ATTACHMENT A

Technical Information to Supplement Schedule S

A.1 SCOPE AND PURPOSE

The purpose of this Attachment is to provide the Commission with the technical characteristics of the VIASAT-3 satellite, as modified. This attachment contains information that cannot be entered into the Schedule S submission.

A.2 GENERAL DESCRIPTION

The VIASAT-3 satellite will provide a variety of Ka-band satellite services from the nominal 89º W.L. orbital location, with an offset of 0.1° and the station-keeping box centered at 88.9° W.L.

The VIASAT-3 satellite's beam coverage, both transmit and receive, consists of multiple spot beams. Figure A.2-1 shows the satellite's service area in both the uplink and downlink directions.

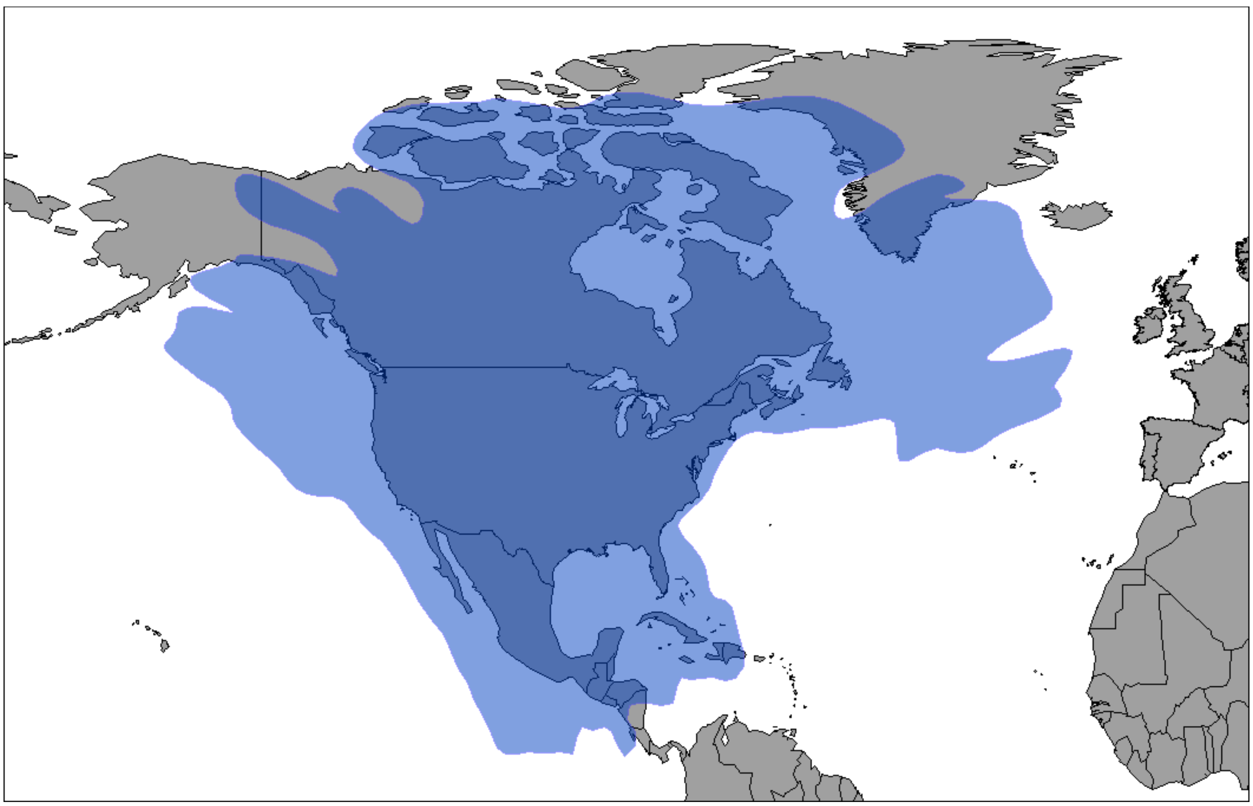
ViaSat has been granted U.S. market access for the 18.3-19.3 GHz and 19.7-20.2 GHz downlink bands, and the 28.1-29.1 GHz and 29.5-30.0 GHz uplink bands. This application for modification does not seek market access for any additional frequency bands, and thus, ViaSat provides technical information pertaining to the capabilities of the satellite for which market access has already been granted.

The satellite network will provide service to small, fixed and temporary-fixed user antennas as well as to very small antennas for mobile applications. In addition, larger gateway-type antennas will be employed. The gateway-type antennas will have the capability of transmitting in any channel within the 28.1-29.1 GHz and 29.5-30.0 GHz bands. Uplink transmissions from the smaller user terminals will occur in the 28.35-29.1 GHz and 29.5-30.0 GHz bands.

The satellite typically uses asymmetric forward (gateway-to-subscriber) and return (subscriber-to-gateway) links. The network will use adaptive coding and modulation to combat rain fades. That is, the modulation type, amount of coding and/or user data rate will be dynamically varied to meet the link requirements during rain events (in addition to employing uplink power control).

Figure A.2-1. The VIASAT-3 satellite's service area.

The map below illustrates the coverage area of the VIASAT-3 satellite. The coverage includes the entire service area for which U.S. market access has already been granted.



A.3 FREQUENCY AND POLARIZATION PLAN

The relevant frequency plan is given in Table A.3-1, indicating channel center, polarization and bandwidth. The table also shows the connectivity between each uplink and downlink band. Circular polarization is used on both the uplink and downlink with the downlink polarization being orthogonal to the uplink polarization. The satellite re-uses the spectrum such that any channel is re-used multiple times by a combination of polarization and spatial isolation. This satisfies the requirements of §25.210(f) of the FCC's Part 25 rules (the "Rules").

Table A.3-1. Frequency Plan for U.S. Market Access

Uplink Center Frequency (MHz)	Uplink Polarization	Corresponding Downlink Center Frequency (MHz)	Downlink Polarization	Bandwidth (MHz)
28350	RHCP, LHCP	18550	LHCP, RHCP	500
28850	RHCP, LHCP	19050	LHCP, RHCP	500
29750	RHCP, LHCP	19950	LHCP, RHCP	500

As explained in section A.11, the 28.6-29.1 GHz and 18.8-19.3 GHz bands, or a portion thereof, will cease to be used in the event that there is a need to protect an NGSO network.

A.4 MAXIMUM DOWNLINK EIRP AND EIRP DENSITY

The maximum operational downlink EIRP of all spot beams is 72.7 dBW. The maximum operational downlink EIRP density varies by sub-band. The maximum operational downlink EIRP density towards U.S. territory in the 18.3-18.8 GHz and 19.7-20.2 GHz bands varies slightly depending on the spreading loss. ViaSat will not exceed a PFD on U.S. territory of -118 $dBW/m^2/MHz$ consistent with §25.138 (a)(6), which is the limit that is currently authorized for VIASAT-3. Because PFD is dependent on the slant path and hence spreading loss, the maximum EIRP density from the satellite can vary accordingly. For example, for a spreading loss of 162.1 dB, VIASAT-3 satellite transmissions would not exceed an EIRP density of 44.1 dBW/MHz.

The maximum operational downlink EIRP density towards U.S. territory in the 18.8-19.3 GHz band will not exceed 40.9 dBW/MHz.

A.5 SATELLITE ANTENNA BEAMS AND ANTENNA GAIN CONTOURS

The satellite's antenna gain contours are being provided to the Commission in a GIMS container file.

The satellite's payload employs multiple spot beams in both the uplink and downlink directions. There are two types of spot beams: small beams ("A"-type beams) and larger beams ("B"-type beams). For each beam-type, the beams are nominally identical.

ViaSat is providing the Commission with an isoline gain contour, in both uplink and downlink directions, that depict, on a composite basis across the entire coverage area, the maximum gain of all spot beams that may be operated within that area. In addition, the predicted antenna gain contours for one transmit and receive representative spot beam for each of the two beam types, and in both polarizations, is included in the associated GIMS file.

For on-station operations, the TT&C locations have not yet been selected. In the associated GIMS file, the TT&C beams provided are identical to the composite beams described above. On-station TT&C operations are conducted through the communications spot beams.

For clarity, the following beams have been included in the associated GIMS file:

1) RXAR and RXAL. These contain a composite beam contour, in both polarizations, for the uplink A-type beams.
2) TXAR and TXAL. These contain a composite beam contour, in both polarizations, for the downlink A-type beams.
3) RXBR and RXBL. These contain a composite beam contour, in both polarizations, for the uplink B-type beams.
4) TXBR and TXBL. These contain a composite beam contour, in both polarizations, for the downlink B-type beams.
5) CUR and TDR. These contain a composite beam contour, representing the uplink and downlink on-station TT&C beams, respectively.
6) UPAT. This contains a composite beam contour, representing the uplink autotrack beams.
7) DNAT. The downlink beam used in support of the autotrack function.
8) RXAR_REP and RXAL_REP. Representative spot beam contours for the uplink A-type beams, in both polarizations. Beam RXAR_REP also serves as the representative beam for command beam CUR.

9) TXAR_REP and TXAL_REP. Representative spot beam contours for the downlink A-type beams, in both polarizations. Beam TXAR_REP also serves as the representative beam for telemetry beam TDR.
10) RXBR_REP and RXBL_REP. Representative spot beam contours for the uplink B-type beams, in both polarizations.
11) TXBR_REP and TXBL_REP. Representative spot beam contours for the downlink B-type beams, in both polarizations

The near-omni directional beams (beams OMNUR and OMNDR) used for on-station emergency situations have gain contours that vary by less than 8 dB across the surface of the Earth, and accordingly the gain at 8 dB below the peak falls beyond the edge of the Earth. Therefore, pursuant to Section 25.114(c)(vi)(A) of the Rules, contours for these beams are not required to be provided and have not been included in the associated GIMS file.

A.6 TT&C CHARACTERISTICS

The information provided in this section complements that provided in the associated Schedule S submission.

The TT&C sub-system provides for communications during pre-launch, transfer orbit and on-station operations, as well as during spacecraft emergencies. When on-station, uplink beacon transmissions are used to control pointing of the satellite’s antennas. The TT&C sub-system will operate at the edges of the uplink and downlink frequency ranges during all phases of the mission. All transmissions will operate in a circular polarization mode.

During transfer orbit and on-station emergencies the TT&C subsystem employs a near-omni-directional antenna configuration. During normal on-station operation, the telecommand transmissions will be received via one of two uplink spot beams. A summary of the TT&C subsystem's characteristics is given in Table A.6-1.

Table A.6-1. Summary of the TT&C Subsystem Characteristics

Parameter	**Transfer Orbit and Emergency**	**On-Station**
Command/Ranging Frequencies and Polarizations	29,501 MHz - RHCP 29,999 MHz - RHCP	29,501 MHz - RHCP 29,999 MHz - RHCP
Minimum Command Flux Density	-82 dBW/m^2	-117 dBW/m^2
Uplink Antenna Beam	Near-Omni	Spot
Telemetry/Ranging Frequencies and Polarizations	18,301 MHz - RHCP 18,303 MHz - RHCP	18,301 MHz - RHCP 18,303 MHz - RHCP
Downlink Antenna Beam	Near-Omni	Spot
Maximum Downlink EIRP	7 dBW	40 dBW

Additionally, an uplink autotrack beacon will be transmitted at a frequency of 29,501 MHz and in RHCP, a downlink continuous wave ("CW") signal is transmitted at 18,799.6 MHz in vertical polarization in support of the autotrack function, as well as a 400 kHz pseudo-noise ("PN") modulated downlink carrier also transmitted at 18,799.6 MHz in vertical polarization. The CW and PN carriers can be individually "extracted" on the ground, despite the fact that they transmit on the same center frequency.

A.7 CESSATION OF EMISSIONS

Consistent with the originally authorized parameters for VIASAT-3, all downlink transmissions can be turned on and off by ground telecommand, thereby causing cessation of emissions from the satellite, as required by § 25.207 of the FCC's rules.

A.8 POWER FLUX DENSITY AT THE EARTH'S SURFACE (18.3-19.3 GHZ BAND)

The maximum PFD emitted over U.S. territory by VIASAT-3 will remain compliant with the §25.208(c) PFD limits that apply in the 18.3-18.8 GHz band. The PFD limits of §25.208(c) are as follows:

- -115 dB(W/m^2) in any 1 MHz band for angles of arrival between 0 and 5 degrees above the horizontal plane;
- -115+(δ-5)/2 dB(W/m^2) in any 1 MHz band for angles of arrival δ (in degrees) between 5 and 25 degrees above the horizontal plane; and
- -105 dB(W/m^2) in any 1 MHz band for angles of arrival between 25 and 90 degrees above the horizontal plane.

In addition, §25.208(d) contains PFD limits that apply in the 18.6-18.8 GHz band produced by emissions from a space station under assumed free-space propagation conditions as follows:

- -95 dB(W/m^2) for all angles of arrival. This limit may be exceeded by up to 3 dB for no more than 5% of the time.

In the worst case, the PFD limits of §25.208(d) correspond to a PFD of -118 dBW/m^2/MHz (*i.e.*, -95-10*log(200)).

§25.208 does not contain any PFD limits that apply in the 18.8-19.3 GHz band for GSO satellite networks, however it is noted that Article 21 of the ITU Radio Regulations does include PFD limits applicable to GSO satellites using the 18.8-19.3 GHz band. The ITU limits are identical to those in §25.208(c).

As explained in section A.9.1, ViaSat will operate the satellite such that downlink transmissions in the 18.3-18.8 GHz band will not exceed a PFD level of -118 dBW/m^2/MHz. This PFD level is in compliance with both §25.208(c) and §25.208(d).

The maximum downlink EIRP density transmitted in the 18.8-19.3 GHz band will be 1.8 dB lower than that transmitted in the 18.3-18.8 GHz band, therefore downlink transmissions in this band also meet the applicable PFD limits.

A.9 TWO DEGREE COMPATIBILITY

The VIASAT-3 satellite network also remains compliant with the uplink off-axis EIRP density and downlink PFD levels of §25.138, regardless of whether the frequency band used is subject to §25.138.

A.9.1 Frequency Bands Subject to §25.138

For those frequency bands subject to §25.138, compliance with the Commission's two-degree spacing policy is ensured provided:

1) The uplink off-axis EIRP density levels of §25.138(a)(1) of the Rules for blanket licensing are not exceeded;

2) The maximum PFD levels of §25.138(a)(6) of the Rules for blanket licensing are not exceeded.

ViaSat will ensure that no authorized uplink transmissions towards the VIASAT-3 satellite will exceed the clear sky uplink off-axis EIRP density limits of §25.138(a)(1). In cases where a transmitting earth station does not meet the off-axis gain mask requirements of §25.209(a) and (b), the maximum input power density into the antenna will be correspondingly reduced such that off-axis EIRP density requirements of §25.138(a)(1) are still met.

In addition, ViaSat will ensure that no downlink transmissions in the 18.3-18.8 and 19.7-20.2 GHz bands from the VIASAT-3 satellite towards U.S. territory will exceed the -118 dBW/m^2/MHz limit set forth in §25.138 (a)(6) of the Rules.

A.9.2 Frequency Bands Not Subject to §25.138

This section demonstrates that uplink transmissions in the 28.1-28.35 GHz and 28.6-29.1 GHz bands and downlink transmissions in the 18.8-19.3 GHz band are two-degree compatible.

Currently there are no operational GSO Ka-band satellites that use the 28.1-28.35 GHz, 28.6-29.1 GHz and 18.8-19.3 GHz bands at or within two degrees of the 88.9º W.L. location, nor are there any pending applications before the Commission for use of these bands by a GSO satellite at or within two degrees of 88.9° W.L. Therefore, in order to demonstrate two-degree compatibility, the transmission parameters of the VIASAT-3 satellite have been assumed as both the wanted and victim transmissions.

Table A.9-2 provides a summary of the uplink and downlink transmission parameters. These parameters were derived from the VIASAT-3 link budgets that are embedded in the Schedule S form and were used in the interference analysis. The interference calculations assumed a 1 dB advantage for topocentric-to-geocentric conversion and that all wanted and interfering carriers are co-polarized. The C/I calculations were performed on a per Hz basis.

Table A.9-3 shows the results of the interference calculations in terms of the overall C/I margins. It can be seen that the C/I margins are positive in all cases.

Table A.9-2. VIASAT-3 transmission parameters.

Carrier ID	Emission Designator	Bandwidth (MHz)	Tx E/S Gain (dBi)	Uplink EIRP (dBW)	Downlink EIRP (dBW)	Rx E/S Gain (dBi)	C/I Criterion (dB)
1	500MG7D	500	65.0	75.0	67.9	49.3	20.5
2	500MG7D	500	65.0	75.0	67.9	40.7	13.8
3	500MG7D	500	65.0	75.0	67.9	40.7	7.4
4	500MG7D	500	65.0	75.0	67.9	33.7	9.3
5	6M25G7D	6.25	44.3	48.8	48.9	61.4	16.4
6	3M13G7D	3.125	44.3	48.8	45.9	61.4	15.1
7	1M56G7D	1.563	44.3	48.8	42.9	61.4	10.1
8	782KG7D	0.7813	44.3	46.6	39.9	61.4	8.9
9	3M87G7D	3.874	37.3	39.9	46.8	61.4	9.3

Table A.9-3. Summary of the overall C/I margins (dB).

		Interfering Carriers								
	Carrier ID	1	2	3	4	5	6	7	8	9
Wanted Carriers	1	8.3	8.3	8.3	8.3	6.3	5.0	3.1	2.5	2.4
	2	6.5	6.5	6.5	6.5	6.1	5.8	5.2	5.0	5.0
	3	12.8	12.8	12.8	12.8	12.5	12.2	11.6	11.4	11.3
	4	4.0	4.0	4.0	4.0	3.9	3.8	3.7	3.6	3.6
	5	19.4	19.4	19.4	19.4	7.3	4.4	1.4	0.5	0.4
	6	22.6	22.6	22.6	22.6	11.6	8.7	5.7	4.9	4.8

	7	28.9	28.9	28.9	28.9	19.5	16.6	13.7	12.9	12.7
	8	30.4	30.4	30.4	30.4	21.5	18.6	15.7	14.9	14.8
	9	19.0	19.0	19.0	19.0	7.6	4.7	1.7	0.9	0.7

A.10 SHARING WITH LMDS AND WITH NGSO FSS IN THE 28.1-28.35 GHZ BAND

VIASAT-3 is authorized to operate in the United States using the 28.1-28.35 GHz band designated for LMDS on a primary basis and for the FSS on a secondary basis. The modifications to the satellite design do not impact the demonstration of compatibility provided in ViaSat's original letter of intent application. Applications for the earth station antennas communicating with the VIASAT-3 and using the 28.1-28.35 GHz band within the U.S. will include an appropriate demonstration that the proposed operations will not cause harmful interference into any licensed LMDS station. The earth station licensee will take appropriate actions to protect any future licensed LMDS station that has the potential to receive harmful interference, including ceasing transmissions in the 28.1-28.35 GHz band if necessary.

O3b Limited ("O3b") has received licenses from the Commission for gateway earth stations located in Hawaii and Texas, and fixed terminals in Hawaii, to communicate with O3b's constellation of NGSO satellites using the 28.1-28.35 GHz band on a secondary basis.[1] In addition, O3b has pending applications for fixed earth stations to be located in Virginia proposing to use the 28.1-28.35 GHz band on a secondary basis.[2] The analysis in the following section, which demonstrates the compatibility of VIASAT-3 operations in the United States with those O3b earth stations located in the U.S. operating in the 28.6-29.1 GHz and 18.8-19.3 GHz bands, is equally applicable to operations in the 28.1-28.35 GHz band. Currently no other operational NGSO systems are authorized by the Commission to use the 28.1-28.35 GHz band, nor are there any other pending applications before the Commission for use of the 28.1-28.35 GHz band by a NGSO system.

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[1] *See* SES-LIC-20100723-00952; SES-LIC-20130124-00089; SES-LIC-20141022-00809.

[2] *See* SES-LIC-20130618-00516; SES-AMD-20131122-01187; SES-LIC-20150310-00138.

A.11 SHARING WITH NGSO FSS IN THE 28.6-29.1 GHZ AND 18.8-19.3 GHZ BANDS

VIASAT-3 is authorized to operate in the United States using the 28.6-29.1 GHz band designated for NGSO FSS on a primary basis and for GSO FSS on a secondary basis. ViaSat's U.S. operations will be consistent with the obligations of a secondary user of spectrum to avoid harmful interference into, and to accept any interference received from, primary users.

The highest interference levels that could occur into NGSO networks from the VIASAT-3 network are when there is an "in-line" event. On the uplink for example, an in-line event occurs when the NGSO satellite, the GSO satellite and the interfering GSO earth station are all in a line. As the NGSO satellite continues to move within its orbit, an angle between the NGSO satellite and the GSO satellite, subtended at the GSO earth station, is created. As long as the GSO earth station does not transmit when the NGSO satellite is within a certain angle, no harmful interference to the NGSO satellite will occur. A similar situation exists on the downlink. The amount of angular separation required will be dependent on the orbital and transmission characteristics of the NGSO FSS networks, their earth station locations, and their interference criteria.

O3b has received U.S. market access for its constellation of NGSO satellites. O3b has Commission authorization to use 28.6-29.1 GHz and 18.8-19.3 GHz bands to communicate with gateway earth stations located in Hawaii and Texas as well as for earth stations on vessels ("ESV") operating within U.S. waters.[3] In addition, O3b is authorized to operate fixed terminals in Haleiwa, Hawaii, and on a blanket basis for the operation of fixed earth stations (1.2 meter, 1.8 meter, 2.2 meter and 2.4 meter) in CONUS, Hawaii, Puerto Rico and the U.S. Virgin Islands.[4] O3b also has pending applications for fixed earth station antennas (1.2 and 2.4 meter) to be located in Bristow, Virginia.[5] As was the case with ViaSat's original letter of intent

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[3] *See, e.g.,* SES-LIC-20100723-00952; SES-LIC-20130124-00089; SES-LIC-20130528-00455; *see also* SAT-LOI-20141029-00118.

[4] *See* SES-LIC-20141022-00809; SES-LIC-20141001-00781.

[5] *See* SES-LIC-20130618-00516; SES-AMD-20131122-01187; SES-LIC-20150310-00138.

application, the following analysis demonstrates that no harmful interference between O3b's system and the VIASAT-3 satellite network will occur.

Currently no other NGSO networks are authorized by the Commission to use the 28.6-29.1 GHz and 18.8-19.3 GHz bands. Northrop Grumman Space and Mission Systems Corp. ("Northrop Grumman") had previously received Commission authorization for its Global EHF Satellite Network ("GESN") and ATCONTACT Communications, LLC ("ATCONTACT") had previously received Commission authorization for its NGSO network. Both networks were to utilize highly elliptical orbits ("HEO"). The interference analysis contained herein demonstrates that the operations of the modified VIASAT-3 satellite network also would protect the HEO satellite systems previously licensed to ATCONTACT and NGST from harmful interference.

A.11.1 Sharing with the O3b System

As described above, O3b has Commission authorization for operation of gateways in Hawaii and Texas, fixed terminals in Hawaii, and blanket licensed fixed terminals in CONUS, Hawaii, Puerto Rico and the U.S. Virgin Islands, and for the operation of ESVs within U.S. coastal waters. O3b also has pending applications for operation of fixed earth stations in Virginia. ViaSat has examined each of these O3b scenarios and has found that the highest potential for interference from the VIASAT-3 network into the O3b network would occur into O3b's ESV operations because these are the O3b ground antennas that can be located closest to the equator. Due to its equatorial orbit, the closer to the equator that an O3b earth station is located, the more interference it can receive from a GSO network. Similarly, the closer to the equator that a GSO earth station is located, the more interference it can receive from the O3b network. The location closest to the equator that is within U.S. territory, and within the service area of the VIASAT-3 satellite, has been assumed to be located at 24.0°N, 80.5°W, which is in U.S. waters and approximately halfway between the southern coast of Florida and the northern coast of Cuba. The following analysis assumes the VIASAT-3 and O3b networks each have an ESV collocated at these geographic coordinates.

Table A.11-1 shows the pertinent transmission parameters of the VIASAT-3 network and the O3b system.

Table A.11-1. Summary of VIASAT-3 and O3b parameters.

Parameters	VIASAT-3	O3b System
ESV Uplink Input Power Density	-56.5 dBW/Hz	-53.4 dBW/Hz
Satellite Rx Antenna Gain	53.6 dBi	34.5 dBi
Satellite Rx System Noise Temp	1380 K	1000 K
Satellite Tx EIRP Density	-19.1 dBW/Hz	-28.32 dBW/Hz
Earth Station Rx System Noise Temperature	224 K	225 K

Table A.11-2 shows the interference calculations for the assumed worst case situation described above. The results show that the O3b system is adequately protected. The calculated ΔT/T values in all cases are small, indicating the technical compatibility of the VIASAT-3 satellite network with the O3b network and with an O3b earth station located anywhere within U.S. territory. ViaSat makes the following additional observations:

1) In order to be conservative, the interference calculation of uplink interference into ViaSat uses an O3b uplink input power density of -53.4 dBW/Hz. This value is actually for an O3b gateway, not an ESV. The maximum power for an ESV is approximately 4 dB lower.

2) In order to be conservative, the interference calculation of downlink interference into O3b uses a VIASAT-3 downlink EIRP density of -19.1 dBW/Hz, which is the highest EIRP density that can be transmitted in the 18.8-19.3 GHz band by any VIASAT-3 downlink beam (*i.e.*, most beams will transmit at a somewhat lower EIRP density level).

3) The interference analysis does not address the mutual interference environment with respect to O3b operations located outside of the U.S. For non-U.S. locations, ViaSat will operate in a manner consistent with Ofcom's rules between U.K. registered satellite operators.

Table A.11-2. Interference calculations between VIASAT-3 and O3b.

Victim network		O3b	VIASAT-3
Interfering network		VIASAT-3	O3b
Uplink:			
Frequency band	GHz	28.85	28.85
Interfering uplink input power density	dBW/Hz	-56.5	-53.4
Angular separation between interfering E/S and victim satellite	degrees	12.6	12.6
Slant range (Interfering path)	km	9048	36502
Free space path loss (Interfering path)	dB	200.8	212.9
Atmospheric losses	dB	1.2	1.2
Victim satellite receive antenna gain	dBi	34.5	53.6
Victim Satellite's Antenna Discrimination towards Interfering E/S	dB	0	0
Victim satellite Rx system noise temperature	K	1000	1380
No	dBW/Hz	-198.6	-197.2
Io	dBW/Hz	-222.5	-212.4
Io/No	dB	-23.9	-15.2
ΔT/T	%	0.41	3.0
Downlink:			
Frequency band	GHz	19.05	19.05
Interfering satellite downlink EIRP density	dBW/Hz	-19.1	-28.32
Slant range (Interfering path)	dB	36502	9048
Free space path loss (Interfering path)	dB	209.3	197.2
Atmospheric losses	dB	1	1
Angular separation between interfering satellite and victim E/S	degrees	12.6	12.6
Interfering Satellite's Antenna Discrimination towards Victim E/S	dB	0	0
Victim Rx earth station system noise temperature	K	225	224
No	dBW/Hz	-205.1	-205.1
Io	dBW/Hz	-227.9	-225.0
Io/No	dB	-22.8	-19.9
ΔT/T	%	0.53	1.0

A.11.2 Sharing with HEO Systems

This section analyzes compatibility of the modified VIASAT-3 satellite network with HEO systems. Table A.11-3 summarizes the salient parameters of the VIASAT-3 network and the GESN and ATCONTACT HEO satellite networks. The HEO network's parameters are identical to those used by Northrop Grumman and ATCONTACT to demonstrate independently that their GSO operations in the 28.6-29.1 GHz and 18.8-19.3 GHz bands were compatible with the other's proposed NGSO operations.[6] The parameters of the two HEO networks are identical, allowing a single interference analysis to be performed with respect to the VIASAT-3 network.

Table A.11-3. Summary of VIASAT-3 and GESN / ATCONTACT Parameters.

Parameters	VIASAT-3	GESN / ATCONTACT Systems
Minimum Operational Altitude	GSO	16000 km
Earth Station Uplink Input Power Density	-56.5 dBW/Hz	-63.45 dBW/Hz
Satellite Rx Antenna Gain	61.0 dBi	46.5 dBi
Satellite Rx System Noise Temp	1023 K	504 K
Satellite Tx EIRP Density	-19.1 dBW/Hz	-18 dBW/Hz
Earth Station Rx System Noise Temperature	224 K	315 K

In order to demonstrate compatibility with these two NGSO networks, a worst case, static interference analysis is performed. The smallest possible angle will occur when the GSO satellite, the NGSO satellite and the relevant earth station are all on the same longitude and the earth station is at a high latitude. Assuming a minimum 10° elevation angle for the GSO earth station, this sets the latitude to 71.4°N. The GESN and ATCONTACT satellites do not transmit when they are at an altitude below 16000 km, which translates to a latitude of 31.9°N. With this information, the smallest possible angular separation is then calculated to be 27.4 degrees. Both the transmitting GSO earth station (uplink calculation) and the victim NGSO earth station (downlink calculation) have been assumed to be at a latitude of 71.4°N.

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[6] *See* SAT-AMD-20040719-00138 and SAT-AMD-20040719-00141.

Table A.11-4 shows the results of interference calculations from the VIASAT-3 network into the GESN and ATCONTACT networks and vice versa. The calculated ΔT/T values in all cases are small, indicating the technical compatibility of the VIASAT-3 network with the GESN and ATCONTACT networks.

The compatibility of these networks is largely due to the fact that the two NGSO networks do not communicate with earth stations when their satellites cross the equatorial plane, thus in-line events with a GSO network do not occur. For other types of NGSO constellations that do communicate with earth stations when the satellites pass through the equatorial plane, it is possible that an in-line interference event could occur. In order to protect such systems, ViaSat will cease transmissions from the VIASAT-3 satellite and its associated earth stations such that the required amount of angular separation with the NGSO network is always maintained.

Table A.11-4. Interference calculations between VIASAT-3 and GESN / ATCONTACT.

Victim network Interfering network		GESN / ATCONTACT VIASAT-3	VIASAT-3 GESN / ATCONTACT
Uplink:			
Frequency band	GHz	28.85	28.85
Interfering uplink input power density	dBW/Hz	-56.5	-63.45
Angular separation	degrees	27.4	27.4
Slant range (Interfering path)	km	21046	40586
Space loss (Interfering path)	dB	208.1	213.8
Atmospheric losses	dB	1.2	1.2
Victim satellite receive antenna gain	dBi	46.5	61
Victim satellite Rx system noise temperature	K	504	1023
No	dBW/Hz	-201.6	-198.5
Io	dBW/Hz	-223.3	-221.4
Io/No	dB	-21.7	-22.9
ΔT/T	%	0.680	0.512
Downlink:			
Frequency band	GHz	19.05	19.05
Interfering satellite downlink EIRP density	dBW/Hz	-19.1	-18
Slant range (Interfering path)	dB	40586	21046
Space loss (Interfering path)	dB	210.2	204.5
Atmospheric losses	dB	1	1
Angular separation	degrees	27.4	27.4
Victim Rx earth station system noise temperature	K	315	224
No	dBW/Hz	-203.6	-205.1
Io	dBW/Hz	-234.2	-227.4
Io/No	dB	-30.6	-22.3
ΔT/T	%	0.087	0.582

A.12 ORBITAL DEBRIS MITIGATION PLAN

A.12.1 Spacecraft Hardware Design

The VIASAT-3 satellite is based on the flight proven Boeing 702 HP heritage platform. The following updated orbital debris mitigation plan takes into account the selected spacecraft bus.

ViaSat has assessed and limited the amount of debris released in a planned manner during normal operations. The VIASAT-3 satellite has been designed so as to not become a source of debris during launch, drift, or operating mode. All separation and deployment mechanisms, and any other potential source of debris, are expected to be retained by the spacecraft or launch vehicle.

In conjunction with the satellite manufacturer, ViaSat has assessed and limited the probability of the satellite becoming a source of debris by collisions with small debris or meteoroids of less than one centimeter in diameter that could cause loss of control and prevent post-mission disposal. ViaSat and the satellite manufacturer have taken steps to limit the effects of such collisions through shielding, the placement of components, and the use of redundant systems.

The VIASAT-3 satellite includes redundant TT&C, bus control electronics and propulsion subsystems to ensure successful end-of-life disposal. The spacecraft TT&C system, vital for orbit raising, will be extremely rugged with regard to meteoroids smaller than 1 cm, by virtue of its redundancy, shielding, separation of components and physical characteristics. The TT&C subsystem will have no single points of failure. Near-omni-directional antenna coverage is provided through the use of a combination of independent bicone and forward/aft pipe antennas. These antenna feeds are extremely rugged and capable of providing adequate coverage even if struck, bent or otherwise damaged by a small or medium sized particle. The command receivers and decoders and telemetry encoders and transmitters will be located within a shielded area and will be totally redundant and physically separated. Two shielded xenon tanks and a redundant pairs of thrusters provide the energy for orbit-raising.

A.12.2 Minimizing Accidental Explosions

In conjunction with the satellite manufacturer, ViaSat has assessed and limited the probability of accidental explosions during and after completion of mission operations through a failure mode verification analysis. The satellite manufacturer has taken steps to ensure that debris generation will not result from the conversion of energy sources on board the satellite into energy that fragments the satellite. All vessel pressures and battery cell voltages will be monitored by telemetry. At end-of-life and once the satellite has been placed into its final disposal orbit, ViaSat will remove all stored energy from the spacecraft by depleting any residual fuel, leaving the liquid propellant latch valves open, venting the pressure vessels (except with respect to helium tanks as discussed below) and leaving the batteries in a permanent state of discharge. For xenon propellant, the tanks are vented by opening latch valves downstream of the tanks to allow cold flow through the xenon ion thrusters, and the latch valve is open if negligible xenon remains. Otherwise, the xenon latch valves may remain closed.

The Boeing 702HP spacecraft uses a bus that has a liquid propulsion system consisting of two helium tanks plus two pairs of fuel and oxidizer tanks and uses a xenon ion propulsion system consisting of two xenon tanks. Venting of the excess propellant in the fuel, oxidizer and xenon tanks is performed as part of the end-of-life shutdown operations. The helium tanks provide proper propellant tank pressurization for apogee engine firings during transfer orbit. Consistent with Boeing's practice with respect to a number of its spacecraft buses, both helium tanks are isolated at the end of transfer orbit by firing pyro-valves. The spacecraft's helium system will be sealed when tanks are isolated, resulting in a final pressure of ~230 psi, which is extremely low relative to the design burst pressure of 5250 psig (actual test performance at 6660 psig). Due to the low pressure at end-of-life in the helium tanks and their enclosure in the spacecraft body, an explosive event is extremely unlikely (even in the event of a tank rupture, *e.g.*, a meteorite strike), minimizing the potential of any release of orbital debris.

A.12.3 Safe Flight Profiles

ViaSat has been granted authorization to locate the VIASAT-3 satellite at 88.9º W.L. and does not seek to change this location in this application.

A.12.4 Post-Mission Disposal

There is no change to the originally planned post-mission disposal orbit altitude of 300 km above the normal GSO operational orbit, which was based on the following analysis and calculation under §25.283:

Total Solar Pressure Area "A" = 128 m^2
"M" = Dry Mass of Satellite = 4197 kg
"C_R" = Solar Pressure Radiation Coefficient = 1.3

Therefore the Minimum Disposal Orbit Perigee Altitude:

$$= 36{,}021 \text{ km} + 1000 \times C_R \times A/m$$
$$= 36{,}021 \text{ km} + 1000 \times 1.3 \times 128/4197$$

=   36,061 km

=   275 km above GSO (35,786 km)

To provide adequate margin, increasing the disposal orbit to 300 km will require 1.6 kg of xenon propellant, taking account of all fuel measurement uncertainties, which will be allocated and reserved in order to perform the final orbit-raising maneuver.

A.13 WAIVER REQUEST

Section 25.210(i) of the Rules, 47 C.F.R. § 25.210(i), requires that space station antennas in the FSS be designed to meet a cross-polarization isolation of 30 dB within the primary coverage area of the antenna. The VIASAT-3 satellite's transmit and receive antennas, including those used for TT&C, can have a cross-polarization isolation as low as 24 dB. In support of its requested waiver, ViaSat notes the following:

1) The cross-polarization isolation shortfall creates a negligible amount of additional self-interference into the VIASAT-3 satellite network. All intra-system interference contributions, including the reduced cross-polarization isolation, have been taken into account in the design of the link budgets for the services that the satellite will provide. The link budgets are sufficiently robust to compensate for the negligible degradation caused by the reduced cross-polarization isolation performance.

2) The uplink cross-polarization isolation shortfall is solely an intra-system design issue and has no effect on adjacent satellite networks.

   The downlink cross-polarization isolation shortfall creates a negligible amount of additional downlink interference into adjacent satellite networks. This is because the overall interference isolation of adjacent satellites is dominated by the receive earth station antenna off-axis discrimination for co-polar signals, and the contribution from the cross-polar component is negligible. A 24 dB cross-polarization isolation will decrease the downlink C/I into an adjacent satellite network by approximately 0.017 dB. In granting a similar waiver of Section 25.210(i), the Commission has determined that this level of increased interference is considered to be negligible.[7] Thus, grant of the requested waiver is consistent with prior Commission decisions granting similar waivers of Section 25.210(i), in which the Commission determined that cross-polarization performance of the downlink satellite antenna has only a second-order effect on the interference into the neighboring system.[8]

A.14 MAXIMUM SATURATION FLUX DENSITY

The following is the maximum saturation flux density required by Section 25.114(c)(4)(v) of the Commission's rules:

Beam ID	Max Saturation Flux Density
RXAR	-85 dBW/m2
RXAL	-85 dBW/m2
RXBR	-85 dBW/m2
RXBL	-85 dBW/m2
UPAT	-95 dBW/m2
CUR	-95 dBW/m2
OMNRR	-80 dBW/m2

[7] *See EchoStar Satellite Operating Corporation*, DA 06-2590 ¶ 7 n.21 (rel. Dec. 22, 2006) (allowing a cross-polarization isolation of 22 dB, finding that cross-polar interference contribution representing a C/I decrease of 0.03 dB is negligible).

[8] *See id.* ¶ 7.

CERTIFICATION OF PERSON RESPONSIBLE FOR PREPARING ENGINEERING INFORMATION

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

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Daryl T. Hunter, P.E.
ViaSat, Inc.