031-42 ¶¶ 43-69 (2016).

The MCSAT-2 LEO-2 satellite network includes a range of mutually exclusive orbit configurations. The LeoSat system will make use of a subset of the MCSAT-2 LEO-2 frequency assignments corresponding to the orbit parameters described in this FCC filing.

## 8. CESSATION OF EMISSIONS (§ 25.207)

Each satellite transmission chain can be individually turned off by ground telecommand, thereby causing cessation of emissions from the satellite, as required by 47 C.F.R. § 25.207.

The satellites will be neutralized by ground procedures once the satellite reaches the disposal orbit, including the following:

- cessation of payload emissions and complete switch-off of all payload units;
- disabling of all Failure Detection, Isolation and Recovery routines;
- passivation of solar power source from the bus and inhibition of battery charging routines;
- switch-off the last telemetry transmitter;
- if some energy remains in the batteries, all remaining operating units will switch-off as a result of bus undervoltage[7] and remain off.

## 9. ORBITAL DEBRIS MITIGATION (§ 25.114(d)(14))

As discussed in the accompanying Petition for Declaratory Ruling, the LeoSat constellation is expected to be licensed by France. Thus, LeoSat's debris mitigation plans will be subject to direct and effective French regulatory oversight, and are not required to be submitted to the Commission under 47 C.F.R. § 25.114(d)(14)(v).

Nonetheless, additional information regarding LeoSat's proposed debris mitigation strategy is provided below to facilitate Commission review.

### 9.1 Limiting Debris Released During Normal Operations

By design, no debris will be released in a planned manner during normal operations of the LeoSat space stations at any mission phase. In addition, the probability of the LeoSat space stations becoming a source of debris by collisions with small debris or meteoroids smaller than one centimeter in diameter that could cause loss of control and prevent post-mission disposal will be assessed and limited.

Associated detailed computations will be led during the design and development of the LeoSat satellites by Thales Alenia Space in their capacity as the system prime contractor. The satellite subcontractors will be required to incorporate into their designs explicit features for minimization of the generation of orbital debris. This includes, for example, the use of non-debris generating appendage hold down and release mechanisms, selection of appropriate construction materials (*e.g.,* external thermal control surfaces and coatings), and operational procedures.

[7] Undervoltage is a hardware routine inside each unit leading to complete shutdown.

## 9.2 Mitigating Accidental Explosions

The probability of accidental explosions during and after completion of mission operations will be assessed and limited as part of the LeoSat satellite design. The only sources of stored energy on the LeoSat satellites are listed below:

- Chemical/pressure: pressurized gas tank, battery and heat pipes; and
- Kinetic: reaction wheels, solar array drive motors, Ka-band antenna drive motors and optical terminal drive motors.

During the LeoSat satellite design and development program conducted by Thales Alenia Space, the satellite subcontractors will be required to perform failure modes and effects analyses ("FMEA") to demonstrate acceptably low probability of failure from all possible failure sources. These analyses include the probability of failure of pressure vessels resulting in an accidental explosion. Suitable design safety margins will be required and formally verified in order to demonstrate the achievement of acceptably low probabilities of occurrence of such failure modes.

At end-of-life of any given LeoSat satellite, mission operational rules and procedures call for the maneuvering of the satellite to a disposal orbit, followed by passivation of all stored energy sources. This includes de-spinning of the reaction wheels, venting of residual gas by opening all thruster valves, and connection of on-board electrical loads sufficient to cause the satellite's battery to fully discharge, which also results in the passivation of all other on-board kinetic energy sources.

The batteries used on LeoSat are based on Li-ion cells. Each cell incorporates a "leak before burst" safety disk to prevent explosion in the event of overcharge.

The heat pipes used in the construction of the LeoSat space stations are aluminum tubes filled with anhydrous ammonia. They are inherently low pressure, and built to leak before burst due to the soft aluminum alloy used. There are no known events of on-orbit explosion of a heat pipe using this type of construction, which has been commonly used for many decades in space. Furthermore, there is no self-destruct system inside the satellite.

## 9.3 Collision Avoidance

The probability of the LeoSat space stations becoming a source of debris by collisions with large debris or other operational space stations will be assessed and limited. The orbit design of the LeoSat satellite system explicitly took into account the probability of collision with large debris, including other operational LeoSat satellites. In particular, the phasing offsets selected for LeoSat satellites in adjacent orbital planes were specifically analyzed and selected so as to minimize collision probabilities at the convergent polar crossings that occur each orbit.

The individual LeoSat satellites in their approximately 1400 km circular mission orbit will be maintained within specific orbital tolerances via periodic propulsive station-keeping.

LeoSat will use specialized software in its mission control facility to regularly evaluate collision risks with other space stations, based on the most current available space station orbital element sets maintained and disseminated by USSTRATCOM. Collision avoidance maneuvers will be executed as required to reduce probabilities below recommended thresholds. A portion of LeoSat's mission orbit maintenance propellant budget will be specifically reserved for collision avoidance maneuvers.

Whenever LeoSat satellites are required to undergo orbital maneuvers, pre-maneuver coordination with USSTRATCOM will be accomplished so that the appropriate authorities are aware of the maneuver plans and can advise LeoSat whether such maneuvers pose any risks. This includes screening planned launch trajectories and ascent from injection orbit to storage, drift, or mission orbit.

Orbit control is specified that any one satellite be within certain radial, intrack, and crosstrack variations from its nominal position, as required to maintain LeoSat operations and support collision avoidance.

The satellite design will also limit consequences in case of small debris collision.

All ground operational procedures for orbit raising operations, mission station-keeping operations and de-orbiting operations will be verified before use.

### 9.4 Post-Mission Disposal

LeoSat's individual satellites will be placed in a disposal orbit at end-of-life. The propellant budget will include an allocation of maneuvering and attitude control propellant to accomplish this disposal orbit maneuvering. Sufficient propellant will be reserved to take into account various uncertainties in the maneuvering process.

Although details of its post-mission disposal strategy will be determined as the satellite design is further developed, LeoSat anticipates that, consistent with NASA, French, IADC, and other international guidelines for LEO systems, post-mission disposal may be performed by propulsive maneuvering of the satellite into either (i) a higher orbit (*i.e.,* a perigee altitude higher than 2000 km); or (ii) a lower orbit for which the predicted orbital lifetime is less than 25 years, until atmospheric re-entry occurs as a result of natural orbital decay processes.[8]

Following final completion of the post-mission disposal, passivation of the satellite will be accomplished to remove on-board stored energy from the vehicle, as described above.

[8] A casualty risk assessment will be conducted by Thales Alenia Space, using a debris assessment software to demonstrate compliance with the established guideline of 1:10,000.

## 10. ADDITIONAL INFORMATION CONCERNING SCHEDULE S DATA

In the Schedule S, the maximum e.i.r.p. for transmit beams indicated corresponds to a 500 MHz channel. LeoSat satellite beams may also transmit 400 MHz channels, in which case the maximum e.i.r.p. is decreased by 1 dB.

## 11. ANNEX 1: DEMONSTRATION OF EPFD UP COMPLIANCE

In order to demonstrate compliance with the equivalent power flux density ($EPFD_{up}$) limits, in the Earth-to-space direction, all the technical assumptions considered in this Annex are described in the table below:

| LeoSat Parameters | |
|---|---|
| **Maximum number of co-frequency tracked non-GSO satellites** | 1 |
| **Minimum elevation angle** | 10° |
| **Maximum number of co-frequency ES transmitting simultaneously per cell or beam** | 1 |
| **Average distance between cell or beam footprint centres** | 739 km |
| **Earth station e.i.r.p. mask** | The figure 1 provides the Earth Station off-axis e.i.r.p. mask in dBW/40kHz |
| **Minimum GSO arc avoidance angle** | 7° |

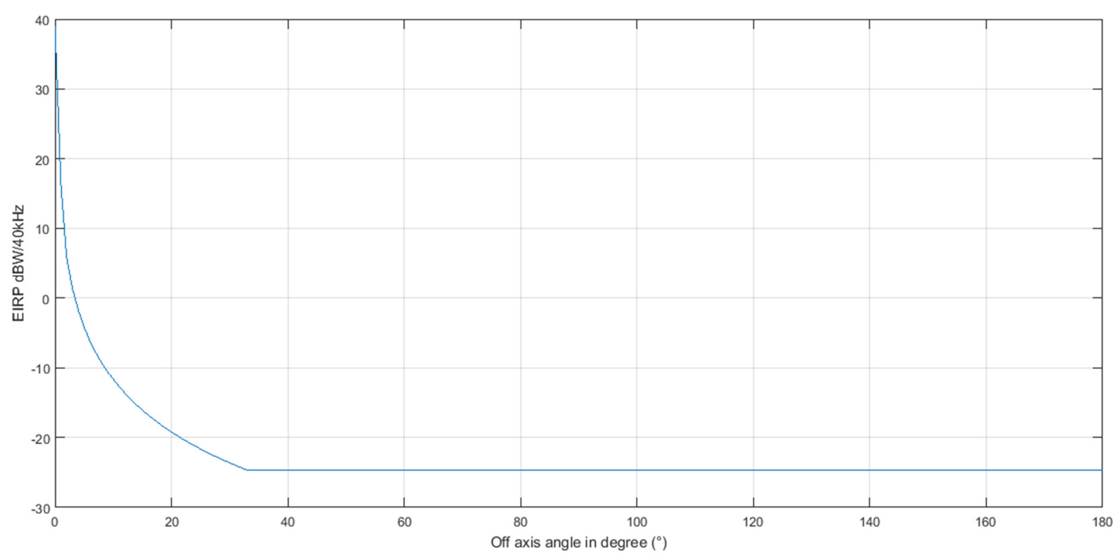



Figure 1: LeoSat Earth Station e.i.r.p. mask.

The figure 2 provides the $EPFD_{up}$ cumulative distribution function from the EPFD validation algorithm using the different assumptions defined and the methodology described in

Recommendation ITU-R S.1503-2.

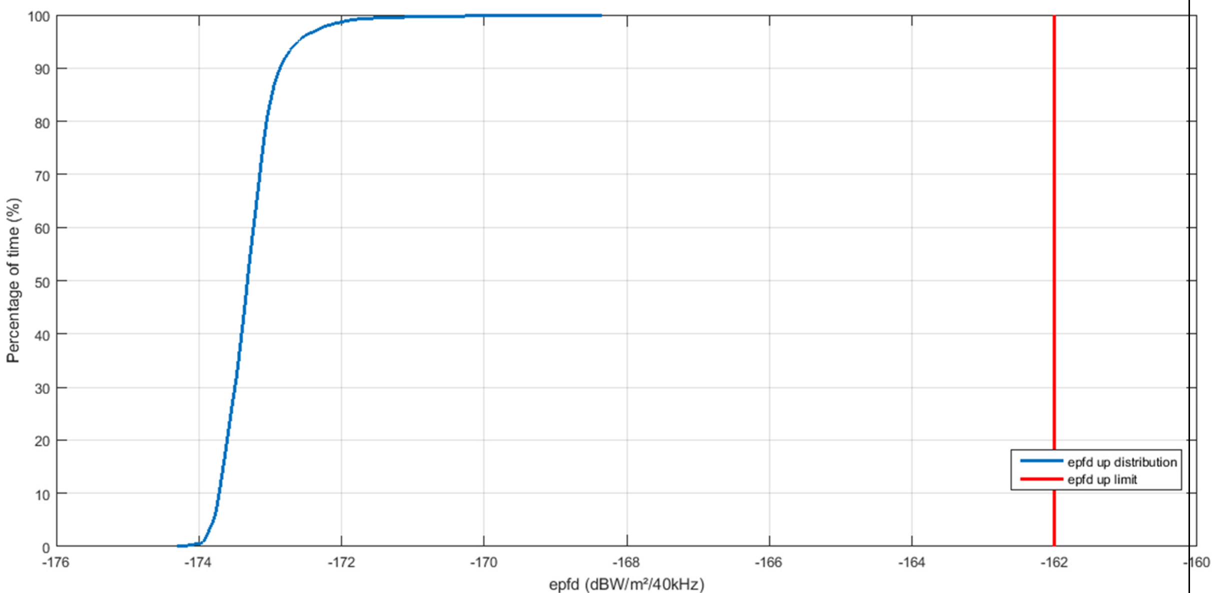



Figure 2: $EPFD_{up}$ distribution for LeoSat Earth Station deployment.

The results in the Figure above demonstrate that the LeoSat system complies with a significant margin to the $EPFD_{up}$ limits.

## 12. ANNEX 2: DEMONSTRATION OF EPFD DOWN COMPLIANCE

In order to demonstrate compliance with equivalent power flux density ($EPFD_{down}$) limits, in the space-to-Earth direction, LeoSat is providing the Commission with all the technical assumptions needed to make the calculation. Since the currently available ITU computer program does not adequately model some non-GSO satellites constellations using steerable beams such as LeoSat, the algorithm described in the Working Document WP4A/196/Annex21 has been used, consistently with WRC-15 decisions.
All the technical assumptions are described below:

- The maximum number of LeoSat satellites transmitting with overlapping frequencies to a given location (Nco) is equal to 1 for all latitudes.
- The minimum avoidance angle seen from the GSO earth station between the non-GSO satellites and the GSO arc is 7°.
- The minimum elevation angle at which any associated earth station can communicate to a non-GSO satellite is 10°.
- Minimum tracking duration is the minimum time during which the earth station must remain connected to the non-GSO satellite. This additional parameter has been introduced to better model the behavior of steerable beams in non-GSO constellations. The minimum tracking duration is latitude and frequency band dependent. The values are provided in the following table.
- Downlink power adjustment is implemented on LeoSat satellites. Maximum satellite e.i.r.p. is dependent of the non-GSO earth station location. The information is provided in figure 1 of this Annex.

The Table 1 provides all the minimum earth station tracking duration per latitude for the frequency band 19.7-20.2 GHz and per antenna used for a specific LeoSat setting. The LeoSat minimum tracking duration in the frequency band 17.8-18.6 GHz is 30 seconds.

| Latitude | **LeoSat earth station minimum tracking duration in seconds** |
|---|---|
| | 19.7-20.2 GHz frequency bands |
| 0° | 30s |
| 5° | 30s |
| 10° | 60s |
| 15° | 60s |
| 20° | 60s |
| 25° | 60s |
| 30° | 60s |
| 35° | 90s |
| 40° | 150s |
| 45° | 150s |
| 50° | 450s |
| 55° | 600s |
| 60° | 650s |
| 65° | 700s |

| | |
|---|---|
| 70° | 750s |
| 75° | 800s |

The minimum earth station tracking duration does not impose additional constraints on the LeoSat System. The following Figure (Figure 1) shows the number of available LeoSat satellites as a function of latitude; a LeoSat satellite is considered available when it meets operational parameters including minimum earth station tracking duration defined here above and also the protection of all GSO systems.

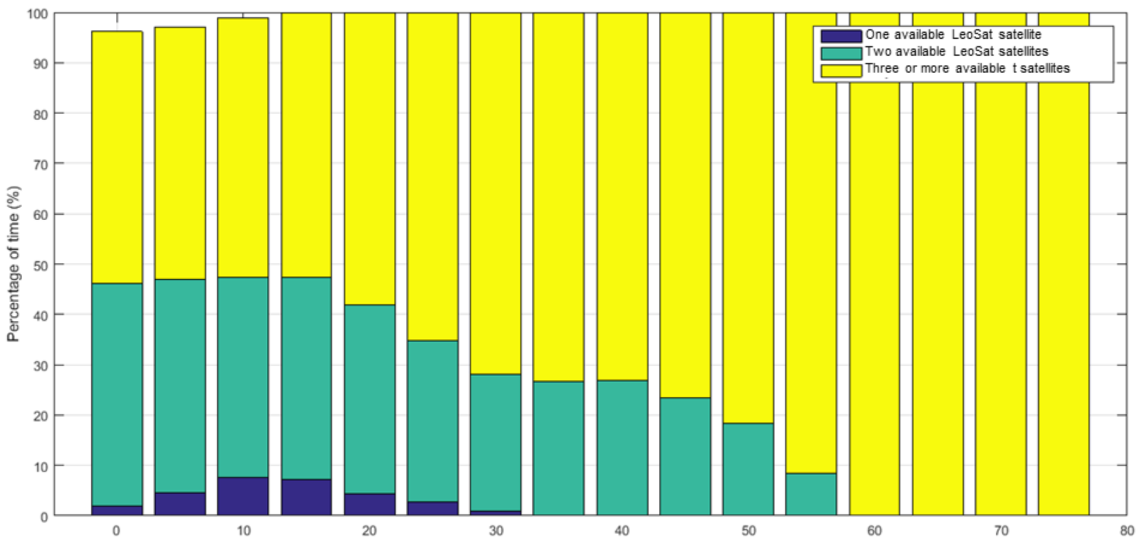


Figure 1: Number of available LeoSat satellites as a function of latitude.

Figures 2 &3 provide the maximum e.i.r.p. that is intended to be used by the LeoSat system, according to satellite beam boresight latitude location (*i.e.*, the latitude of the point on earth that is targeted by the LeoSat satellite antenna).

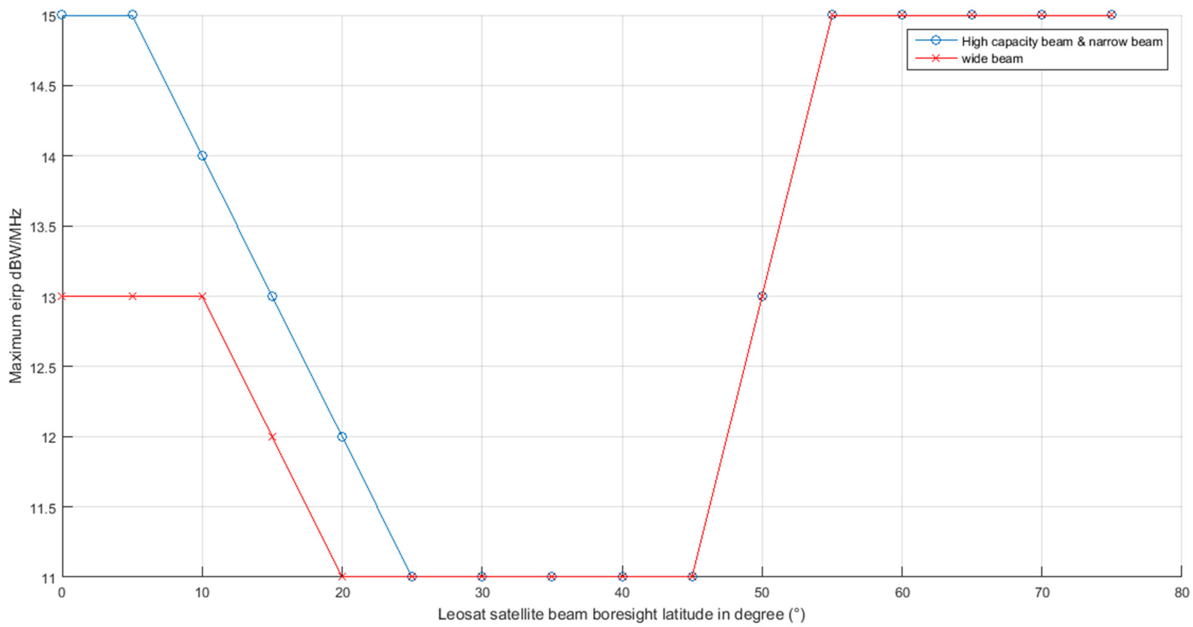



Figure 2: Maximum e.i.r.p. per latitude in the frequency band 19.7-20.2 GHz.

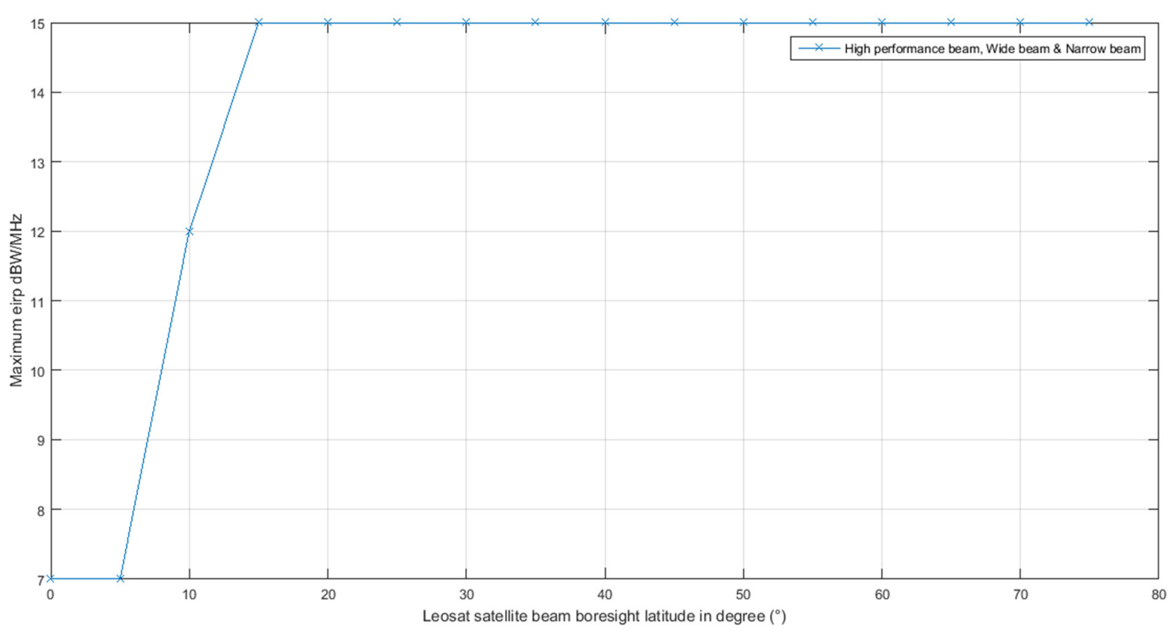



Figure 3: Maximum e.i.r.p. per latitude in the frequency band 17.8-18.6 GHz.

Other combinations of minimum tracking duration and maximum satellite beam e.i.r.p. could be implemented to meet the $EPFD_{down}$ limits.

The results from the EPFD algorithm using all the assumptions described in this annex are provided below.

Each figure corresponds to one of the GSO reference earth station described in ITU RR 22.5C (Tables 22-1B and 22-1C). The $EPFD_{down}$ distribution is provided for different GSO earth station latitudes. On each diagram the EPFD mask is shown by the red dotted line. The labeling of each figure indicates the frequency band, the GSO antenna diameter, the reference bandwidth and the LeoSat beam type.

*17.8-18.6 GHz frequency band*
*1 m GSO antenna size*
*Reference bandwidth: 40 kHz*
*LeoSat beam: high capacity beam and narrow beam*

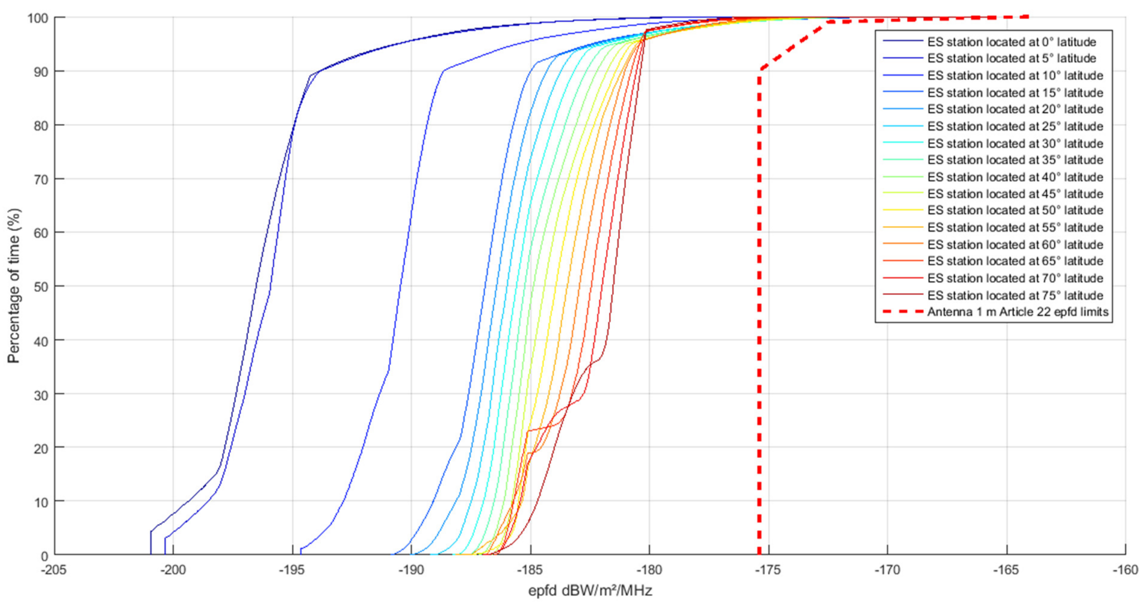



Figure 4: $EPFD_{down}$ results

*17.8-18.6 GHz frequency band*
*2 m GSO antenna size*
*Reference bandwidth: 40 kHz*
*LeoSat beam: high capacity beam and narrow beam*

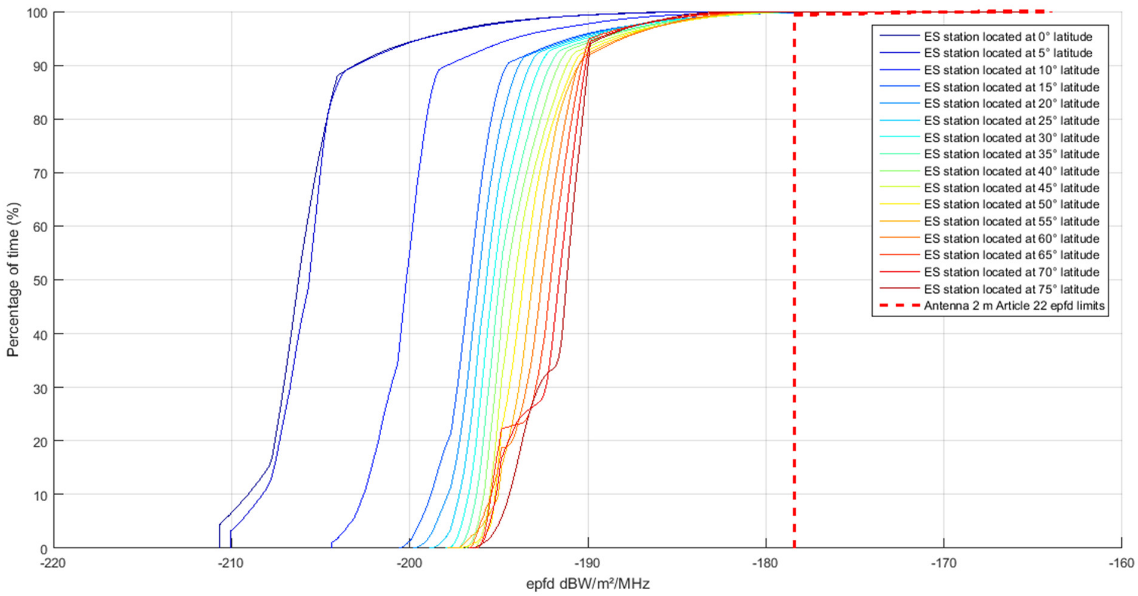



Figure 5: $EPFD_{down}$ results

*17.8-18.6 GHz frequency band*
*5 m GSO antenna size*
*Reference bandwidth: 40 kHz*
*LeoSat beam: high capacity beam and narrow beam*

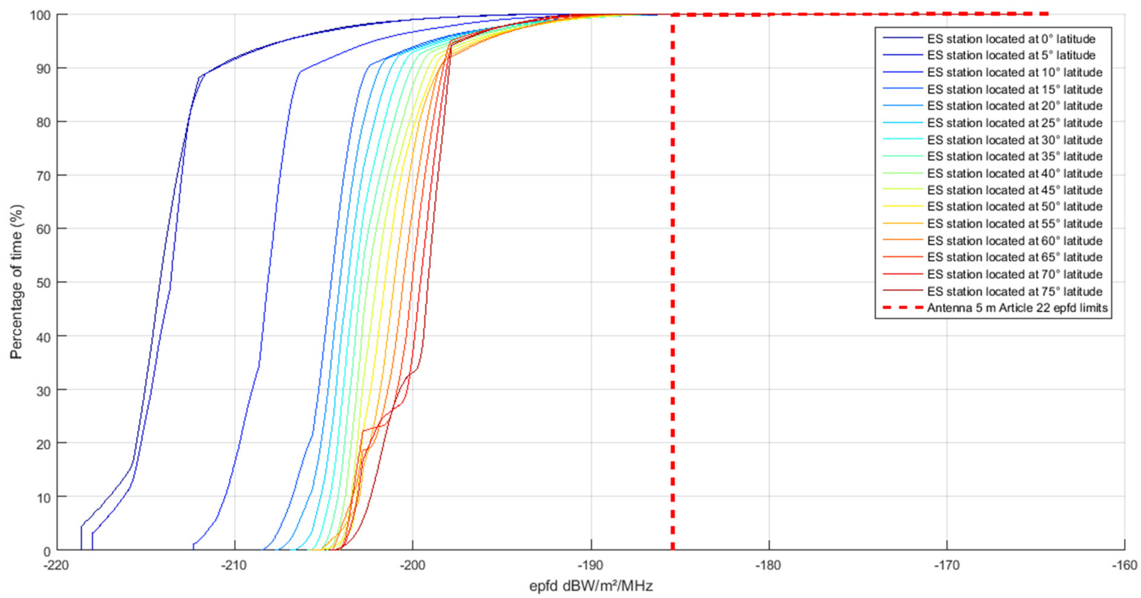



Figure 6: $EPFD_{down}$ results

*19.7-20.2 GHz frequency band*
*0.7 m GSO antenna size*
*Reference bandwidth: 40 kHz*
*LeoSat beam: high capacity beam and narrow beam*

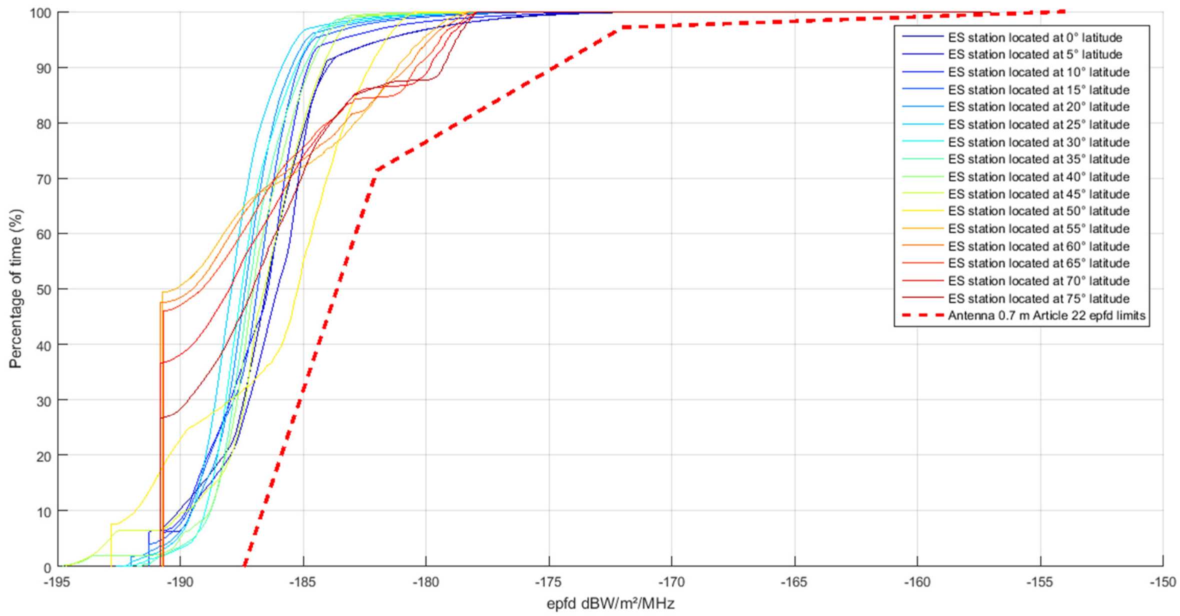



Figure 7: $EPFD_{down}$ results

*19.7-20.2 GHz frequency band*
*0.9 m GSO antenna size*
*Reference bandwidth: 40 kHz*
*LeoSat beam: high capacity beam and narrow beam*

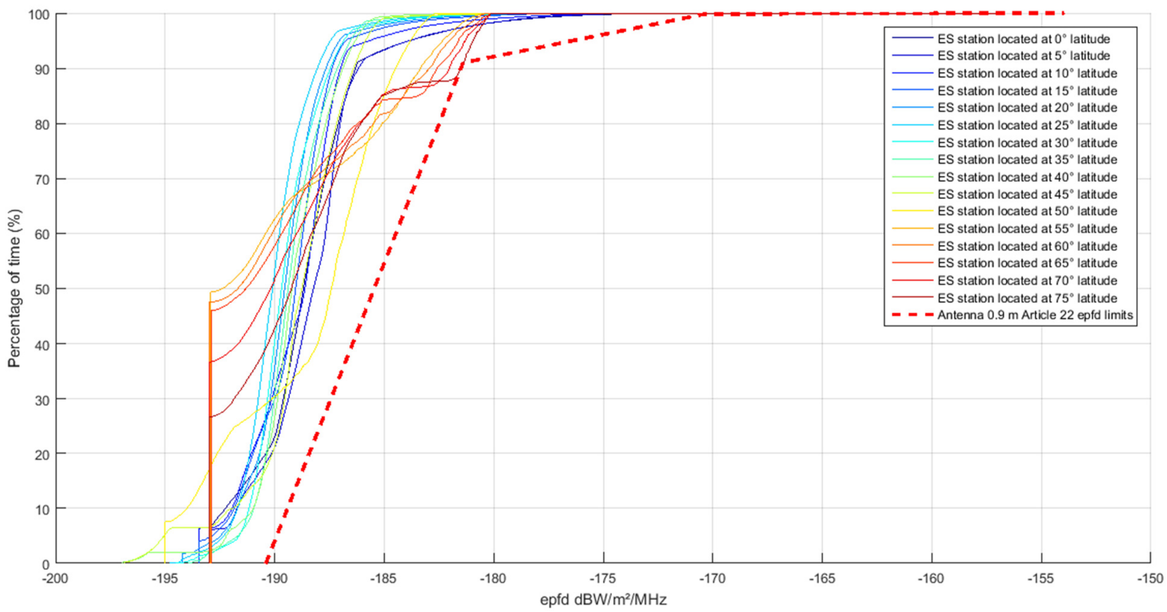



Figure 8: $EPFD_{down}$ results

*19.7-20.2 GHz frequency band*
*2.5 m GSO antenna size*
*Reference bandwidth: 40 kHz*
*LeoSat beam: high capacity beam and narrow beam*

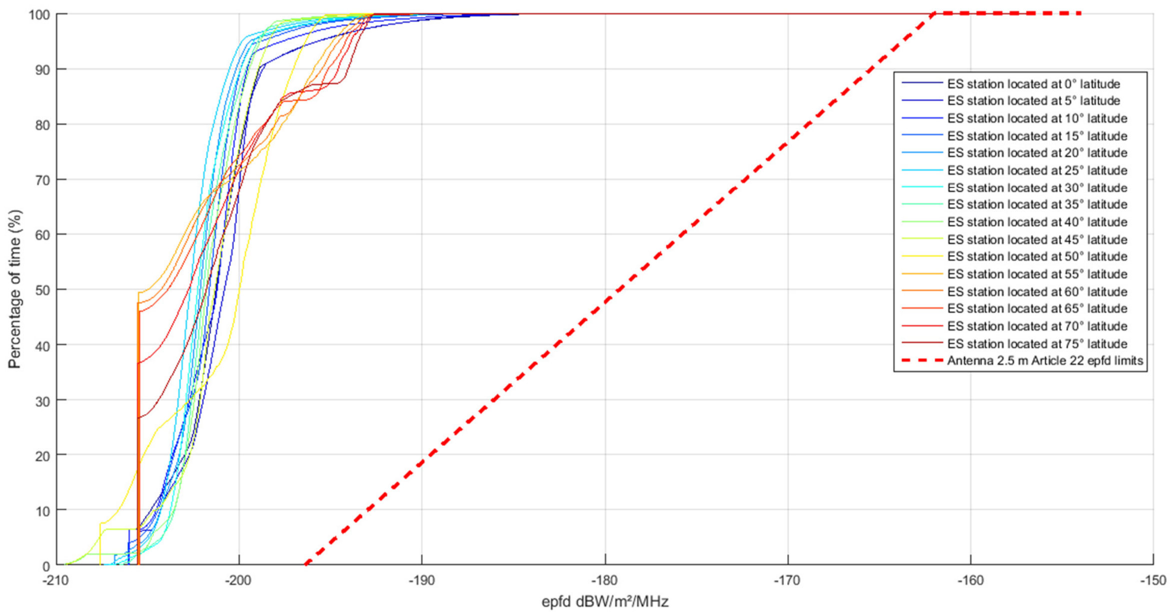



Figure 9: $EPFD_{down}$ results

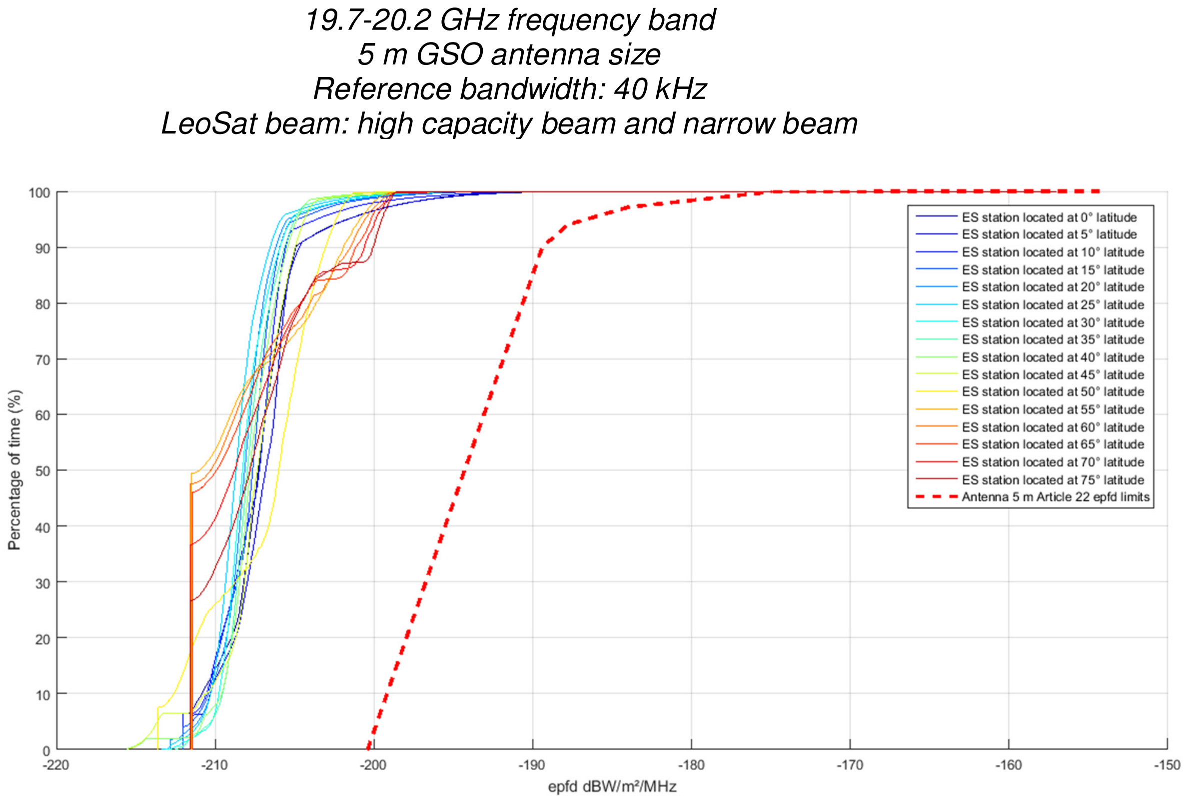



Figure 10: $EPFD_{down}$ results

*17.8-18.6 GHz frequency band*
*1 m GSO antenna size*
*Reference bandwidth: 40 kHz*
*LeoSat beam: wide beam*

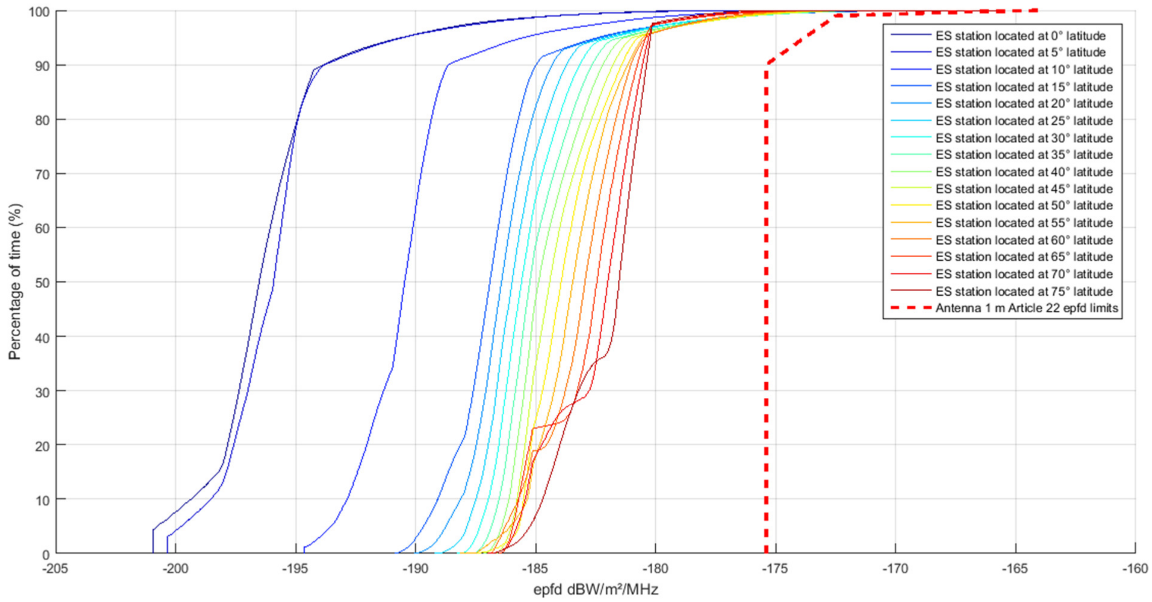



Figure 11: $EPFD_{down}$ results

*17.8-18.6 GHz frequency band*
*2 m GSO antenna size*
*Reference bandwidth: 40 kHz*
*LeoSat beam: wide beam*

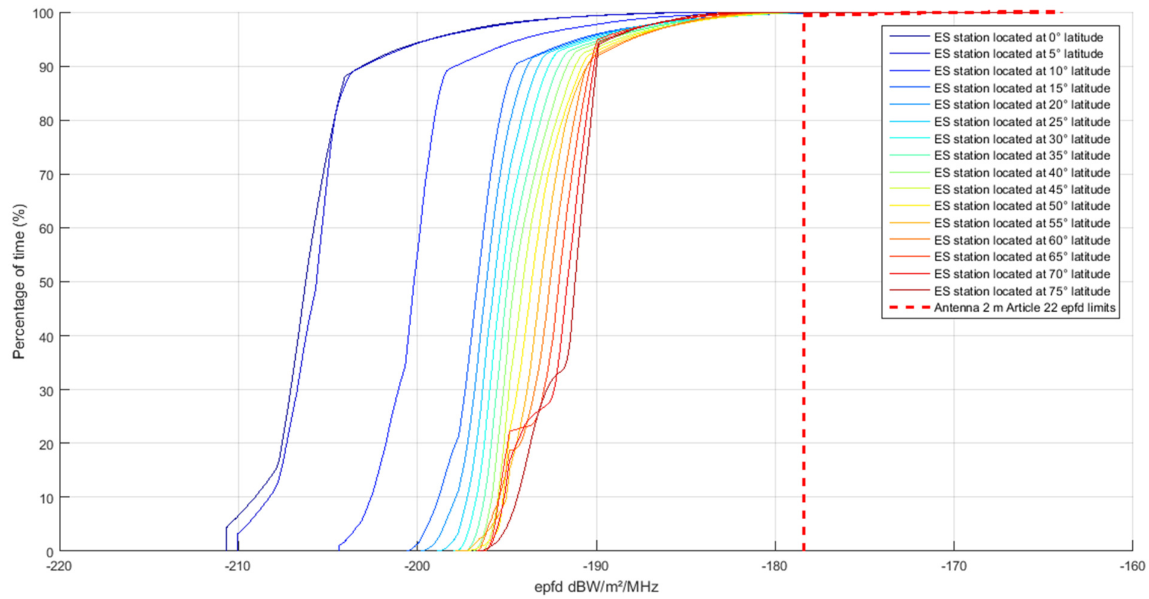



Figure 12: $EPFD_{down}$ results

*17.8-18.6 GHz frequency band*
*5 m GSO antenna size*
*Reference bandwidth: 40 kHz*
*LeoSat beam: wide beam*

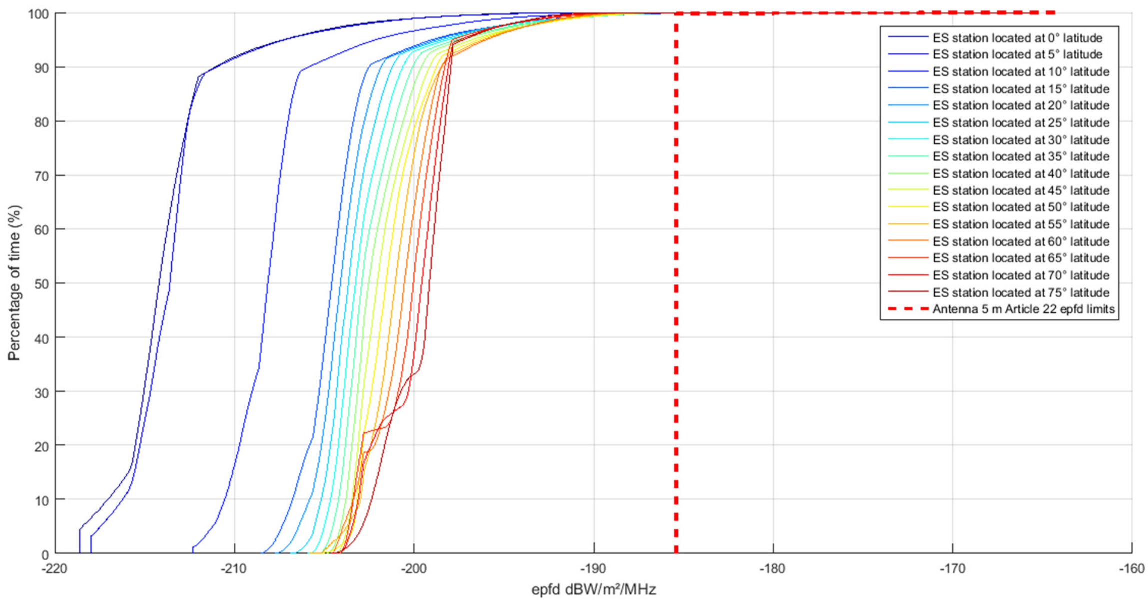



Figure 13: $EPFD_{down}$ results

*19.7-20.2 GHz frequency band*
*0.7 m GSO antenna size*
*Reference bandwidth: 40 kHz*
*LeoSat beam: wide beam*

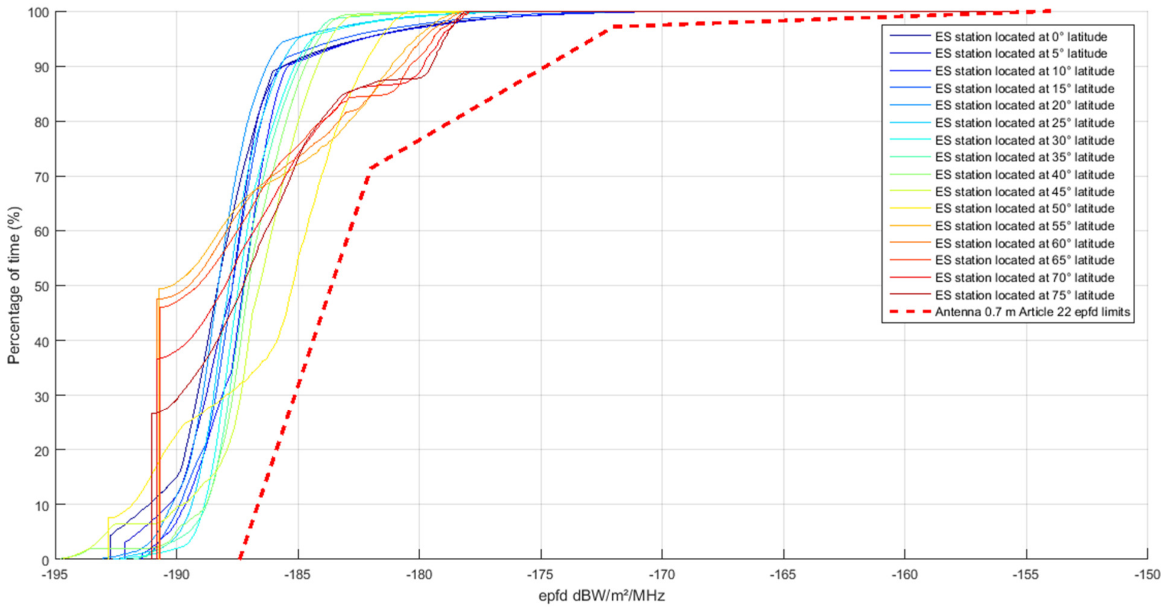



Figure 14: $EPFD_{down}$ results

*19.7-20.2 GHz frequency band*
*0.9 m GSO antenna size*
*Reference bandwidth: 40 kHz*
*LeoSat beam: wide beam*

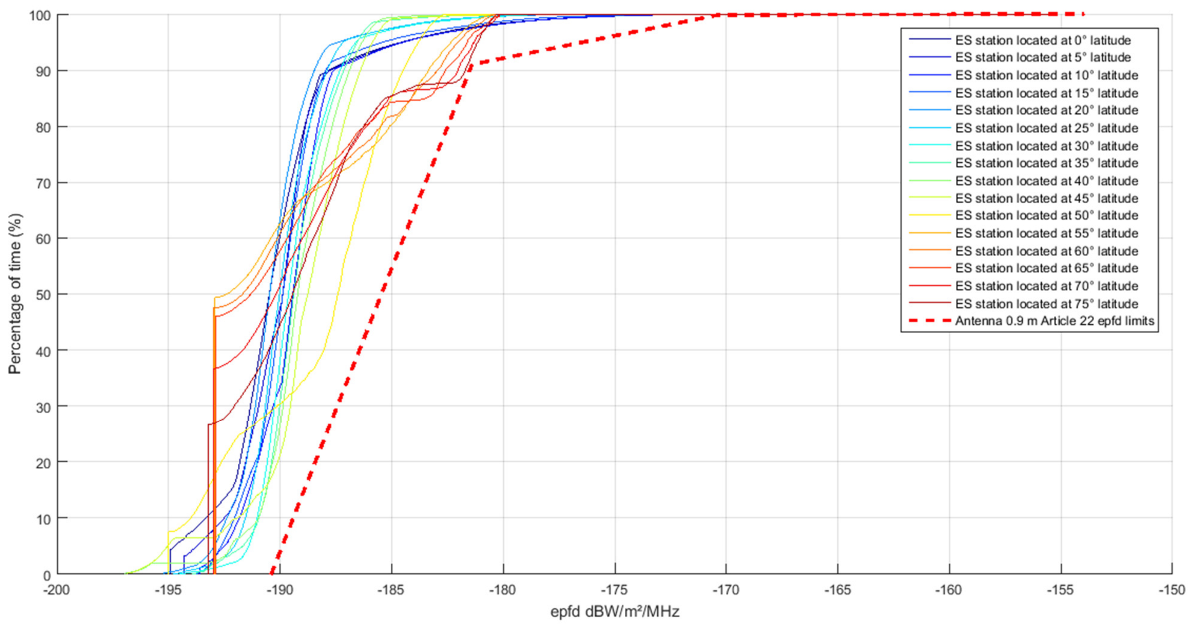



Figure 15: $EPFD_{down}$ results

*19.7-20.2 GHz frequency band*
*2.5 m GSO antenna size*
*Reference bandwidth: 40 kHz*
*LeoSat beam: wide beam*

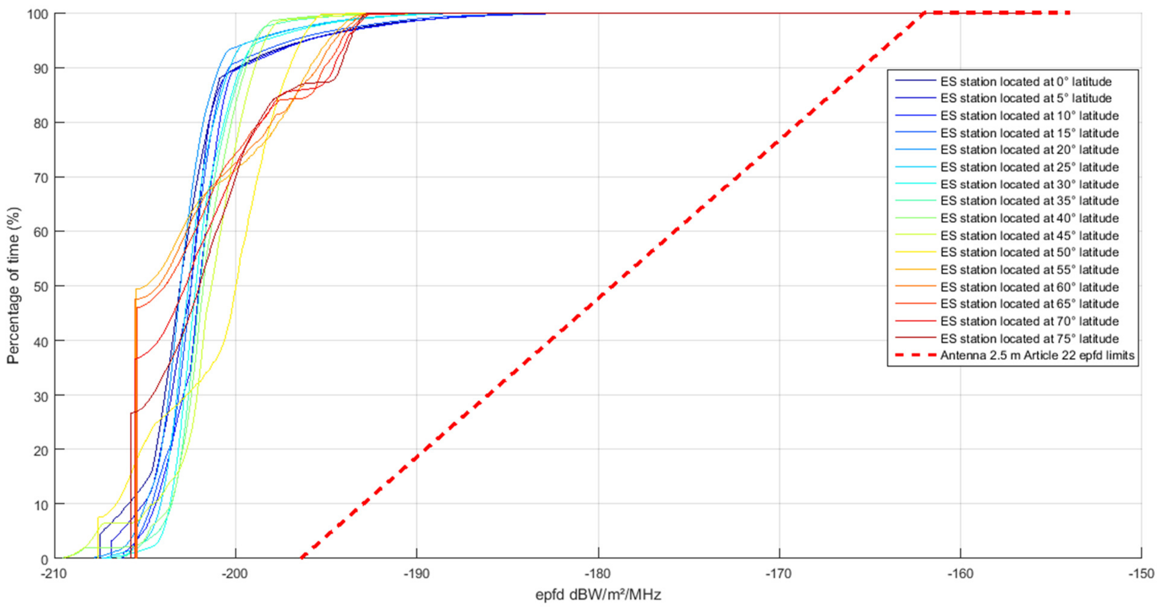



Figure 16: $EPFD_{down}$ results

*19.7-20.2 GHz frequency band*
*5 m GSO antenna size*
*Reference bandwidth: 40 kHz*
*LeoSat beam: wide beam*

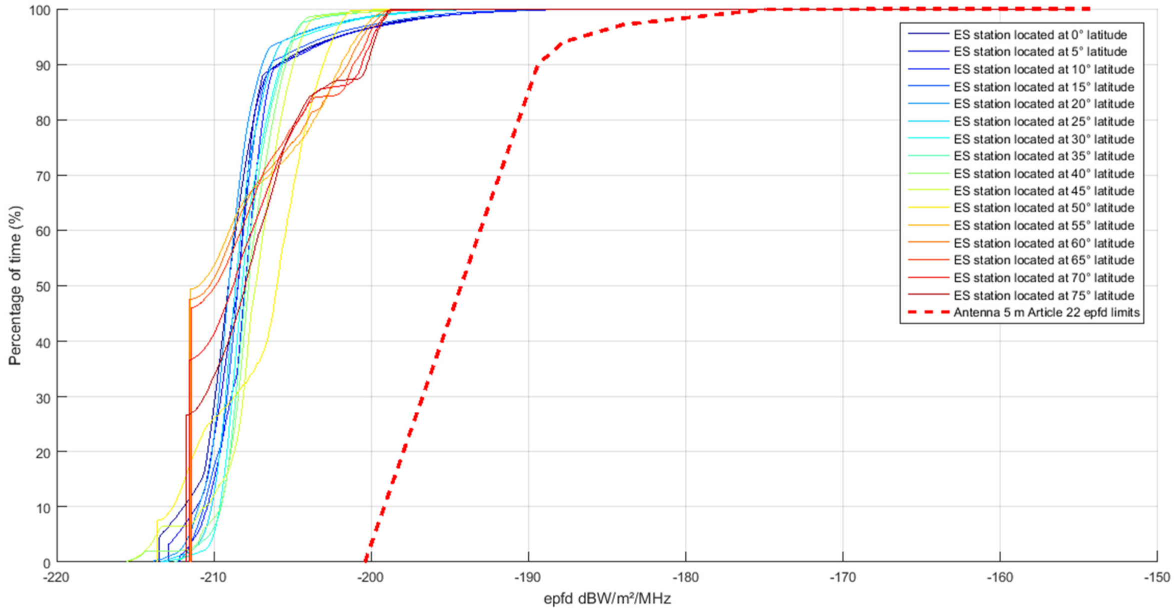



Figure 17: $EPFD_{down}$ results

The results in the Figures above demonstrate that the LeoSat system complies with $EPFD_{down}$ limits.

## 13. ANNEX 3: EPFD-INTER SATELLITE ANALYSIS

The ITU $EPFD_{is}$ limits protect GSO space station receivers in the 17.8-18.4 GHz band, which is allocated bi-directionally to FSS. The technical assumptions used in this Annex 3 include the following:

- The orbital parameters of LeoSat constellation are consistent with associated Schedule S submission.
- The space station e.i.r.p. mask (dBW/40kHz).
  This mask provided in Figure 1 below defines the off-axis e.i.r.p. density of the LeoSat transmitting space station as a function of an angle defined as the angle seen at the non-GSO satellite between the non-GSO sub-point on the earth and the GSO arc. A single mask is defined that represents the highest density levels for all point directions toward the GSO arc (dBW/40kHz).
- The minimum GSO avoidance angle is 7°.

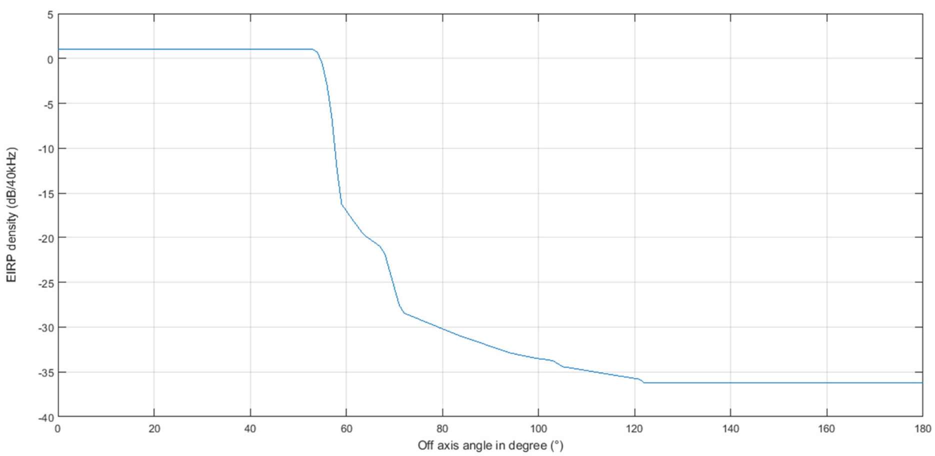



Figure 1: Space station e.i.r.p. mask (dBW/40kHz)

Two worst-case geometries have been considered in this Annex:

- Case 1, the GSO satellite beam is pointing at 0° elevation toward non-GSO satellites.
- Case 2, the GSO satellite beam is pointing at its sub-point (minimum distance between LeoSat non-GSO satellite and the GSO satellite).

The figure below describes the two worst-case geometry situations.

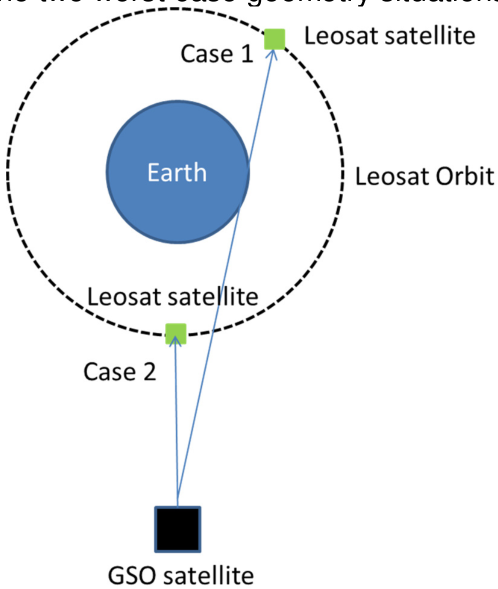



Figure 2 : Worst Case geometry situations

The Figure 3 provides the $EPFD_{is}$ cumulative distribution function using the methodology described in Recommendation ITU-R S.1503-2.

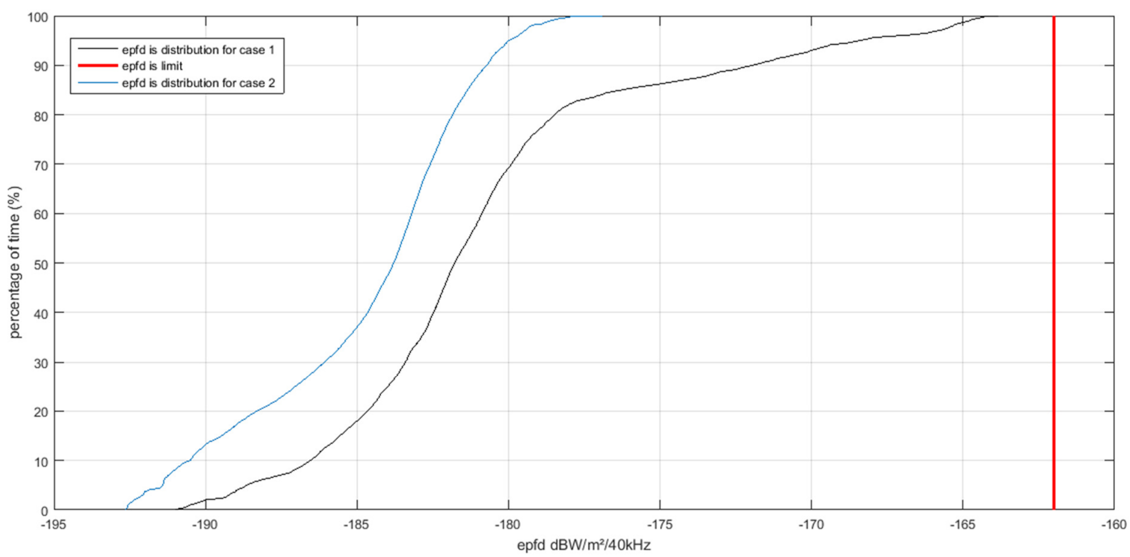



Figure 3 : $EPFD_{is}$ distributions for LeoSat space station in two worst-case geometry situations.

The results in Figure 3 above demonstrate that LeoSat compliance with $EPFD_{is}$ limits.

## 14. ANNEX 4: LIST OF ACRONYMS

| | |
|---|---|
| ACM | Adaptive Coding and Modulation |
| AOCS | Attitude and Orbital Control Systems |
| API | Advanced Publication Information |
| BPSK | Binary Phase-Shift Keying |
| CDF | Cumulative Distribution Function |
| CFR | Code of Federal Regulations |
| DAS | Debris Assessment Software |
| DVB | Digital Video Broadcast (Standard) |
| EIRP | Equivalent Isotropic Radiated Power |
| EPFD | Equivalent PFD |
| ES | Earth Station |
| ESA | European Spatial Agency |
| FCC | Federal Communications Commission |
| FDIR | Failure detection, Isolation and Recovery |
| FMEA | Failure Mode Effect Analysis |
| FS | (terrestrial) Fixed Service |
| FSS | Fixed Satellite Service |
| GPS | Global Positionning System |
| GSO | Geostationary Earth Orbit |
| IADC | Inter-Agency Space Debris Coordination Committee |
| IFIC | International Frequency Information Circular |
| ISL | Inter-Satellite Link |
| ITU | International Telecommunication Union |
| LEO | Low Earth Orbit |
| LEOP | Launch and Early Orbit Phase (Operations) |
| LHCP | Left-Hand Circular Polarization |
| LMDS | Local Multipoint Distribution Service |
| MEO | Medium Earth Orbit |
| MSS | Mobile Satellite Service |
| NASA | National Aeronautic and Space Administration |
| NGSO | Non-GSO |
| OBP | On-Board Processor |
| OISL | Optical ISL |
| PFD | Power Flux Density |
| PM | Phase Modulation |
| RF | Radio Frequency |
| RHCP | Right-Hand Circular Polarization |
| RR | Radio Regulation |
| SCPC | Single Channel Per Carrier |
| TAS | Thales Alenia Space |

| | |
|---|---|
| TC | Telecommand |
| TDM | Time Division Multiplexing |
| TM | Telemetry |
| TT&C | Telemetry, Tracking, and Command |
| VPN | Virtual Private Network |
| WRC | World Radiocommunications Conference |