ATTACHMENT A

Technical Information to Supplement Schedule S ("Technical Annex")

TABLE OF CONTENTS

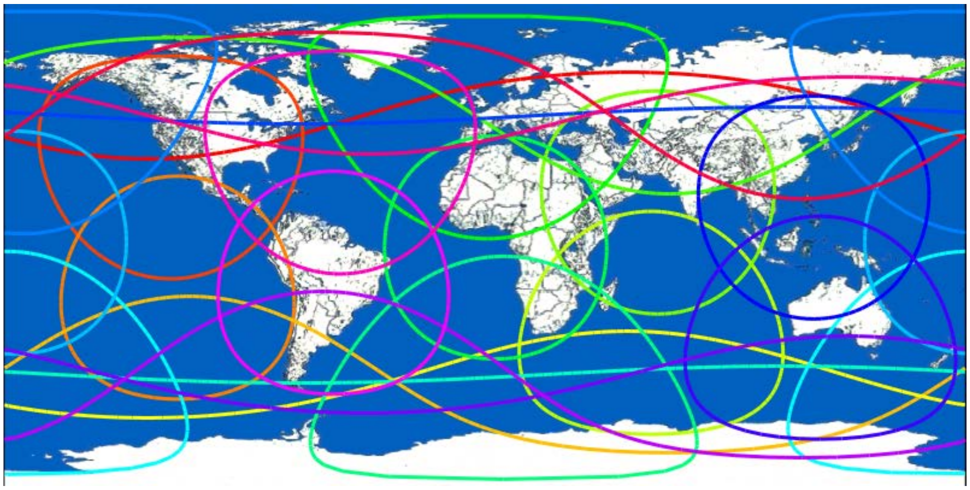
This Technical Annex provides technical information regarding the VIASAT-NGSO satellite network for which market access is sought and supplements the information provided in the Schedule S accompanying this submission.

I. TECHNICAL INFORMATION FOR NGSO SYSTEMS REQUIRED BY §25.114

A. §25.114(d)(1) Overall description of system facilities, operations and services and explanation of how uplink frequency bands would be connected to downlink frequency bands

The VIASAT-NGSO satellite network includes a constellation of 24 MEO FSS satellites in 3 orbital planes of 8 satellites each, plus one spare satellite per plane. The planes are inclined at 87° to the equator and the satellites are in circular orbits at an altitude of 8,200 km. In addition to the satellite constellation, the system includes (i) end-user earth stations, (ii) gateway-type earth stations that provide aggregation and interconnection with the internet backbone and the public switched telephone network (referred to as "Satellite Access Nodes" or "SANs"), and (iii) a network operations center ("NOC").

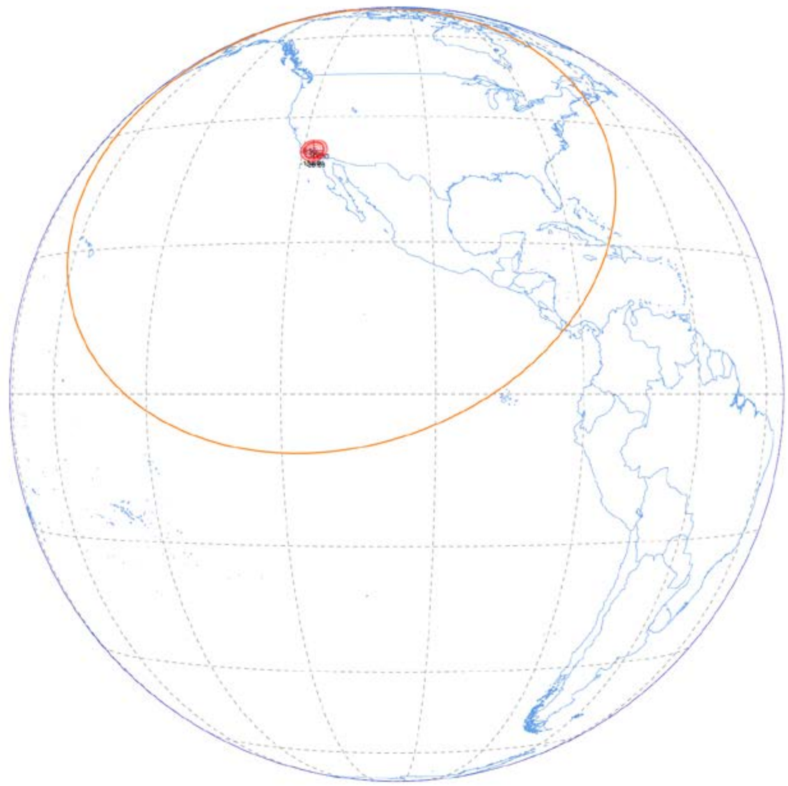
The VIASAT-NGSO satellite network will use Ka-Band and V-Band frequencies to provide broadband access and communications to customers located in CONUS, Hawaii, Alaska, Puerto Rico, and the U.S. Virgin Islands (as well as locations outside of the United States). Each satellite has a coverage area defined by a 25° elevation mask, which limits the round-trip latency to less than 150 milliseconds. The satellites orbit the Earth every 4.9 hours and coverage areas move with the satellites. A snapshot of the coverage footprints is shown below. Within its coverage area, each satellite in the constellation uses dynamically steered beams to provide on demand service to subscribers and to connect to the SANs. This allows the satellites to continuously reuse the Ka-Band and V-Band FSS spectrum within their coverage areas.

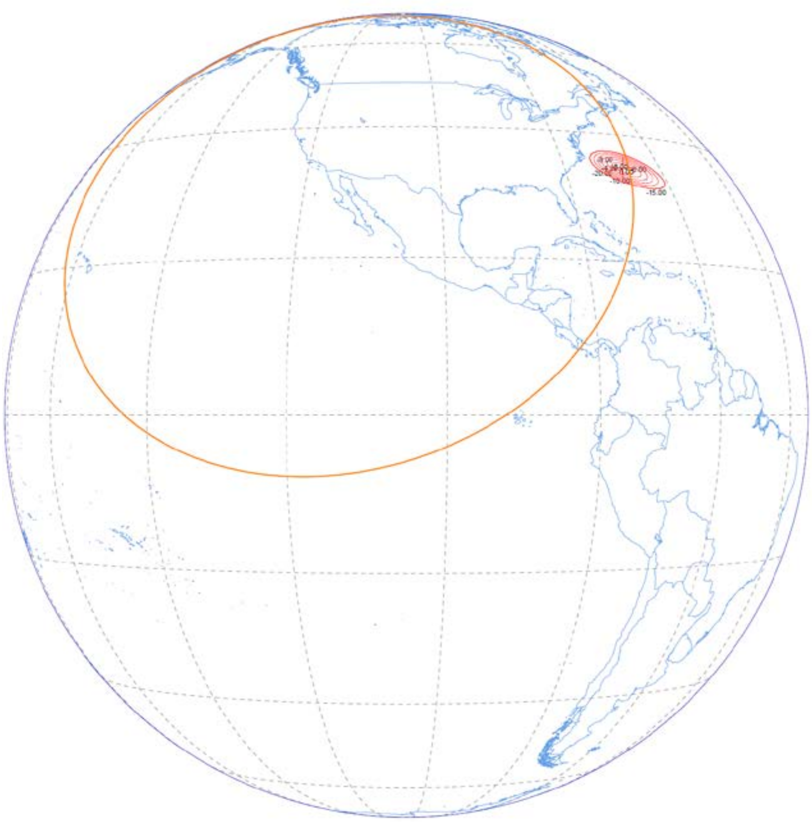


Each satellite has active phased array antennas to form up to 80 transmit and 80 receive beams. The number of beams by band and polarization are shown in the following table. Each frequency band and each polarization is reused multiple times within a satellite's coverage area. The beams are fungible; they can be used interchangeably for end-user and SAN links.

	Ka-Band		V-Band	
	RHCP	LHCP	RHCP	LHCP
Transmit Beams	8	8	32	32
Receive Beams	8	8	32	32

The following figures show one of the Ka-band transmit beams for the main communications beams on a satellite in the constellation that is assumed to be positioned directly over Los Angeles, CA in its orbit. The first figure shows the beam contours at the sub satellite point, and the second figure shows the beam contours when the beam is steered to the edge of the coverage footprint. The larger contour in both figures is the satellite coverage area. Patterns for all such beams have been included in the companion Schedule S. For each such beam, patterns at the sub satellite point and steered to the edge of the coverage footprint are provided. These are the extremes of the patterns as the beams are steered throughout the coverage footprint.





Each satellite uses a footprint coverage antenna beam to transmit a downlink control channel (DCCH), and receive an uplink access channel (UACH). When a terminal is powered on, it acquires a satellite DCCH and monitors it for frequency/time slot assignments, including handover information. Terminals use the UACH for bandwidth requests. If a terminal is active in the network when the satellite providing coverage changes, it is handed over to the new satellite.

The following table shows the frequency band segments in which U.S. market access is being sought for the VIASAT-NGSO satellite network.

Band Segment (GHz)	**Description**[1]
17.8-18.3	Ka-Band Downlinks
18.3-18.6	Ka-Band Downlinks
18.6-18.8	Ka-Band Downlinks[2]
18.8-19.3	Ka-Band Downlinks
19.7-20.2	Ka-Band Downlinks
27.5-28.35	Ka-Band Uplinks
28.35-28.6	Ka-Band Uplinks
28.6-29.1	Ka-Band Uplinks
29.5-30.0	Ka-Band Uplinks
37.5-40.0	V-Band Downlinks
40.0-42.0	V-Band Downlinks
47.2-48.2	V-Band Uplinks
48.2-50.2	V-Band Uplinks
50.4-51.4	V-Band Uplinks

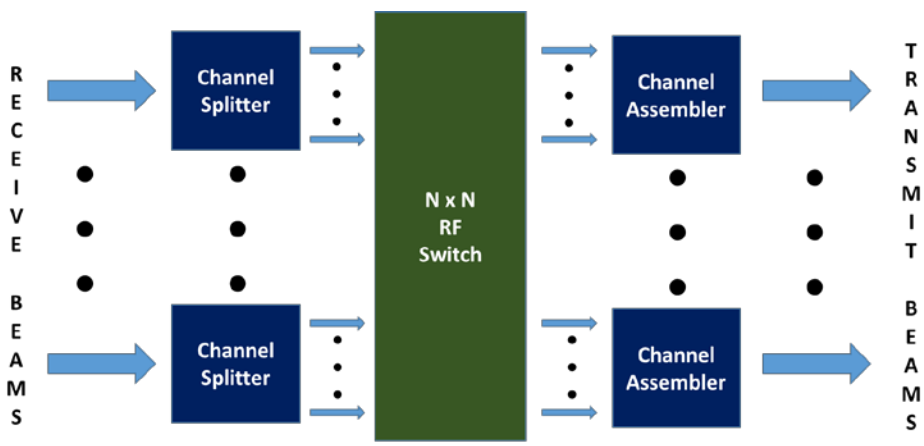
---

1 In many instances, a given band segment is currently available under existing Commission practices to serve both "gateway-type" earth stations as well as end users; in others, that currently is not the case. *See Use of Spectrum Bands above 24 GHz for Mobile Radio Services*, 31 FCC Rcd 8014, at ¶ 69 n.166 (2016) ("*Spectrum Frontiers Order*"); 47 C.F.R. § 25.202(a)(1) & n.1. ViaSat seeks market access for the VIASAT-NGSO satellite network to the fullest extent a given band segment is permitted to be used now or may be permitted to be used in the future, as specifically authorized for such purpose in a grant of earth station authority or otherwise.

2 Use limited to receiving downlink signals from GSO spacecraft transmitting in this band segment.

All bands are used in both RHCP and LHCP to maximize spectral efficiency. The DCCH and UACH are clustered at the lower 50 MHz of each band overlapping the communications channels. The VIASAT-NGSO Network Operations Center (NOC) manages sharing of the spectrum between these channels to maximize spectral efficiency. Uplink power control is used on all links to mitigate the potential for interference.

The satellite payload downconverts the received uplink channels from each receive beam and routes them to an adaptive channelizer. The channelizer divides the uplink channels into sub-channels and regroups these sub-channels into downlink channels for each downlink beam. The channelizer outputs are upconverted and routed to the transmit beams. A functional illustration of the adaptive channelizer follows. The channel/beam mapping implemented by the channelizer is adapted to maximize frequency reuse, and hence capacity, within the satellite coverage area.



The channelizer optimization is managed by the VIASAT-NGSO NOC. Control tables are uploaded to the satellites from the SANs using in band control channels. These channels with NOC messages are routed to the satellite payload processor, and are not rebroadcast by the satellites. The NOC processes the satellite locations, SAN locations, end-user locations, and bandwidth demand from the end-user earth stations to compute the channel/beam mappings implemented by each satellite in the constellation. This allows the VIASAT-NGSO satellite network to provide a mix of dedicated and on-demand bandwidth to each end user to maximize spectral efficiency.

The NOC also takes into consideration geostationary satellite orbit ("GSO") arc avoidance when preparing the channel/beam mappings to mitigate any potential interference to, or from, GSO satellites. Beams are assigned to maintain a minimum 5° GSO arc avoidance angle. The channel/beam mappings are also used to enable coordination agreements with other NGSO systems, and other services using the spectrum.

While ViaSat is not applying for earth station authorizations at this time, a brief discussion of end-user earth stations and SAN characteristics is provided for information. The VIASAT-NGSO earth stations use phased array antennas, adaptive beam forming, and satellite tracking. Diversity SANs are used to mitigate the effects of atmospheric propagation loss due to rain. Typical end-user earth stations are dual polarization and capable of operating in both Ka and V Bands. The VIASAT-NGSO satellite network supports two classes of end-user earth stations, consumer and enterprise. Representative consumer earth stations use 30 cm diameter phased array antennas and representative enterprise earth stations use 60 cm phased array antennas. Electronically steered phased array antennas allow the terminals to "make-before-break," connecting to a new satellite before disconnecting form the current one, and ensuring uninterrupted connectivity.

VIASAT-NGSO SANs are distributed within the service area to provide site diversity. Typical SAN antennas are 1 m in diameter. All earth stations operate with a 25° elevation mask, which significantly mitigates the potential for interference to, and from, terrestrial systems.

The VIASAT-NGSO TT&C operations are conducted from facilities outside of the United States at the edges of the 18.8-19.3 GHz and 28.6-29.1 GHz band segments. TT&C links are used during the entire satellite life-cycle, from pre-launch, to transfer orbit, to in-constellation operation, and for end-of-life ("EOL") disposal, as well as during spacecraft emergencies. As these TT&C links will not be used in the United States, their parameters have not been included in the companion Schedule S that forms part of this application.

When a satellite is operating as part of the VIASAT-NGSO constellation, a footprint coverage antenna is used for TT&C. At all other times (i.e., pre-launch, transfer orbit, EOL disposal, in-orbit spare, emergency operations), a near-omni-directional antenna is used. The VIASAT-NGSO TT&C RF plan is shown in the following table.

Parameter	In Constellation	Other Phases of Operation
Receive Frequencies and Polarizations	28,601 MHz - RHCP 29,199 MHz - RHCP	28,601 MHz - RHCP 29,199 MHz - RHCP
Minimum Command Flux Density	-96 dBW/m^2	-82 dBW/m^2
Receive Antenna Gain	13.9 dBi	~0 dBi
Transmit Frequencies and Polarizations	18,801 MHz - RHCP 18,803 MHz - RHCP	18,801 MHz - RHCP 18,803 MHz - RHCP
Transmit Antenna Gain	13.9 dBi	~0 dBi
Maximum Transmit EIRP	21 dBW	7 dBW

In addition to the main communications payload described above, each of the VIASAT-NGSO MEO satellites will be equipped with a payload for communications with GSO networks. The MEO-to-GSO payload differs from the main payload in that the transmitting and receiving components, including the antennas, are designed to track and communicate with GSO satellite networks as the MEO satellite moves through its orbit. The MEO-to-GSO payload would transmit (uplink) to GSOs in the 27.5-29.1 GHz and 29.5-30 GHz band segments, and receive (downlink) signals from GSOs in the 17.8-18.6 GHz, 18.6-18.8 GHz, 18.8-19.3 GHz and 19.7-20.2 GHz band segments, for which market access is sought.

The function of the MEO-to-GSO payload is to provide high-speed communications links with GSO satellite networks in order to provide an additional and alternative means of transmitting and receiving data between a MEO satellite and the Earth.[3] It is anticipated that there could be a variety of additional payloads on the MEO satellites, including for various space-based sensing applications; however, those payloads may not have a separate capability for transmitting and receiving data from Earth. For a variety of reasons, it may not be feasible to route this data using the main communications channels on the MEO spacecraft. Instead, this data could be (i) uplinked from the MEO spacecraft to GSO spacecraft (using the 27.5-29.1 GHz and 29.5-30 GHz band segments), and then downlinked by the GSO spacecraft to Earth, and also (ii) uplinked to the GSO spacecraft from Earth, and then downlinked to the MEO spacecraft (using the 17.8-18.6 GHz, 18.6-18.8 GHz, 18.8-19.3 GHz and 19.7-20.2 GHz band segments).

The MEO-to-GSO capabilities address a number of challenges encountered when providing space-based sensing services. First, for new sensing technologies without ready access to satellite uplink and/or downlink spectrum, these capabilities make existing satellite broadband capabilities available for transmitting payload mission data to Earth, and also for transmitting important updated tasking and programming to the space-based sensors, among other things. Thus, these MEO-to-GSO capabilities facilitate efficient spectrum use and reduce the need to find, coordinate, reserve and license additional spectrum (such as S-Band and X-Band frequencies) for sensing missions. Second, MEO-to-GSO communications provide many more transmission opportunities in real-time and near real-time than using traditional 'store and

---

[3] For example, VIASAT-NGSO will be able to communicate with a growing list of GSO satellites that serve the United States, including: WildBlue-1, ViaSat-1, ViaSat-2, Galaxy-KA, and the forthcoming global ViaSat-3 constellation, and potentially with other GSO satellite networks as well.

forward' sensing downlinks and ground stations. Accordingly, valuable data can be retrieved faster and made available in a more timely manner for processing and analysis. Finally, MEO-to-GSO communications links provide important communications redundancies for both the main communications payload and for any sensing payloads that may be included on the MEO satellites, increasing the likelihood of communications with the MEO satellites if there ever is a problem with the MEO-to-Earth communications path.

As a general matter, once the MEO-to-GSO payload is able to successfully receive signals from the intended GSO satellite, it will attempt to roam into the intended GSO network by transmitting the normal login sequence and then beginning data transmissions under control of the intended GSO satellite's communications network control center. The MEO-to-GSO payload is designed to ensure that the transmit signal levels at the intended GSO satellite match that of typical small, ground-based terminals communicating with that GSO satellite. In other words, given that the MEO satellite is much closer to the GSO satellite than a ground-based terminal, the MEO-to-GSO payload transmit power levels will be much lower than the comparable ground-based terminal power levels in order to have the same transmit power values at a similar point in space.

The following is data associated with the MEO-to-GSO payload:

Nature of service	Description	Frequency Band(s)	Mode/Type
FSS	MEO-to-GSO	27.5-29.1 GHz	Transmit
FSS	MEO-to-GSO	29.5-30.0 GHz	Transmit
FSS	GSO-to-MEO	17.8-19.3 GHz	Receive
FSS	GSO-to-MEO	19.7-20.2 GHz	Receive

The orbital information is the same as provided in the Schedule S for VIASAT-NGSO.

Receiving Beams 19:

Beam ID	RG1B
Receive Beam Frequency	17.8-19.3 GHz
Beam Type	Steerable
Polarization	LH&RHCP
Peak Gain	39.1 dBi
Antenna Pointing Error	0.1 degrees
Antenna Rotational Error	0.0 degrees
Polarization Switchable	Yes
Polarization Alignment Relative to the Equatorial Plane	45.0 degrees
G/T at Max. Gain Point	14.2 dB/K
Min. Sat Flux Density	N/A
Max. Sat Flux Density	N/A
Service Area Description	Visible GSO

Receiving Beams 20:

Beam ID	RG2B
Receive Beam Frequency	19.7-20.2 GHz
Beam Type	Steerable
Polarization	LH&RHCP
Peak Gain	39.5 dBi
Antenna Pointing Error	0.1 degrees
Antenna Rotational Error	0.0 degrees
Polarization Switchable	Yes
Polarization Alignment Relative to the Equatorial Plane	45.0 degrees
G/T at Max. Gain Point	14.6 dB/K
Min. Sat Flux Density	N/A
Max. Sat Flux Density	N/A
Service Area Description	Visible GSO

Receiving Channels (4)

Channel ID	CH BW (MHz)	Center Freq (MHz)	Link Type
R01G	500	18050.0	Service Link
R02G	500	18550.0	Service Link
R03G	500	19050.0	Service Link
R04G	500	19950.0	Service Link

Transmitting Beams 19:

Beam ID	TG1B
Transmit Beam Frequency	27.5-29.1 GHz
Beam Type	Steerable
Polarization	LH&RHCP
Peak Gain	42.7 dBi
Antenna Pointing Error	0.1 degrees
Antenna Rotational Error	0.0 degrees
Polarization Switchable	Yes

Polarization Alignment Relative to the Equatorial Plane	45.0 degrees
Max. Transmit EIRP Density	-28.42 dBW/Hz
Max. Transmit EIRP	56.7 dBW
Service Area Description	Visible GSO

Transmitting Beams 20:

Beam ID	TG2B
Transmit Beam Frequency	29.5-30.0 GHz
Beam Type	Steerable
Polarization	LH&RHCP
Peak Gain	42.9 dBi
Antenna Pointing Error	0.1 degrees
Antenna Rotational Error	0.0 degrees
Polarization Switchable	Yes
Polarization Alignment Relative to the Equatorial Plane	45.0 degrees
Max. Transmit EIRP Density	-28.2 dBW/Hz
Max. Transmit EIRP	56.9 dBW
Service Area Description	Visible GSO

Transmitting Channels (4)

Channel ID	CH BW (MHz)	Center Freq (MHz)	Link Type
T01G	600	27800.0	Service Link
T02G	500	28350.0	Service Link
T03G	500	28850.0	Service Link
T04G	500	29750.0	Service Link

B. §25.114(d)(14) A description of the design and operational strategies that will be used to mitigate orbital debris

ViaSat has conducted a preliminary assessment of orbital debris mitigation for the VIASAT-NGSO satellite network in accordance with the objectives of § 25.114(d)(14) of the FCC's rules, which will be incorporated into the Technical Specifications, Statement of Work and Test Plans for the satellite system. The Statement of Work will include provisions to review orbital debris mitigation as part of the preliminary design review ("PDR") and the critical design review ("CDR") and to incorporate its requirements, as appropriate, into its Test Plan, including a formal Failure Mode Verification Analysis ("FMVA") for orbital debris mitigation involving particularly the TT&C, propulsion and energy systems. Any updates to the Orbital Debris Mitigation Plan will be reflected in any market access modification application.

1. Spacecraft Hardware Design

ViaSat will assess and limit the amount of debris released in a planned manner during normal operations. The VIASAT-NGSO satellites will not generate debris during deployment and will not generate any debris during normal operation. The satellites will not use exterior materials or designs that could generate debris due to environmental factors such as radiation degradation or thermal fatigue.

ViaSat will assess and limit the probability of a satellite in the proposed VIASAT-NGSO network becoming a source of debris by collisions with small debris or meteoroids that could cause loss of control and prevent post-mission disposal. Debris shielding techniques, such as bumper shields, debris blankets, and redundancy for vulnerable and critical spacecraft elements will be used.

2. Minimizing Accidental Explosions

ViaSat will assess and limit the probability of accidental explosions during and after completion of mission operations. All energy sources, including chemical, pressure, and kinetic energy, will be removed at EOL by depleting the residual fuel and leaving all fuel line valves open, venting all pressurized systems, leaving all batteries in a permanently discharged state, and removing all other remaining sources of stored energy.

3. Safe Flight Profiles

ViaSat has assessed and limited the probability of a satellite in the proposed VIASAT-NGSO network becoming a source of debris by collision with large debris or other space vehicles. ViaSat has selected an orbital altitude of 8,200 km, which provides a minimum 100 km margin with respect to other large MEO satellite networks notified to the ITU or in coordination through the ITU process. The MEO constellations considered in this analysis are shown in the following table. Constellations with notices that have been canceled, and GNSS constellations operating near 20,000 km altitude, were not included.

Constellation	Orbit Altitude(s)
O3b-A	8062 km
O3b-B	8062 km
O3b-C	8062 km, 9000 km
O3b-D	8062 km, 9000 km
MCSAT-2 MEO-1	8000 km, 8100 km
MCSAT-2 MEO-2	7500 km, 8100 km
MCSAT-2 LEO-2	8100 km
JFDSAT-MEO-D-C	8100 km
JFDSAT-MEO-D-QV	8100 km

If other networks are subsequently deployed at, or near, the 8,200 km altitude, ViaSat will coordinate with the operators of those networks to minimize potential collision risk. ViaSat plans to maintain the orbital parameters of the satellites in the VIASAT-NGSO network to the following accuracies:

Parameter	Accuracy
Apogee	±10 km
Perigee	±10 km
Inclination	±2.0°
Right Ascension of Ascending Node	±3.0°

NASA's Orbital Debris Engineering Model (ORDEM) 3.0 calculates that the probability of an orbiting VIASAT-NGSO satellite being struck by debris larger than 1 cm diameter during its 20-year life is less than 0.0008%.

4. Post-Mission Disposal

At EOL, ViaSat will dispose of the VIASAT-NGSO satellites by moving them to a storage orbit at 8,500 km. This is compliant with U.S. Government Orbital Debris Mitigation Standard Practices, Objective 4, Post-mission Disposal Of Space Structures. Sufficient fuel will be reserved for the post-mission disposal maneuvers.

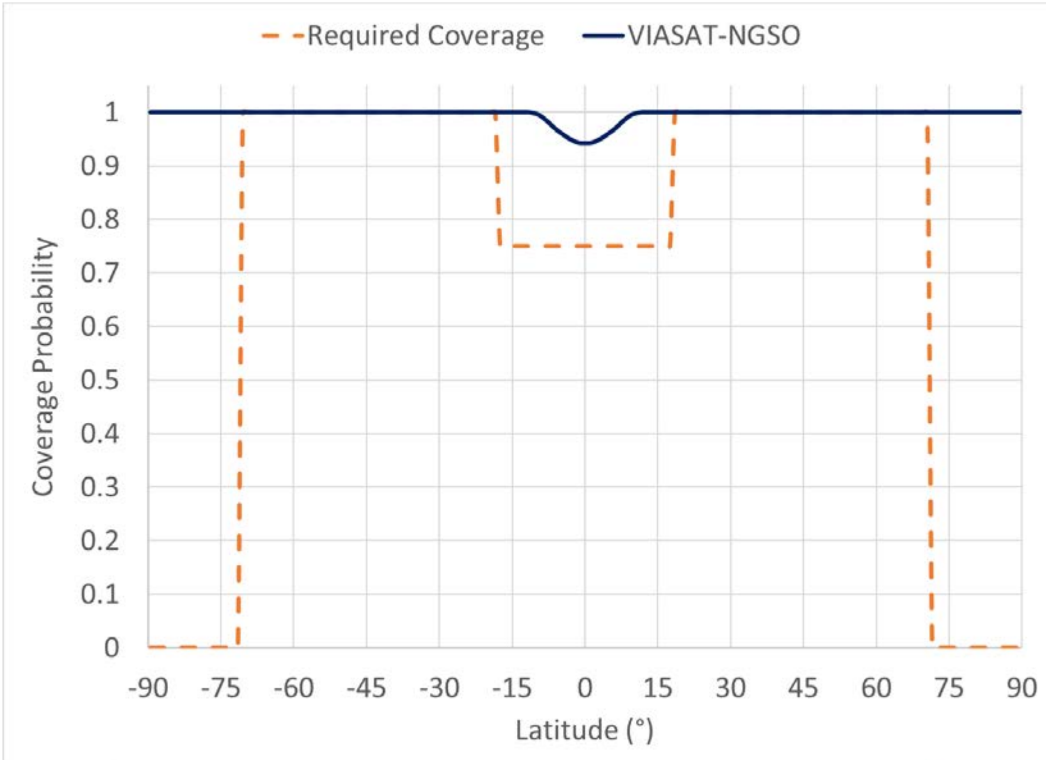
II. ADDITIONAL DEMONSTRATION REQUIRED BY §25.145(c)

§25.145(c) requires that FSS systems operating in the 18.3-20.2 GHz and 28.35-30.0 GHz band segments be capable of providing FSS:

- to all locations as far north as 70° North Latitude and as far south as 55° South Latitude for at least 75% of every 24-hour period; and
- on a continuous basis throughout the fifty states, Puerto Rico and the U.S. Virgin Islands.

The most northern and southern points in the fifty states, Puerto Rico and the U.S. Virgin Islands are Point Barrow, Alaska (71°23′20″N, 156°28′45″W) and Southwest Point, U.S. Virgin Islands (17°40′26″N, 64°54′03″W), respectively. The VIASAT-NGSO satellite network satisfies these coverage requirements by providing continuous coverage from below 17° North latitude to above 72° North latitude, and providing coverage for at least 75% of every 24-hours period at all other latitudes.

The following plot demonstrates that the VIASAT-NGSO satellite network exceeds these coverage requirements. It shows the probability of coverage by the VIASAT-NGSO satellite network as a function of end-user earth station latitude. The VIASAT-NGSO satellite network's coverage is independent of end-user longitude. This plot takes into account both the VIASAT-NGSO satellite network's 25° elevation mask and its active avoidance of the GSO arc.



III. COMPLIANCE WITH PART 25 SUBPART C—TECHNICAL STANDARDS

The VIASAT-NGSO satellite network is compliant with all of the Part 25 Subpart C technical standards applicable to this application, as demonstrated in the following subsections. Many of the technical standards in Subpart C apply to earth stations. ViaSat is not applying for earth station authorizations at this time, and will demonstrate compliance with those standards in an appropriate application.

As certified in the companion Schedule S that forms part of this application, the VIASAT-NGSO satellite network complies with all applicable requirements of the following rules:

- §25.202(e) Frequency tolerance, space stations
- §25.202(f) Emission limitations
- §25.207 Cessation of emissions

- §25.210 Technical requirements for space stations

A. §25.202 Frequencies, frequency tolerance, and emission limits

The relevant §25.202 requirements are discussed in this section. Section 25.202(d) requires the carrier frequency of each earth station transmitter to be maintained within 0.001 percent of the reference frequency. Section 25.202(j) applies to earth stations in the FSS that transmit in the 49.7-50.2 GHz and 50.4-50.9 GHz band segments and establishes a limit for the unwanted emission power in the 50.2-50.4 GHz band segment. These provisions apply to earth stations, and ViaSat is not seeking authority to operate earth stations at this time. However, ViaSat acknowledges that earth stations operating within the VIASAT-NGSO satellite network would be subject to these limits and will demonstrate compliance with these requirements in an appropriate application.

1. Frequency bands

The frequency band segments for which U.S. market access is being sought are summarized above in Section I.A and in Section II.B of the narrative portion of this Petition for Declaratory Ruling (the "Narrative"). The Narrative includes a description of the availability of these band segments for U.S. service by an NGSO FSS system under the International and United States Tables of Frequency Allocations, Section 25.202(a)(1) of the Commission's rules, and the applicable band plan (Ka or V) established by the Commission. Sharing analysis for each of these band segments is provided in the Sharing Discussion section of this document. The main communications payload of the VIASAT-NGSO satellite network would also be capable of operating in the 17.7-17.8 GHz, 20.2-21.2 GHz, 30.0-31.0 GHz, 42.0-42.5 GHz and 51.4-52.4 GHz band segments. As the Narrative explains, since authority for those band segments for that purpose is not being sought at this time, otherwise-applicable information for these band segments is not included in the Schedule S.

2. TT&C

§25.202(g) requires that TT&C signals transmitted in frequencies within the assigned bands that are not at a band edge cause no greater interference and require no greater protection from harmful interference than the communications traffic on the satellite network. It also requires that frequencies, polarization, and coding of TT&C transmissions be selected to minimize interference into other satellite networks.

The VIASAT-NGSO satellite network complies with these requirements, as demonstrated in the TT&C discussion in Section I.A above.

B. §25.208 Power flux density limits

1. The VIASAT-NGSO satellite network meets all of the applicable PFD limits of §25.208

The applicable PFD limits from §25.208 are shown in the following table. The X parameter in the §25.208(e) limits is a function of the number of satellites in the NGSO constellation. For the 24 satellite VIASAT-NGSO constellation, the value of X is 0. The limits shown for §25.208(r) are the free space condition values from §25.208(r)(1). ViaSat notes that the conditions under which satellites may exceed the PFD limits for normal free space propagation described in §25.208(r)(1) to compensate for effects of rain fading are under study, and that the extent to which these limits can be exceeded is the subject of further rulemaking.[4]

§25.208 Section	VIASAT-NGSO Band Segment	Limits dB(W/m^2) in any 1 MHz		
		0°-5°	5°-25°	25°-90°
(c)	18.3-18.6 GHz	-115	-115+0.5 (δ-5)	-105
(e)	18.8-19.3 GHz	-115-X	-115−X + ((10 + X)/20)(δ−5)	-105
(r)	37.5-40.0 GHz	-132	-132+0.75(δ-5)	-117
(s)	40.0-40.5 GHz	-115	-115+0.5(δ-5)	-105
(t)	40.5-42.0 GHz	-115	-115+0.5(δ-5)	-105

4 47 C.F.R. § 25.208(r), Note to Paragraph (r).

The following table shows the max EIRP density of the VIASAT-NGSO satellite network for each of the band segments in the previous table. The peak flux density at the Earth's surface occurs at the sub satellite point, the point on the Earth closest to the satellite. The spreading loss at this point is 10 x log10(4πR2) where R is the orbital altitude (m). For the 8,200 km altitude at which VIASAT-NGSO satellites would operate, the minimum spreading loss is 149.3 dB. The max PFD at the Earth's surface for each of the band segments, converted to units of dB(W/(m^{2*}MHz)) by noting that VIASAT-NGSO's digital modulation has a nearly flat spectrum, is shown in the table. This demonstrates that the VIASAT-NGSO satellite network meets the applicable §25.208 limits for elevation angles from 25° to 90°, as the spreading loss increases with decreasing elevation angle. The VIASAT-NGSO satellite network operates with a 25° elevation mask. Satellite transmit antenna beams are never pointed outside of the coverage footprints, and the antenna gain falloff with increasing off-axis angle is sufficient to ensure that the applicable §25.208 limits are met for all elevation angles.

VIASAT-NGSO Band Segment	VIASAT-NGSO Max EIRP Density	Max Free Space PFD at Earth's Surface
18.3-18.6 GHz	-24.0 dBW/Hz	-113.3 dB(W/(m^2*MHz))
18.8-19.3 GHz	-15.7 dBW/Hz	-105 dB(W/(m^2*MHz))
37.5-40.0 GHz	-27.7 dBW/Hz	-117 dB(W/(m^2*MHz))
40.0-40.5 GHz	-15.7 dBW/Hz	-105 dB(W/(m^2*MHz))
40.5-42.0 GHz	-15.7 dBW/Hz	-105 dB(W/(m^2*MHz))

2. The VIASAT-NGSO satellite network meets all of the applicable EPFD limits of §25.208

There are no EPFD limits in §25.208 applicable to the frequency bands in this application, however, the ITU Radio Regulations, specifically Nos. 22.5C, 22.5D and 22.5F, impose single-entry EPFD limits in the 17.8-18.6 GHz (s-E), 19.7-20.2 GHz (s-E), 27.5-28.6 GHz (E-s), and 29.5-30 GHz (E-s) band segments. The EPFD analysis included as Exhibit 1 to this Technical Annex demonstrates that VIASAT-NGSO would comply with these requirements.

C. §25.217 Default service rules

These rules apply to frequency bands for which no frequency-band-specific satellite service rules have been adopted.[5] To the extent §25.217 is deemed to apply to the 17.8-18.3 GHz, 27.5-28.35 GHz, 37.5-40.0 GHz, 40.0-42.0 GHz, 47.2-50.2 GHz, and 50.4-51.4 GHz band segments included in this application, the following information is provided.[6]

1. Rule Compliance

§25.217(b)(1) requires compliance with the following rules, notwithstanding the frequency bands specified in those rule provisions:

a. 25.142(d)

This requirement is addressed in the Narrative.

b. 25.143(b)(2)(ii)

This rule requires that the VIASAT-NGSO satellite network be capable of providing service to all locations as far north as 70° North latitude and as far south as 55° South latitude for at least 75% of every 24-hour period. As demonstrated above in the discussion relating to §25.145(c), the VIASAT-NGSO satellite network meets this requirement.

c. 25.143(b)(2)(iii)

This rule requires that the VIASAT-NGSO satellite network be capable of providing service on a continuous basis throughout the fifty states, Puerto Rico and the U.S. Virgin Islands. As demonstrated above in the discussion relating to §25.145(c), the VIASAT-NGSO satellite network meets this requirement.

---

5 As noted above, Section 25.145 addresses NGSO FSS licensing in the 18.3-20.2 GHz and 28.35-30.0 GHz band segments.

6 The service rules regarding earth station operations in the 27.5-28.35 GHz and 37.5-40 GHz band segments address coexistence with terrestrial uses of this spectrum, not the operation of spacecraft.

d. 25.204(e)

This rule applies to earth stations, as discussed above, ViaSat is not applying for earth station authorizations at this time and will demonstrate compliance with this rule when applications for such authorizations are filed, as appropriate.

e. 25.210(d)

This rule part is marked [Reserved] in the Commission's current rules.

f. 25.210(f)

As certified in the Schedule S, the VIASAT-NGSO satellite network meets the requirements in §25.210(f) regarding state-of-the-art full frequency reuse.

g. 25.210(i)

As explained in the Narrative, in its recent Part 25 order the Commission eliminated the requirement that FSS space station antennas be designed to provide at least 25 dB cross polarization isolation after concluding that it was no longer necessary with respect to FSS operations.[7]

2. Coordination with NTIA

§25.217(b)(2) requires that the Commission coordinate with NTIA in shared government/non-government frequency bands, pursuant to the procedure set forth in §25.142(b)(2)(ii). To facilitate this coordination, ViaSat is required to provide sufficient information to evaluate EMC compatibility with the Federal government use of the spectrum. This information is contained throughout this document, and in the companion Schedule S that forms part of this application.

---

[7] *Comprehensive Review of Licensing and Operating Rules for Satellite Services*, Second Report and Order, 30 FCC Rcd 14713, at ¶ 333 (2015).

D. §25.261 Procedures for avoidance of in-line interference events for Non-Geostationary Satellite Orbit (NGSO) Satellite Network Operations in the Fixed-Satellite Service (FSS) Bands

ViaSat will engage in good faith coordination discussions with other NGSO FSS operators in the band segments included in this application. In the event that coordination cannot be achieved, §25.261 provides default coordination procedures that would apply during in-line interference events, as defined in §25.261(b). Notably, §25.261 expressly applies only the 28.6-29.1 GHz and 18.8-19.3 GHz band segments.

As ViaSat has indicated elsewhere in this Petition, and as discussed in more detail below in Section IV.B, the extent to which the NGSO constellations proposed in the Ka-Band and V-Band processing rounds can operate on a co-frequency basis depends in large part on the number of proposed systems and their individual technical characteristics. ViaSat is committed to engaging in good faith efforts to facilitate co-frequency compatibility with these other proposed systems to the extent practicable.

IV. SHARING DISCUSSION

The following subsections discuss how the VIASAT-NGSO satellite network will be able to coexist with other services in each of the proposed band segments for which U.S. market is sought.

A. Sharing with GSO FSS Systems

The VIASAT-NGSO satellite network will be compatible with GSO systems that currently operate, or in the future may operate, in the 17.8-18.6 GHz and 19.7-20.2 GHz band segments in the space-to-earth direction and in the 27.5-28.6 GHz and 29.5-30.0 GHz band segments in the earth-to-space direction. In each of these band segments, the VIASAT-NGSO satellite network implements GSO arc avoidance to protect GSO networks, as described in Exhibit 1 to this Technical Annex. As demonstrated in that Exhibit, the EPFD levels produced by the VIASAT-NGSO satellite network in these Ka-band frequencies would comply with the requirements of ITU Radio Regulation Nos. 22.5C, 22.5D and 22.5F, thus ensuring that GSO FSS systems would be protected.

In the 18.8-19.3 GHz and 28.6-29.1 GHz band segments, where NGSO FSS systems are designated on a primary basis in the United States, GSO FSS networks may operate on a secondary or non-conforming basis. Although protection of GSO FSS networks is not required in these band segments in the United States, ViaSat anticipates engaging in any requisite coordination under the ITU Radio Regulations.

Spectrum sharing by the MEO-to-GSO payload with GSO networks is facilitated through the use of antenna and transmitting facilities that are compliant with the Section 25.138 off-axis e.i.r.p. density mask. By complying with the off-axis e.i.r.p. density mask and by also ensuring that the 3-sigma antenna pointing error is less than 0.2°, compatibility with the 2° spacing environment in the GSO arc is ensured, much in the same way that it is for GSO operations more generally.

B. Sharing with NGSO FSS Systems

In the United States, the 18.8-19.3 GHz and 28.6-29.1 GHz band segments are designated on a primary basis for NGSO systems. The Commission has authorized O3b Limited (“O3b”) to serve the United States using its NGSO FSS system in the 17.8-18.3 GHz, 18.3-18.8 GHz, 18.8-19.3 GHz, 27.6-28.35 GHz, 28.35-28.4 GHz, and 28.6-29.1 GHz band segments. The VIASAT-NGSO satellite network can implement avoidance of the equatorial orbit at the 8,062 km altitude in which O3b operates.

By virtue of the 8200 km orbital altitude of the VIASAT-NGSO constellation, the MEO-to-GSO payload will avoid most in-line events with other LEO or MEO constellations when transmitting to GSO satellites because the uplink will be directed away from NGSO stations in lower orbits and instead toward the intended GSO satellite. Likewise, when the MEOs receive downlink communications from GSO satellites, there will be no adverse change in the existing interference environment, because the MEO-to-GSO payload would rely on existing GSO network downlink beams operating in compliance with applicable limits in any given spectrum segment. A representative analysis of this dynamic with the O3b constellation, and the proposed OneWeb/WorldVu constellation, appears below.

If other NGSO networks are deployed with higher altitude orbits, or with greater apogee, than the VIASAT-NGSO network (a "Higher-Orbit NGSO Network"), the possibility of in-line events may arise. Take the example of a system operating in the 27.5-28.6 GHz, 28.6-29.1 GHz, and 29.5-30 GHz band segments. Most of the time, both the Higher-Orbit NGSO Networks and the VIASAT-NGSO network likely can operate in each of the band segments. However, in order to meet $epfd_{up}$ limits in the 27.5-28.6 GHz and 29.5-30.0 GHz band segments (the "EPFD Uplink Bands"), any Higher-Orbit NGSO Networks typically must avoid in-line events with the GSO in the EPFD Uplink Bands by disabling transmissions in those band segments and relying solely on uplinks in the 28.6-29.1 GHz band segment.

When communicating with the relevant GSO satellite network, the VIASAT-NGSO network's MEO-to-GSO payload would not be subject to these $epfd_{up}$ limits and could transmit in the EPFD Uplink Bands toward the intended GSO satellite during the GSO arc alignment period when the Higher-Orbit NGSO System must mute communications using those same frequencies.

In the figures, the salmon colored lines represent the OneWeb/WorldVu orbital planes, the dark blue lines and dots represent the O3b orbital plane and the O3b satellites. The light green line represents the GSO orbital plane and the green dots represent the ViaSat GSO satellites at 115.1º W.L., 111.1º W.L., 89º W.L., and 69.6º W.L. The purple, yellow, and light blue lines and dots represent the VIASAT-NGSO orbital planes and satellites. The light blue shading between the VIASAT-MEO satellites and the GSO satellites represent the antenna beams from the VIASAT-NGSO satellites to the GSO satellites, and a solid light blue line represents an active MEO-to-GSO transmission (either transmit or receive). In that case, the MEO satellite is aligned between the coverage area of the GSO satellite on the ground and the GSO satellite in space. In Figure 1, the MEO-to-GSO transmission is shown communicating with ViaSat-2. The MEO satellite is aligned between the ViaSat-2 footprint on the Earth, shown in light grey, and the ViaSat-2 satellite.

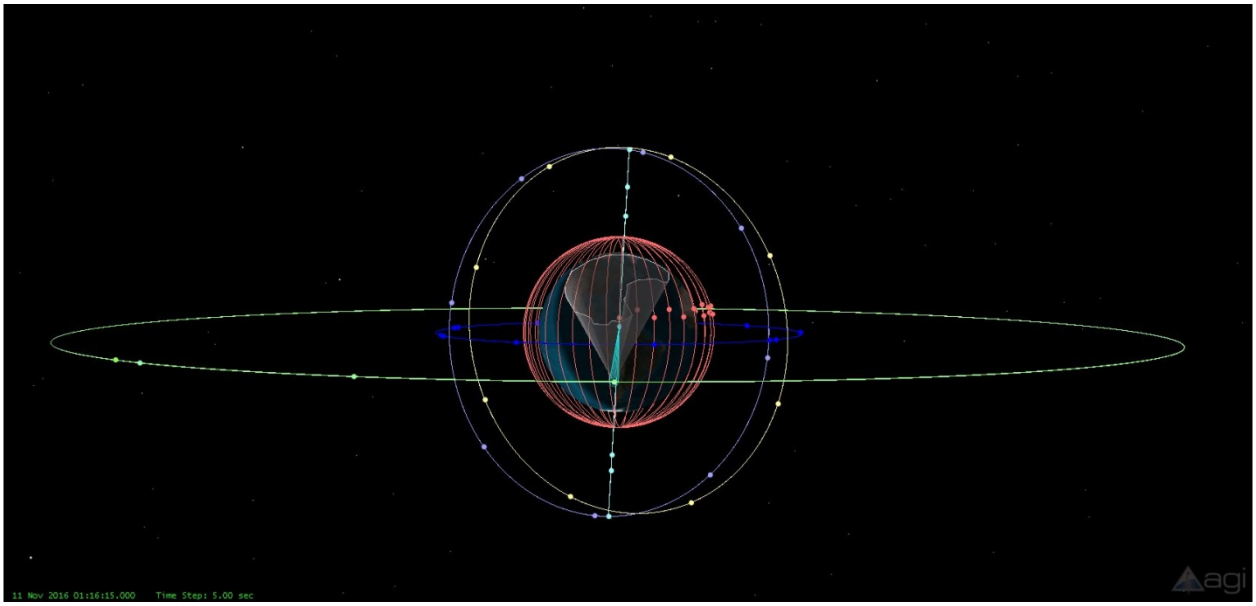


Figure 1 MEO-to-GSO Payload Communicating with ViaSat-2

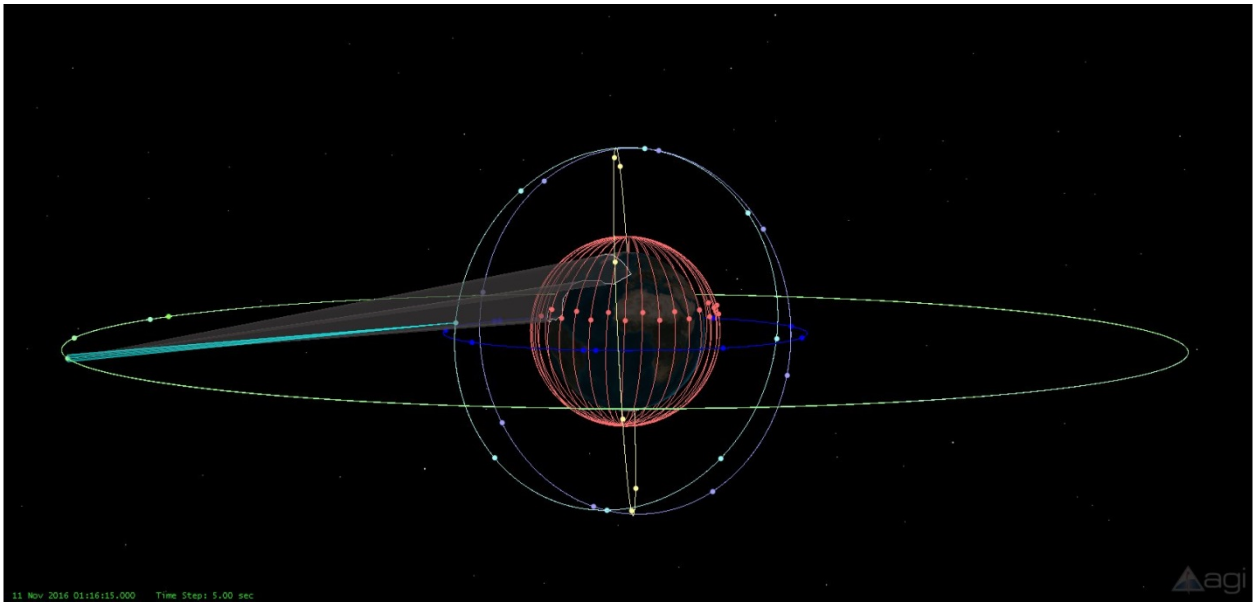


Figure 2 Side view of MEO-to-GSO Payload Communicating with ViaSat-2

Figure 2 shows a side view of the same MEO-to-GSO payload communicating with ViaSat-2. Again, the ViaSat-2 footprint on the Earth is shown in light grey. Figure 3 shows the same MEO-to-GSO satellite communicating with ViaSat-2 but from above. The ViaSat-2 footprint is turned off in Figure 3 to allow a clearer depiction of the non-alignment of the MEO-to-GSO communications links with the other depicted NGSO networks.

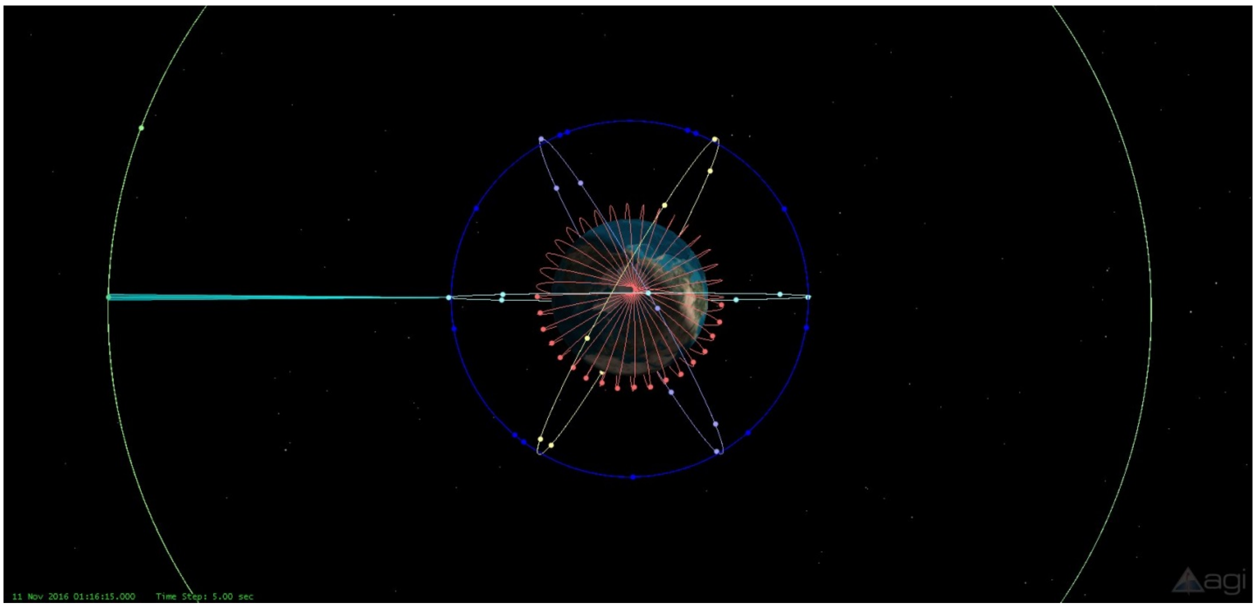


Figure 3 View from above of MEO-to-GSO Payload and ViaSat-2

A separate alignment case with an NGSO network can occur when a GSO satellite network's beam extends beyond the limb of the Earth. In that case an alignment exists that allows the MEO-to-GSO payload to potentially transmit past the limb of the Earth through the orbital planes of a lower-orbit NGSO constellation. Typically, the signal path from this alignment would have a high degree of off-axis gain reduction in the receiving antenna of a lower-orbit NGSO satellite.

As to the other applicants in these processing rounds, the extent to which the NGSO constellations proposed in the Ka-Band and V-Band processing rounds can operate on a co-frequency basis depends in large part on the number of proposed systems and their individual technical characteristics. ViaSat is committed to engaging in good faith efforts to facilitate co-frequency compatibility with these other proposed systems to the extent practicable. In certain scenarios, it may be necessary to resort to band segmentation—possibly only during in-line events, possibly more broadly. These matters will need to be evaluated after the applications filed by the cut-off dates can be reviewed and analyzed for likely compatibility, and after accounting for the results of the Commission's expected NGSO rulemaking.

C. Sharing with Terrestrial Services

1. Fixed Services in the 17.8-18.3 GHz Band Segment

With respect to the 17.8-18.3 GHz band segment, which is designated in the United States for fixed services ("FS") on a primary basis, compliance with applicable PFD limits should provide adequate protection to the FS.

Downlink transmissions from the VIASAT-NGSO satellite network will comply with the applicable ITU PFD limits in this band segment. The ITU Article 21 PFD limits were developed to protect terrestrial fixed and mobile systems from satellite downlink transmissions in frequency bands where terrestrial and space services are shared with equal rights internationally. §25.208(c) adopts these same ITU PFD limits, although domestically, the limits only apply to the adjacent 18.3-18.8 GHz band segment. These are also the same limits imposed by US334 on Federal FSS NGSO systems operating in this band with a number of satellites comparable with that of the VIASAT-NGSO network.

As stated in companion Schedule S that forms part of this application, VIASAT-NGSO downlink transmissions in the 17.8-18.3 GHz band segment toward U.S. territory that is located within a satellite's service area will not exceed the ITU Article 21 PFD limits, thus ensuring protection of the FS. Any FS licensee must anticipate the operation of an international FSS satellite network, such as the VIASAT-NGSO network, that could transmit at the Article 21 PFD limits toward U.S. territory in full conformance with the ITU Radio Regulations.

ViaSat accepts the potential risk from FS stations interfering into any earth stations receiving signals from the VIASAT-NGSO network at 17.8-18.3 GHz.

2. Sharing with Fixed and Mobile Services in the 27.5-28.35 GHz Band Segment

In the United States, the 27.5-28.35 GHz band segment is designated for fixed and mobile terrestrial service ("Upper Microwave Flexible Use" or "UMFU" service) on a primary basis and it is designated for the FSS subject to the sharing terms adopted in the recent Spectrum Frontiers Order.[8] Certain earth stations that are located in the United States may be deployed on a protected basis if they meet the criteria specified in Section 25.136 of the Commission's rules. Alternatively, earth stations may be deployed on a secondary basis to UMFU and must be operated in a manner such that they do not cause harmful interference to UMFU. Technical compatibility will be accomplished either by meeting the protection criteria in Section 25.136, geographic separation between the VIASAT-NGSO earth station beam pattern toward the UMFU stations, employing shielding, and/or such other means as the Commission may approve.

The MEO-to-GEO package uses a directional antenna that is pointed away from the Earth and also transmits using lower power because of the reduced distance to the GSO and because the transmissions originate above the Earth's atmosphere. At nadir the spreading loss to earth from the VIASAT-NGSO orbit is 149.3 dB, so any back-lobe signals from the MEO-to-

---

[8] *See Use of Spectrum Bands above 24 GHz for Mobile Radio Services*, 31 FCC Rcd 8014 (2016) ("*Spectrum Frontiers Order*").

GEO antenna in the direction of Earth will be well below the noise floor of any terrestrial receivers.

3. Sharing with Fixed and Mobile Services in the 37.5-40.0 GHz Band Segment

Earth-to-space communications from the VIASAT-NGSO satellite network will be compatible with fixed and mobile wireless operations in the 37.5-40 GHz band segment by ensuring compliance with the current power flux density limits (PFD) limits for satellite downlinks in this band segment.

The current limits for NGSO systems, with which the VIASAT-NGSO satellite network complies, are:[9]

- −132 dB(W/m^2/MHz) for angles of arrival between 0° and 5°
- −132 + 0.75 (δ−5) dB(W/m^2/MHz) for angles of arrival δ between 5° and 25°
- −117 dB(W/m^2/MHz) for angles of arrival between 25° and 90°.

ViaSat requests authority to provide service consistent with any higher PFD limits that the Commission may adopt in the future.

4. Sharing with Terrestrial Services in the 47.2-48.2 GHz & 50.4-51.4 GHz Band Segments

In the United States, the 47.2-48.2 GHz and 50.4-51.4 GHz band segments are designated for use by terrestrial wireless services on a primary basis, with FSS uses on a secondary basis in the 47.2-48.2 GHz band segment. Uplinks from FSS earth stations that are located in the United States must be operated in a manner such that they do not cause harmful interference to any current or future licensed terrestrial wireless station in these band segments. Technical compatibility will be accomplished by geographic separation between the VIASAT-

[9] 47 C.F.R. § 25.208(r).

NGSO earth station beam pattern toward the terrestrial stations, employing shielding, and/or such other means as the Commission may approve.

D. Sharing with U.S. Government Networks and Radio Astronomy

The following band segments used by VIASAT-NGSO for which authority is sought in this application also have allocations for Federal systems and/or radio astronomy:

- U.S. military agencies utilize the 17.8-18.6 GHz, 18.8-19.3 GHz, and 19.7-20.2 GHz band segments for satellite network downlinks.[10] ViaSat will complete coordination with NTIA in accordance with footnote US334 to the U.S. Table of Frequency Allocations.[11]
- U.S. military agencies utilize the 37.5-38.0 GHz band segment for fixed microwave point-to-point communications systems at military test ranges. The military agencies also use this band for transportable communications systems.[12] NASA plans to use this band for exploration of the solar system and for the wideband data return links to the very long baseline interferometer (VLBI). NASA is conducting research in this band to improve the accuracy of sensor and navigational systems. [13]
- NASA is conducting research in the 38.0-38.6 GHz band segment to improve techniques and accuracy of rainfall measurements.[14]
- NASA plans to use the 40.0-40.5 GHz band segment for solar system exploration.[15]
- NSF conducts radio astronomy scientific research in the 40.5-41.0 GHz band segment.[16]
- NSF uses the 48.2-50.2 GHz band segment for the radio astronomy research of various spectral-lines, and NASA and the military agencies are conducting research and development of radar-target cross sections

---

[10] Federal Spectrum Use Summary, 30 MHz – 3000 GHz, NTIA, OSM, JUNE 21, 2010.

[11] 47 C.F.R. § 2.106 n.US334.

[12] Federal Spectrum Use Summary, 30 MHz – 3000 GHz, NTIA, OSM, JUNE 21, 2010.

[13] *Id.*

[14] *Id.*

[15] *Id.*

[16] *Id.*

operating at 50.0-55.0 GHz.[17] The VIASAT-NGSO satellite network complies with the adjacent band limits in US156 to protect EESS operations in the 50.2-50.4 GHz band segment.

- NASA and the military agencies are conducting research and development of radar-target cross sections at 50.0-55.0 GHz. The VIASAT-NGSO satellite network complies with the adjacent band limits in US156 to protect EESS operations in the 50.2–50.4 GHz band segment.
- With respect to the 40.5-42.0 GHz band segment, footnote US211 to the U.S. Table of Frequency Allocations requires applicants for airborne or space station assignments in this band to take all practicable steps to protect radio astronomy observations in the adjacent bands from harmful interference.

ViaSat will coordinate with NTIA and others as necessary and appropriate to avoid harmful interference to any of these and other Federal government or radio astronomy operations pursuant to the U.S. Table of Frequency Allocations.

ITU RR 5.555 also allocates the 48.94-49.04 GHz segment to the radio astronomy service on a primary basis. ViaSat will coordinate with radio astronomy sites operating in this band segment, and will protect their operations by locating its gateways, which provide the highest uplink power transmission capability, at an acceptable distance from these sites.

V. SCHEDULE S NOTES

The Instructions for Schedule S[18] at 7(e)(i)(8) state that: "For NGSO satellites in polar orbits that are active during the entire orbit, enter -90 degrees for the begin angle and +90 degrees for the end angle" and "For NGSO satellites in orbits inclined more than 0 degrees and less than 180 degrees … enter the minimum and maximum latitudes bounding that segment of arc in the begin angle and end angle respectively." However, the online Schedule S form would not allow the entry of a negative value for the begin angle. ViaSat therefore entered values of 0

---

[17] *Id.*

[18] https://enterpriseefiling.fcc.gov/schedules//resources/Instructions%20for%20Schedule%20S%20vApr2016.pdf

for begin angle and 360 for end angle, to indicate that the satellites are active during the entire orbit.

The Instructions for Schedule S[19] at 9(d) and 11(d) state: "From the drop down list, select whether the channel is used as a feeder link, service link, or for telemetry/telecommand/control (TT&C)." §25.103 defines "feeder link" as "A radio link from a fixed earth station at a given location to a space station, or vice versa, conveying information for a space radiocommunication service other than the Fixed-Satellite Service. The given location may be at a specified fixed point or at any fixed point within specified areas." By this definition, as the VIASAT-NGSO satellite network operates in the Fixed-Satellite Service, none of its links are "feeder links." Therefore, ViaSat has identified all of its channels in Schedule S as "service links." Similarly, the Commission's online Schedule S interface does not allow entry of an answer to the "polarization switchable" data field for the specified transmitting and receiving beams. The beams specified in Schedule S are not polarization switchable.

In addition, ViaSat has been unable to enter into the Schedule S information with respect to its proposed satellite-to-satellite links (*i.e.*, the MEO-to-GSO payload) due to limitations in the Commission's Schedule S interface. Moreover, beam files for the RG1B, RG2B, TG1B, and TG2B beams on the MEO-to-GSO payload are not able to be generated in the GXT/GIMS format because that software produces beams that fall on the Earth's surface, and does not allow the generation of beams directed toward GSO spacecraft. In this case, the MEO-to-GSO beams always point into space—toward a designated GSO spacecraft when the intended satellite is in view and communications with that GSO satellite are occurring.

[19] https://enterpriseefiling.fcc.gov/schedules//resources/Instructions%20for%20Schedule%20S%20vApr2016.pdf

To provide the analog of the data provided by GXT beam files that are used for interference analyses, ViaSat has explained in the Technical Annex that it will use antenna and transmitting facilities on the MEO-to-GSO payload that are compliant with the Section 25.138 off-axis equivalent isotropically radiated power ("EIRP") density mask.[20] By complying with the off-axis EIRP density mask and by also ensuring that the 3-sigma antenna pointing error is less than 0.2 degrees, compatibility with the two-degree spacing environment in the GSO arc is ensured, much in the same way that it is for GSO operations more generally. Thus, ViaSat submits that the provided information about each MEO-to-GSO antenna beam's compliance with Section 25.138 of the Commission's rules, and the intention to communicate with spacecraft on the GSO arc at various longitudes, is a suitable substitute for beam data otherwise provided in GXT/GIMS format.

For these reasons, ViaSat is providing in narrative format in this Technical Annex all material information specified in Section 25.114 with respect to the proposed MEO-to-GSO payload. ViaSat also is prepared to submit this type of data through the Schedule S form based on instructions from the FCC staff.

[20] *See* 47 C.F.R. § 25.138.

EXHIBIT 1

Demonstration of EPFD Compliance

This annex demonstrates that the VIASAT-NGSO system will operate in compliance with the single-entry EPFD limits of No.'s 22.5C, 22.5D and 22.5F of the ITU Radio Regulations ("RR's") in specific Ka-band segments that are applicable to the U.S. market access request for the VIASAT-NGSO system: 17.8-18.6 GHz (space-to-Earth), 19.7-20.2 GHz (space-to-Earth), 27.5-28.6 GHz (Earth-to-space) and 29.5-30 GHz (Earth-to-space).

1.0 EPFD Validation Software

In early-June 2016, the ITU released a beta version of its EPFD validation software.[1] This software was developed to identify coordination requirements under No.'s 9.7A and 9.7B of the RR's and to verify that an NGSO FSS system complies with the ITU Article 22 single-entry EPFD limits. The software is publicly available and was developed in accordance with the specifications stipulated in the most recent version of ITU-R Recommendation S.1503. This software was used to generate the EPFD curves contained herein, and thereby demonstrates that the VIASAT-NGSO system is in compliance with the applicable ITU Article 22 EPFD limits.

ViaSat is providing the Commission, with this application, the input files that allow independent verification that the VIASAT-NGSO system complies with the single-entry EPFD limits of No.'s 22.5C, 22.5D and 22.5F of the RR's in the applicable band segments. These input parameters include the orbital characteristics and transmission parameters of the VIASAT-NGSO system as well as the PFD and/or EIRP masks required by the ITU's EPFD validation software.

2.0 EPFD Down

The downlink PFD masks are provided in "Az/El" format in accordance with PFD mask Option 2 of ITU-R Recommendation S.1503-2. That is, the downlink PFD masks are expressed in terms of azimuth and elevation angles relative to the NGSO satellite's sub-satellite point (*i.e.*, nadir).

[1] *See* ITU Radiocommunication Bureau Circular Letter CR/405, dated June 3, 2016.

The PFD masks vary based on the latitude of the NGSO satellite. For example, higher NGSO satellite latitudes are assigned higher PFD levels due to the inherent geometry that arises from sharing with GSO networks. The corollary is that PFD levels at lower NGSO satellite latitudes are assigned reduced levels relative to higher NGSO satellite latitudes.

The minimum elevation angle is set to be 25°. The maximum number of NGSO satellites transmitting simultaneously on the same frequency to the same geographic location has been set to be two in order to be conservative. Generally, only one satellite will be transmitting to any particular geographic location, although occasionally it is possible that two satellites with partial coverage overlap could be transmitting simultaneously on the same frequency, at the same time, and to the same geographic location.

Figures 1 through 3 show the downlink EPFD results, using the ITU's EPFD validation software, for the 17.8-18.6 GHz band segment, and for the three GSO reference receive antenna sizes contained in Table 22-1B of Article 22 of the RR's. These figures show the calculated EPFD levels for the VIASAT-NGSO system relative to the EPFD limits. These figures demonstrate in all three cases that the VIASAT-NGSO system complies with the applicable downlink EPFD limits.

Figure 1. 1 meter GSO Rx reference antenna; 40 kHz reference bandwidth.

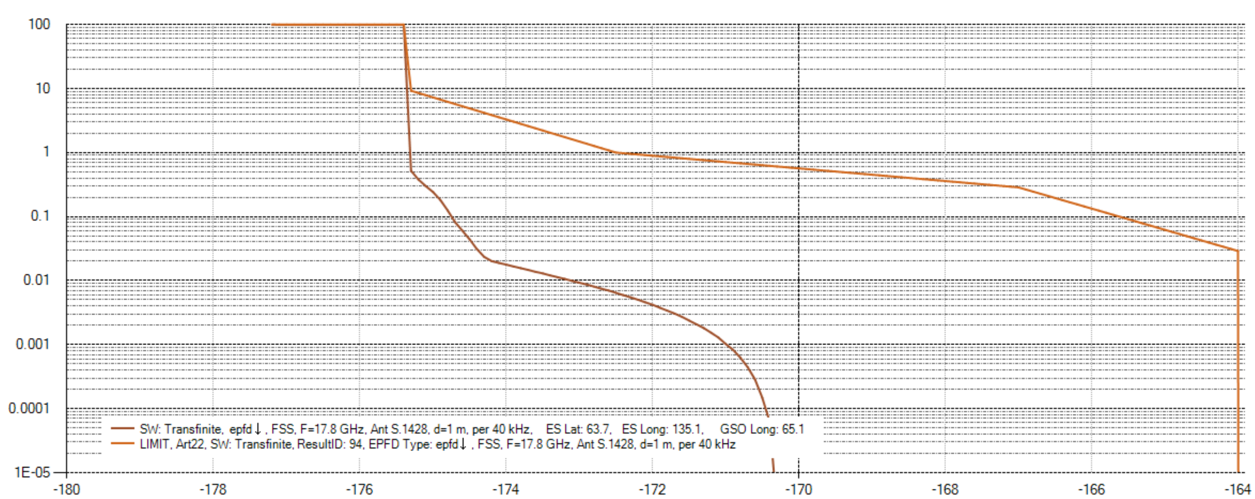


Figure 2. 2 meter GSO Rx reference antenna; 40 kHz reference bandwidth.

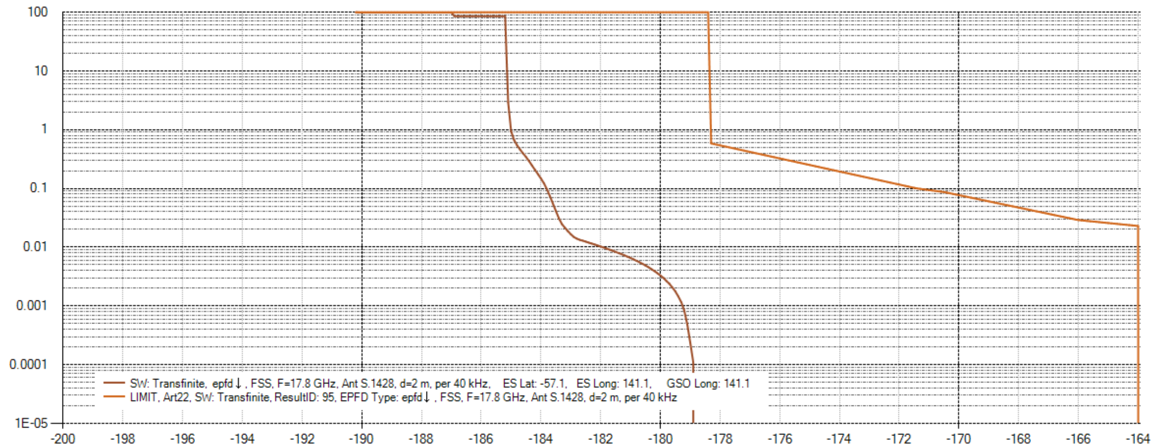
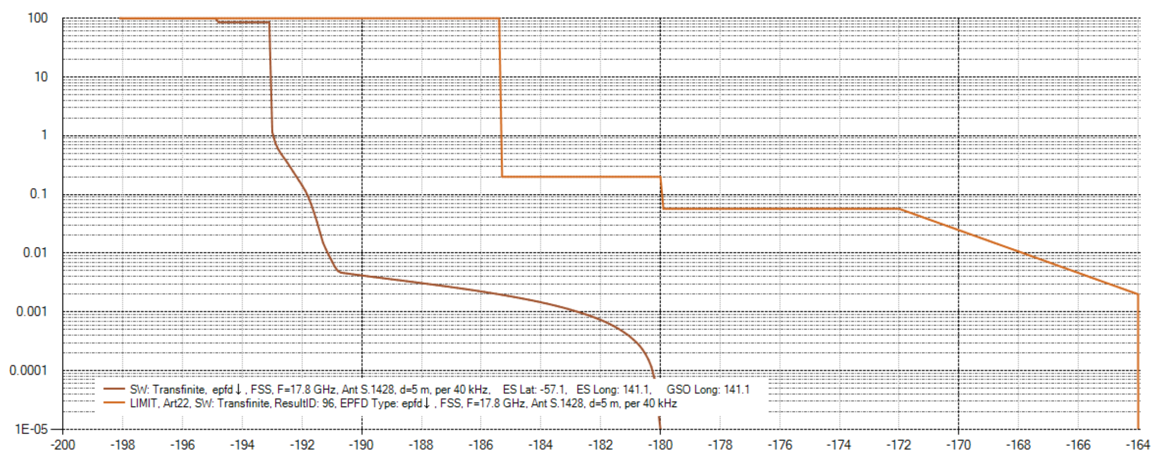


Figure 3. 5 meter GSO Rx reference antenna; 40 kHz reference bandwidth.



Figures 4 through 7 show the downlink EPFD results, using the ITU's EPFD validation software, for the 19.7-20.2 GHz band segment, and for the four GSO reference receive antenna sizes contained in Table 22-1C of Article 22 of the RR's. These figures show the calculated EPFD levels for the VIASAT-NGSO system relative to the EPFD limits. These figures demonstrate in all four cases that the VIASAT-NGSO system complies with the applicable downlink EPFD limits.

Figure 4. 0.7 meter GSO Rx reference antenna; 40 kHz reference bandwidth.

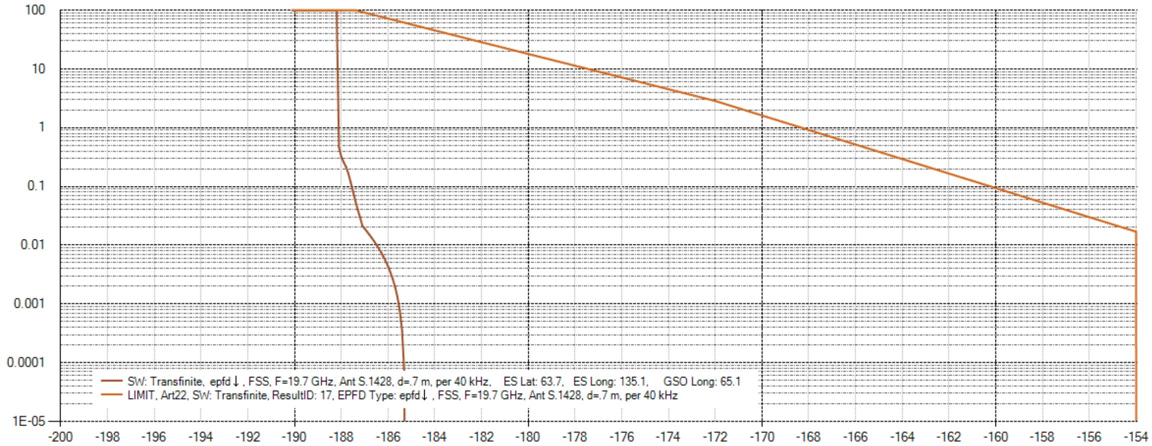


Figure 5. 0.9 meter GSO Rx reference antenna; 40 kHz reference bandwidth.

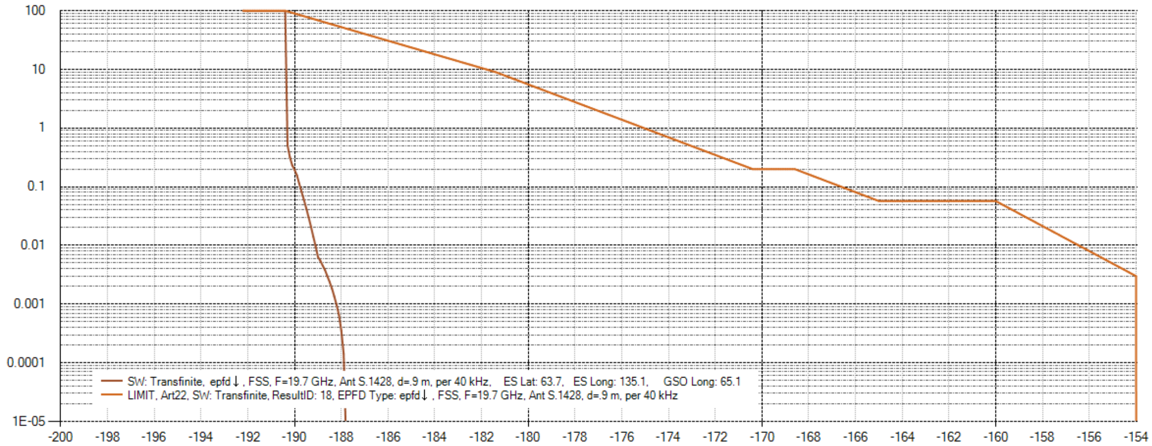


Figure 6. 2.5 meter GSO Rx reference antenna; 40 kHz reference bandwidth.

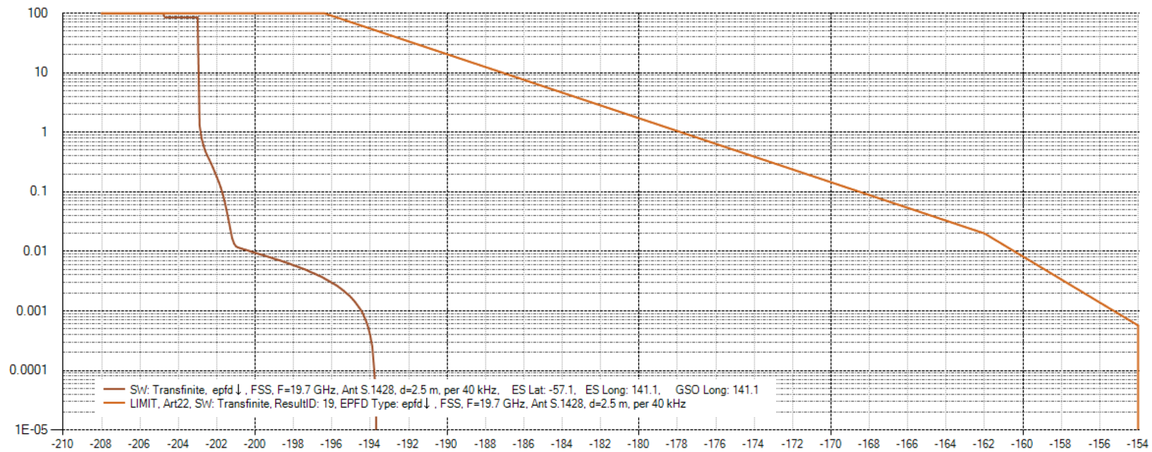
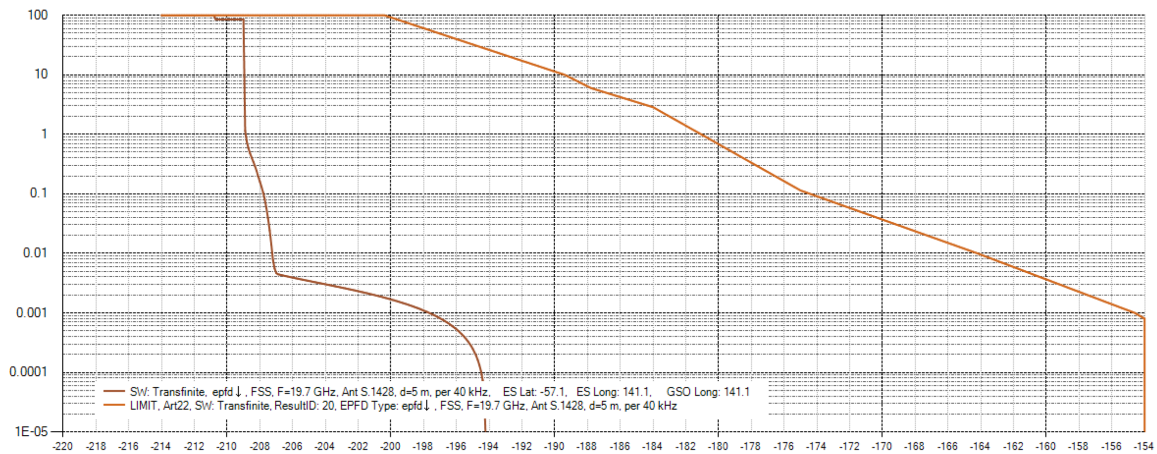


Figure 7. 5 meter GSO Rx reference antenna; 40 kHz reference bandwidth.



3.0 EPFD Up

Similar to the downlink PFD masks, the uplink EIRP masks also vary with NGSO latitude. A restriction is placed upon the transmitting earth stations: it has been assumed that a VIASAT-NGSO earth station will not transmit (*i.e.*, will cease transmissions) when the topocentric angle between a VIASAT-NGSO satellite and the geostationary arc is less or equal to a certain angle. To be conservative, this angle is set to be 3 degrees for earth station antennas 60 cm and larger. For smaller antennas, the angle is set to be 5 degrees.

On the uplink, the EPFD software requires the average number of associated earth stations with overlapping frequencies per square kilometre within a cell (*i.e.*, density) and the average distance between co-frequency cells. For a minimum elevation angle of 25°, and an NGSO altitude of 8200 km, the corresponding Earth's land area can be calculated to be 6.358 x 10^7 km^2. The maximum number of earth stations transmitting simultaneously on the same frequency to a particular NGSO satellite has been assumed to be 20. The average distance between cells is then 1797 km and the average density is 3.097 x 10^{-7} per km^2. Similar to the downlink, and to be conservative, the maximum number of NGSO satellites receiving simultaneously with overlapping frequencies from the associated earth stations within a given cell has been set to two, although in general, this number will only be one.

Figures 8 through 13 show the uplink EPFD results for the VIASAT-NGSO system using the ITU's EPFD validation software for the 27.5-28.6 GHz and 29.5-30 GHz band segment. Three representative uplink antennas have been used for the analysis of each uplink band segment: 30 cm, 60 cm and 7 m. Figures 8 through 11 show the calculated uplink EPFD levels relative to the EPFD limits and demonstrate in all cases that the VIASAT-NGSO system complies with the applicable uplink EPFD limits. The very conservative case represented by the 7 m antenna demonstrates that earth stations much larger than the 1 m antenna described in the Technical Analysis also will comply. ViaSat will ensure that all antenna sizes used for the VIASAT-NGSO system also comply with the uplink EPFD limits.

Figure 8. 27.5-28.6 GHz. 30 cm uplink antenna. 40 kHz reference bandwidth.

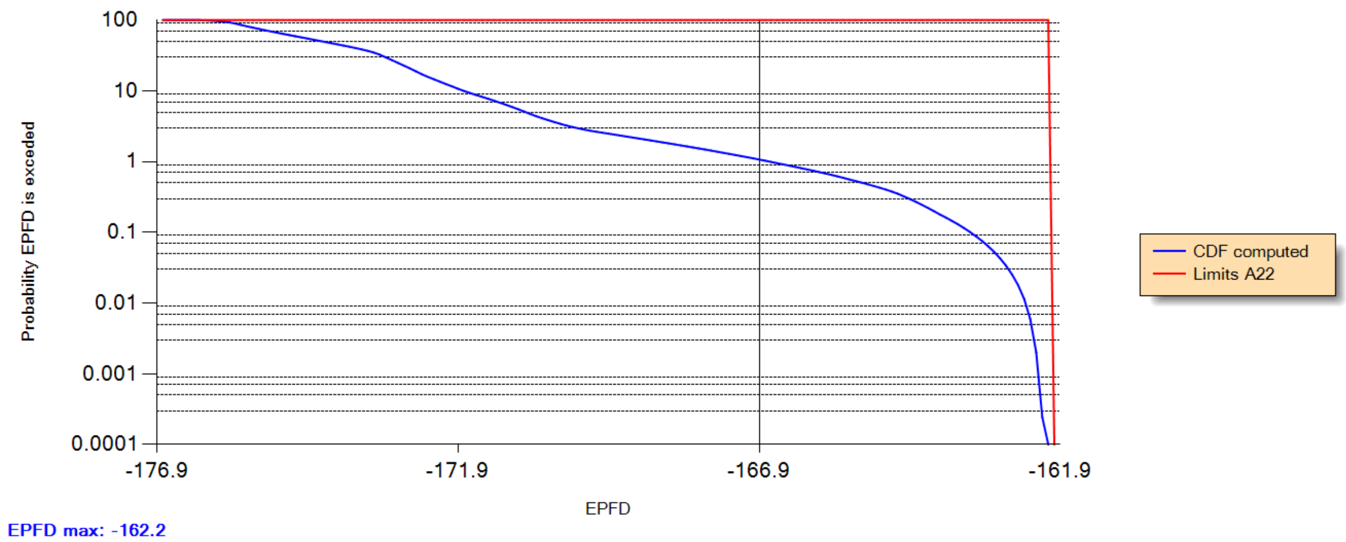


Figure 9. 29.5-30 GHz. 30 cm uplink antenna. 40 kHz reference bandwidth.

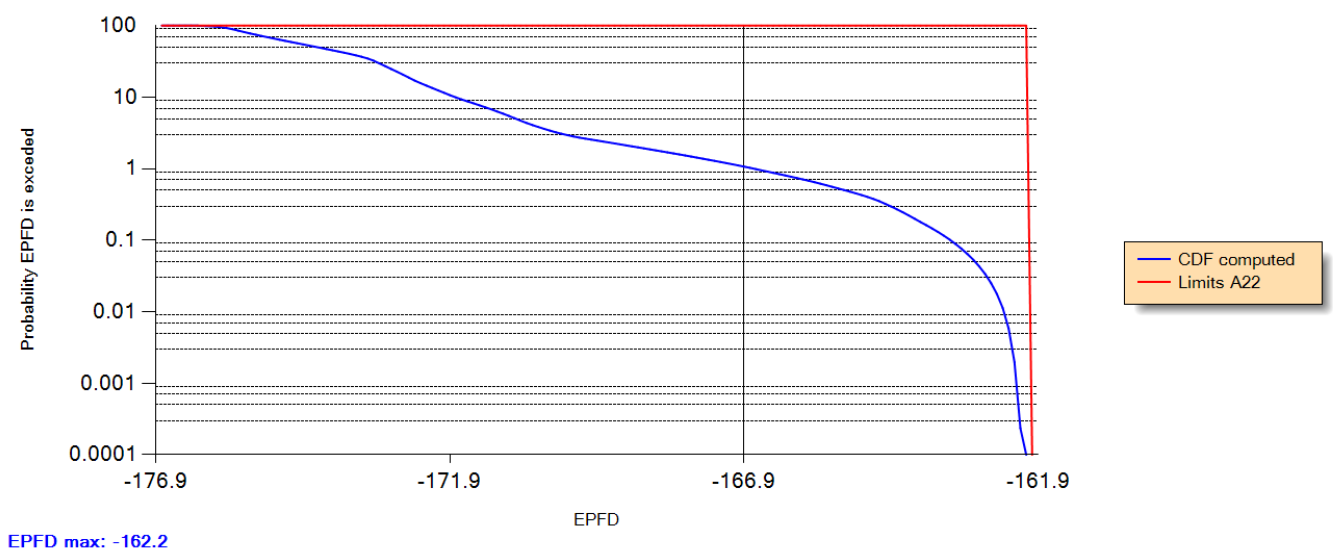


Figure 10. 27.5-28.6 GHz. 60 cm uplink antenna. 40 kHz reference bandwidth.

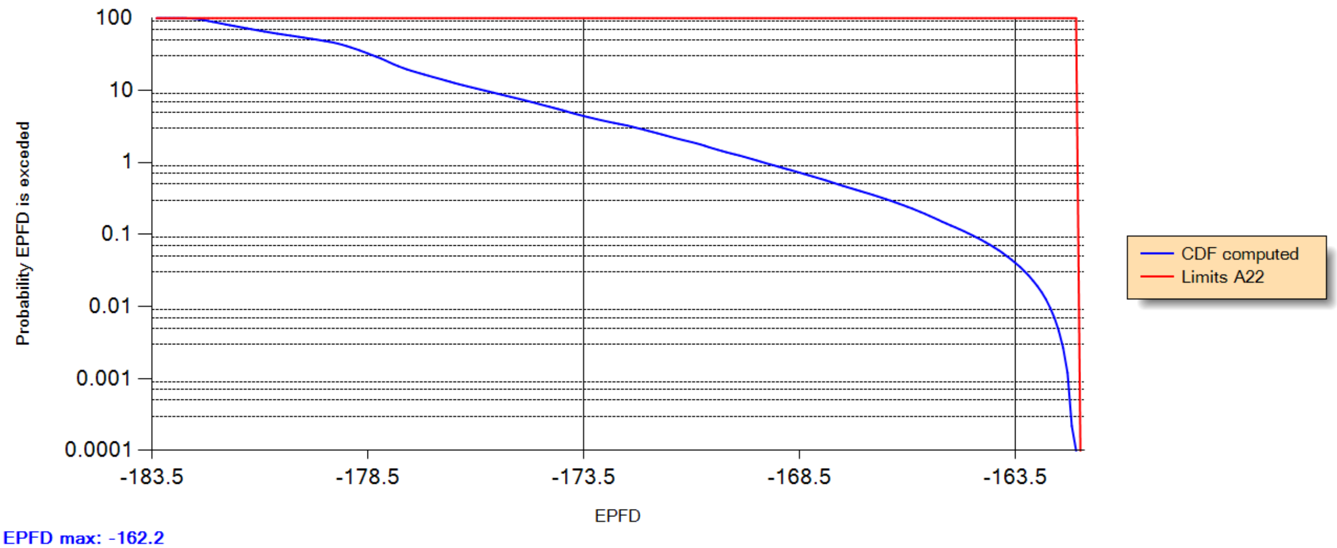


Figure 11. 29.5-30 GHz. 60 cm uplink antenna. 40 kHz reference bandwidth.

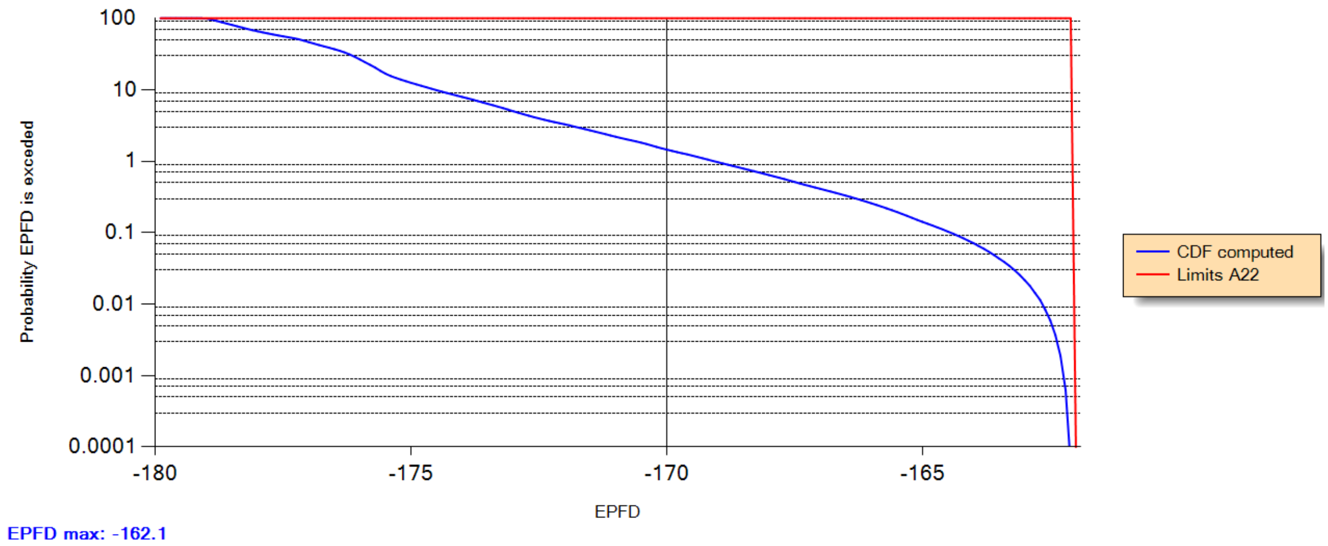


Figure 12. 27.5-28.6 GHz. 7 m uplink antenna. 40 kHz reference bandwidth.

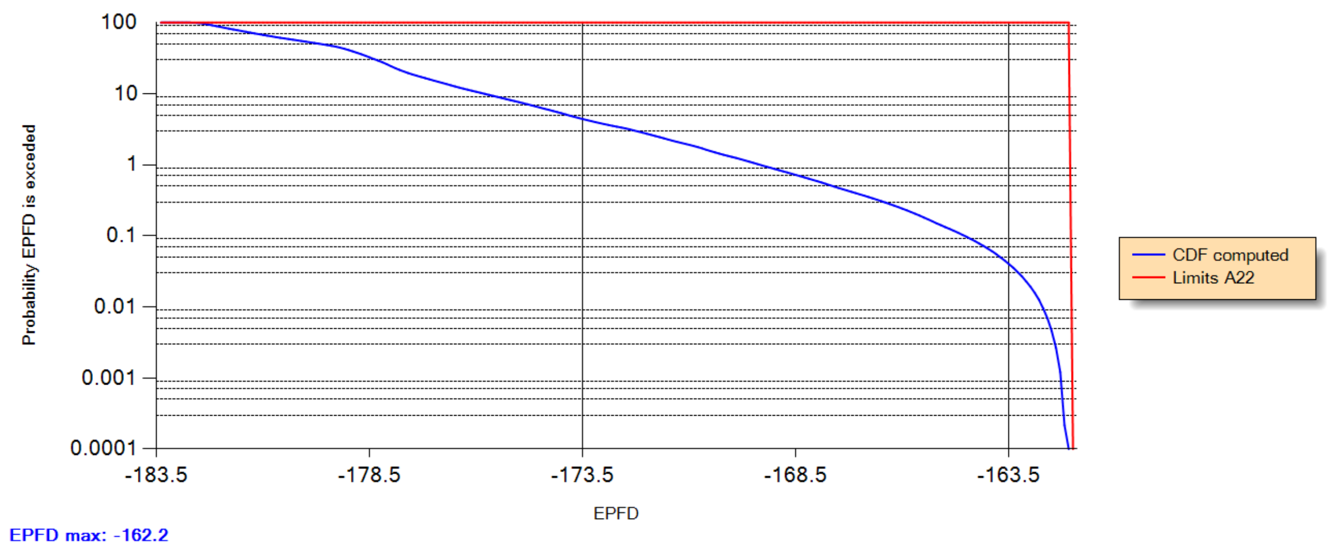
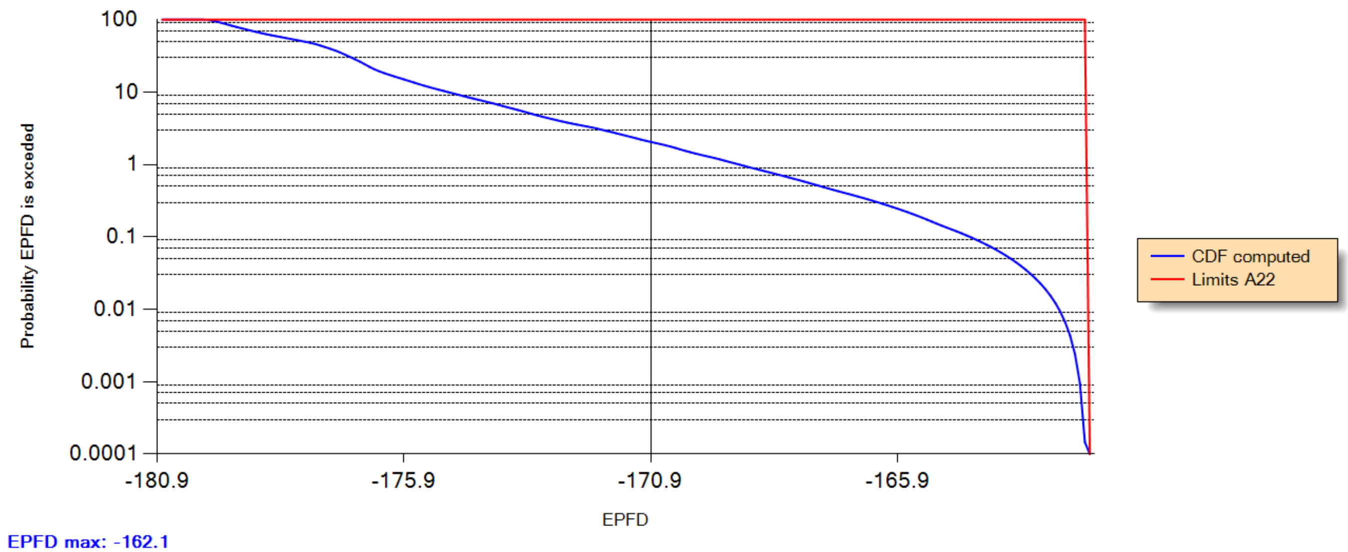


Figure 13. 29.5-30 GHz; 7 m uplink antenna. 40 kHz reference bandwidth.



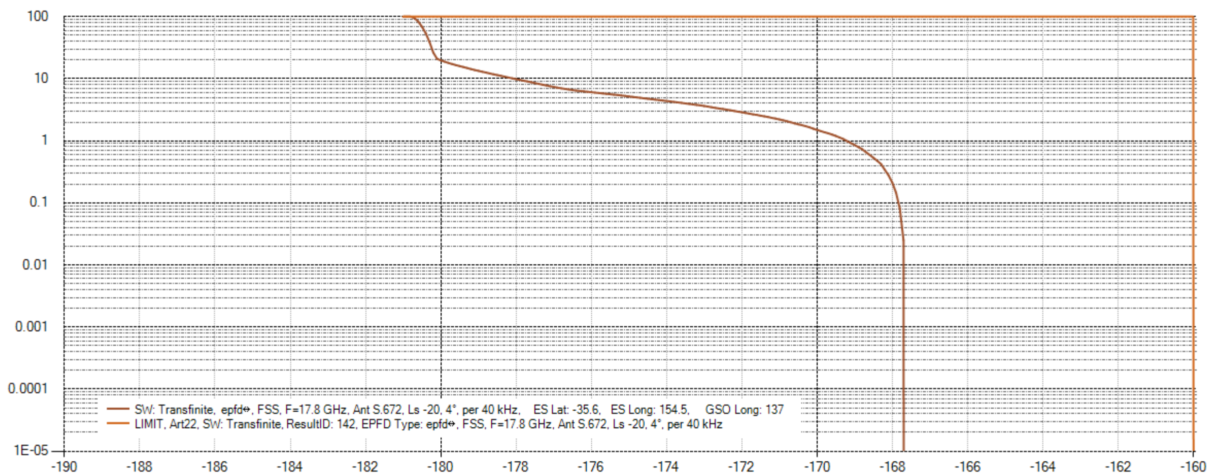
4.0 EPFD Inter-Satellite

The only VIASAT-NGSO frequency for which U.S. market access is sought and to which the inter-satellite EPFD limits apply is the 17.8-18.4 GHz band segment. The ITU's EPFD validation software was used to verify that the VIASAT-NGSO system complies with the inter-satellite EPFD limits of Table 22-3 of Article 22 of the RR's.

Conservative assumptions were used for the potential inter-satellite interference situation. The maximum EIRP density of the VIASAT-NGSO satellites was assumed to be 30 dB down relative to peak at the limb of the Earth (*i.e.*, 22 dBW/40 kHz – 30 = -8 dBW/40 kHz). This is conservative considering that the limb of the Earth is beyond zero degrees elevation angle for a VIASAT-NGSO satellite. Further, for all off-axis angles beyond the limb of the Earth (*i.e.*, backlobes), the maximum EIRP was kept at a constant 30 dB down relative to peak. Note that the peak downlink EIRP density of 22 dBW/40 kHz can only occur at higher VIASAT-NGSO satellite latitudes due to the need to protect the geostationary arc, yet this peak EIRP density has been assumed to apply to all VIASAT-NGSO satellite latitudes. This is "forced" by the format of the ITU's EPFD validation software for inter-satellite interference analysis, since the format does not allow for off-axis EIRP variation based on NGSO satellite latitude.

Figure 14 shows the calculated inter-satellite EPFD levels for the VIASAT-NGSO system relative to the EPFD limits and demonstrates that the VIASAT-NGSO system complies with the applicable inter-satellite EPFD limits.

Figure 14. Inter-satellite EPFD result; 40 kHz reference bandwidth.



5.0 EPFD Input Files Provided to the Commission

In order to allow independent verification regarding the compliance of the VIASAT-NGSO system with the applicable ITU EPFD limits, ViaSat is providing the Commission with all the input files required by the ITU's EPFD validation software. Each file is a zipped file containing the following:

- EPFD input file in mdb format
- Associated PFD or EIRP mask file in mdb format
- Associated PFD or EIRP mask file in xml format. Note that the xml files have been embedded into the associated mask mdb file.

A description of each of the zipped files being provided to the Commission is provided below:

1) EPFD Input #1. This file contains the downlink parameters of the VIASAT-NGSO system transmitting in the 17.8-18.6 GHz and 29.5-30 GHz band segments. There are three mask files contained therein: two downlink PFD masks for each of the downlink band segments and an inter-satellite EIRP mask (17.8-18.4 GHz).

2) EPFD Input #2. This file contains the parameters for 30 cm uplink antennas transmitting in the 27.5-28.6 GHz band segment.

3) EPFD Input #3. This file contains the parameters for 30 cm uplink antennas transmitting in the 29.5-30 GHz band segment.

4) EPFD Input #4. This file contains the parameters for 60 cm uplink antennas transmitting in the 27.5-28.6 GHz band segment.

5) EPFD Input #5. This file contains the parameters for 60 cm uplink antennas transmitting in the 29.5-30 GHz band segment.

6) EPFD Input #6. This file contains the parameters for 7 meter uplink antennas transmitting in the 27.5-28.6 GHz band segment.

7) EPFD Input #7. This file contains the parameters for 7 meter uplink antennas transmitting in the 29.5-30 GHz band segment.

CERTIFICATION

I hereby certify that I am the technically qualified person responsible for preparation of the engineering information contained in this Petition for Declaratory Ruling ("Petition"), that I am familiar with Part 25 of the Commission's rules, that I have either prepared or reviewed the engineering information submitted with this Petition, and that it is complete and accurate to the best of my knowledge, information and belief.

REGISTERED PROFESSIONAL ENGINEER
DARYL T HUNTER
E 16610
ELECTRICAL
STATE OF CALIFORNIA

Daryl T. Hunter, P.E.
Senior Director, Regulatory Affairs
ViaSat, Inc.
6155 El Camino Real
Carlsbad, CA 92009

November 15, 2016