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. This attachment contains the information required by 47 C.F.R. §25.114 and other sections of the FCC's Part 25 rules that cannot be entered into the Schedule S submission.

A.2 GENERAL DESCRIPTION

The VIASAT-3 satellite will operate at the nominal 79° W.L. orbital location and will provide Ka-band services to parts of CONUS, Canada and Mexico. ViaSat proposes to offset the satellite by 0.3° from 79º W.L. and to center the station-keeping box at 79.3° W.L. in part to avoid any possibility of station-keeping overlap with the planned DIRECTV KU-79W satellite that will operate at 79° W.L., but also in order to create a two-degree separation from a Commission-authorized Ka-band satellite at 77.3° W.L.

The VIASAT-3 satellite will operate in the 28.1-29.1 GHz and 29.5-30.0 GHz bands (Earth-to-space) and the 18.3-19.3 GHz and 19.7-20.2 GHz bands (space-to-Earth). The satellite network will provide service to small user antennas. In addition, a limited number of 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 will use a bent-pipe architecture with asymmetric forward (gateway-to-subscriber) and return (subscriber-to-gateway) links. Forward links will consist of a single TDM 500 MHz wide carrier (416.67 Msym/s), while the return links will use MF-TDMA with a variety of bandwidths/data rates employed. 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). The forward links will vary between 16-APSK, 8PSK and QPSK modulations, depending on the amount of rain fade, while the return links will use 8PSK, QPSK and BPSK modulation schemes.

A.3 SPACE STATION TRANSMIT AND RECEIVE CAPABILITY

The VIASAT-3 satellite's beam coverage, both transmit and receive, will consist of 20 beams serving antennas that link to the Internet/PSTN and/or provide TT&C or other system operation functions ("A-Type Spot Beams") and 72 beams that will be used principally to provide service to end users ("B-Type Spot Beams"). For the A-Type Spot Beams, the peak downlink EIRP varies between 56.9 dBW and 62.2 dBW, while the peak G/T varies between 17.1 dB/K and 21.9 dB/K. For the B-Type Spot Beams, the peak downlink EIRP varies between 62.7 dBW and 67.0 dBW, while the peak G/T varies between 18.2 dB/K and 22.7 dB/K.

The satellite's antenna gain contours for the receive and transmit beams, as required by §25.114(d)(3), are given in GXT format. However, because of the large number of beams involved and the known problems of the Schedule S software in handling a large number of beams, the GXT files have not been embedded in the Schedule S software file and are being provided separately to the Commission.

A.4 FREQUENCY AND POLARIZATION PLAN

The VIASAT-3 satellite's frequency plan for normal operating mode is given in Table A.4-1, indicating channel center, polarization and bandwidth. Circular polarization is used on both the uplink and downlink with the downlink polarization being orthogonal to the uplink polarization. The satellite will employ a four-frequency re-use pattern such that any channel is re-used multiple times by a combination of polarization and spatial isolation. This satisfies the requirements of §25.210(d) of the Rules.

Table A.4-1. Frequency Plan (Normal Mode)

Uplink Center Frequency (MHz)	Polarization	Downlink Center Frequency (MHz)	Polarization	Bandwidth (MHz)
28600	RHCP, LHCP	18800	LHCP, RHCP	1000
29750	RHCP, LHCP	19950	LHCP, RHCP	500

As explained in section A.11, the 1000 MHz channel, which supports two 500 MHz carriers, will be reduced to a single 500 MHz channel (supporting one 500 MHz carrier) in the event that there is a need to cease operating in a portion of the assigned spectrum to protect an NGSO network. During the short period of time that the reduced bandwidth mode is in use, the frequency plan is represented by Table A.4-2.

Table A.4-2. Frequency Plan (Reduced Bandwidth Mode)

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

For purposes of clarity, the transponder bandwidth configuration represented in the Schedule S is for normal mode configuration reflected in Table A.4-1 above.

A.5 SERVICES TO BE PROVIDED

The VIASAT-3 satellite will be capable of providing a variety of FSS services, including broadband access. Representative link budgets, which include details of the transmission characteristics, performance objectives and earth station characteristics, are provided in the associated Schedule S submission.

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. Beacon transmissions are used to control on-station spacecraft attitude, gateway uplink power control and the 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 dual omni-directional antenna configuration. During normal on-station operation, the telecommand transmissions will be received via one of two uplink beams (primary plus backup). The TT&C earth station locations have not yet been selected. Each TT&C station will be capable of transmitting at either command frequency and either RHCP or LHCP. The frequency and polarization used will depend upon which command receiver is active at the satellite at that time. 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	29,500.5 MHz – LHCP/RHCP 29,503 MHz – RHCP/LHCP	29,500.5 MHz – LHCP/RHCP 29,503 MHz – RHCP/LHCP
Uplink Flux Density	-76 dBW/m^2	-115 dBW/m^2
Uplink Antenna Beam	Omni	A-Type Spot
Telemetry/Ranging Frequencies and Polarizations	19,701 MHz - LHCP 19,703 MHz - RHCP	19,701 MHz - LHCP 19,703 MHz - RHCP
Downlink Antenna Beam	Omni	A-Type Spot
Maximum Downlink EIRP	14 dBW	25 dBW

A.7 CESSATION OF EMISSIONS

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

§25.208(c) contains 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.

§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).

Compliance with the applicable FCC and ITU PFD limits is demonstrated below using a simple worst-case methodology. The maximum downlink EIRP that the VIASAT-3 satellite can transmit is 67 dBW in 500 MHz. The shortest distance from the satellite to the Earth is 35,786 km, corresponding to a spreading loss of 162.06 dB. Therefore the maximum possible PFD at the Earth's surface could not exceed -95.1 dBW/m^2 in this 500 MHz (*i.e.*, 67 -162.06). When the system is operating in normal mode (*i.e.*, using a 1000 MHz channel in the 18.3-19.3 GHz and 28.1-29.1 GHz frequencies), the two 500 MHz carriers within the 1000 MHz channel will each meet the PFD performance described here. Allowing for the use of digital modulation with an almost flat spectrum, the corresponding maximum PFD at an elevation angle of 90° measured in a 1 MHz band would not exceed -122.1 dBW/m^2. The -122.1 dBW/m^2/MHz level is less than the -

115 dBW/m^2/MHz PFD limit value that applies at elevation angles of 5° and below. Therefore, compliance with the PFD limits is assured.

In addition, §25.208(d) provides an additional aggregate PFD limit in the 200 MHz wide band 18.6-18.8 GHz of -95 dBW/m^2. In the worst case, this would correspond to a PFD limit of -118 dBW/m^2/MHz (*i.e.*, -95-10*log(200)). As demonstrated in the previous paragraph, downlink transmissions from the VIASAT-3 satellite cannot exceed -122.1 dBW/m^2/MHz at any angle of arrival and therefore compliance with §25.208(d) is also assured.

A.9 TWO DEGREE COMPATIBILITY

All transmissions of the VIASAT-3 satellite network will not exceed 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 are lower than the PFD values given in §25.138(a)(6) of the Rules.

The clear sky uplink off-axis EIRP density limits of §25.138(a)(1) are equivalent to a maximum uplink input power density of -56.5 dBW/Hz, assuming the transmitting earth station meets the off-axis gain mask requirements of § 25.209(a) and (b). Table 9-1 compares the uplink input power densities derived from the uplink link budgets that are contained in the Schedule S form with the clear sky limits of §25.138 (a)(1) of the Rules.[1] It can be seen that in all cases the clear sky uplink power limits are met. 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).

Table A.9-1. Demonstration of Compliance with the Uplink Power Limits of §25.138(a)(1) (assuming the transmitting earth station antenna meets the off-axis gain mask requirements of §25.209(a) and (b))

Uplink Antenna Size	Emission	Maximum Clear Sky Uplink Input Power Density (dBW/Hz)	Clear Sky Uplink Input Power Density Limit of §25.138 (a)(1) (dBW/Hz)	Excess Margin (dB)
67 cm	6M25G7D	-63.5	-56.5	7.0
67 cm	3M13G7D	-60.5	-56.5	4.0
67 cm	1M57G7D	-57.5	-56.5	1.0
67 cm	782KG7D	-56.6	-56.5	0.1
7.3 m	25M0G7D	-71.3	-56.5	14.8
7.3 m	500MG7D	-76.9	-56.5	20.4

Further, Section A.8 above demonstrates that the maximum PFD that could be transmitted by the VIASAT-3 satellite, at a 90° elevation angle, is -122.1 dBW/m^2/MHz and therefore the PFD levels at other elevation angles will necessarily be somewhat lower. No downlink transmissions from the VIASAT-3 satellite will exceed the -118 dBW/m^2/MHz limit set forth in §25.138 (a)(6) of the Rules.

[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.

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.

<u>28.1-28.35 GHz Band:</u>

Currently there are no operational GSO Ka-band satellites that use the 28.1-28.35 GHz band at or within two degrees of the 79.3º W.L. location, nor are there any pending applications before the Commission for use of the band by a GSO satellite at or within two degrees of 79.3° 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.

Since the uplink input power densities for both the wanted and victim carriers are assumed to be identical, the uplink C/I is simply the difference between the on-axis gain and the off-axis gain. The uplink C/I ratio is calculated as follows:

$$(C/I)_{up} = G_{max} - (29-25*\log(\theta))$$

$$= 64.9 - (29-25*\log(2)) = 43.4 \text{ dB}$$

The calculated C/I ratio is quite large and therefore clearly demonstrates two-degree compatibility.

<u>28.6-29.1 GHz and 18.8-19.3 GHz Bands:</u>

Hughes Network Systems, LLC (“Hughes”) has Commission-authorization to operate the JUPITER 77W satellite at the 77.3° W.L. orbital location and to use the 28.6-29.1 GHz and 18.8-

19.3 GHz bands.[2] Table A.9-2 provides a summary of the uplink and downlink transmission parameters of the JUPITER 77W satellite network, as taken from Hughes' LOA application.

Table A.9-3 provides a summary of the uplink and downlink transmission parameters of the VIASAT-3 satellite network. These parameters were derived from the VIASAT-3 link budgets that are embedded in the associated Schedule S form.

Interference calculations were performed using the transmission parameters in Tables A.9-2 and A.9-3. The interference calculations assumed a 1 dB advantage for topocentric-to-geocentric conversion, all wanted and interfering carriers are co-polarized and all earth station antennas conform to a sidelobe pattern of 29-25 log(θ). The C/I calculations were performed on a per Hz basis.

Tables A.9-4 and A.9-5 show the results of the interference calculations between the two networks in terms of C/I margins. It can be seen that the C/I margins are positive in all cases.

Note that the JUPITER 77W satellite network's return links (i.e., subscriber-to-gateway links) do not use the uplink 28.6-29.1 GHz band. Accordingly, the C/I calculations for certain interferer/victim carrier combinations only calculate the downlink interference. The grayed cells in Tables A.9-4 and A.9-5 are overall C/I margins (i.e., combined uplink and downlink C/I margins), while the non-grayed cells are downlink C/I margins only.

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2 *See* SAT- LOA-20111223-00248.

Table A.9-2. JUPITER 77W 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	250MG7W	250	58.9	72.0	64.0	42.1	21.5
2	3M67G7W	3.67	N/A	N/A	43.7	55.3	20.4
3	1M22G7W	1.22	N/A	N/A	38.8	55.3	19.3
4	612KG7W	0.612	N/A	N/A	35.8	55.3	18.7

Table A.9-3. 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)
5	500MG7D	500	64.9	75.0	62.0	49.7	20.3
6	500MG7D	500	64.9	75.0	62.0	41.1	13.6
7	500MG7D	500	64.9	75.0	62.0	41.1	7.2
8	6M25G7D	6.25	44.4	48.9	39.2	61.5	16.2
9	3M13G7D	3.125	44.4	48.9	36.2	61.5	14.9
10	1M57G7D	1.563	44.4	48.9	33.1	61.5	9.9
11	782KG7D	0.7813	44.4	46.7	30.1	61.5	8.7
12	25M0G7D	25	64.5	67.2	45.2	60.8	20.8

Table A.9-4. Summary of the C/I margins (dB); VIASAT-3 interfering into JUPITER 77W.

<table>
<tr><td></td><td></td><td colspan="8">Interfering Carriers</td></tr>
<tr><td></td><td>Carrier ID</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td><td>11</td><td>12</td></tr>
<tr><td rowspan="4">Wanted Carriers</td><td>1</td><td>5.1</td><td>5.1</td><td>5.1</td><td>6.2</td><td>4.6</td><td>2.5</td><td>1.8</td><td>8.4</td></tr>
<tr><td>2</td><td>17.5</td><td>17.5</td><td>17.5</td><td>21.3</td><td>21.3</td><td>21.3</td><td>21.3</td><td>21.3</td></tr>
<tr><td>3</td><td>18.6</td><td>18.6</td><td>18.6</td><td>22.4</td><td>22.4</td><td>22.4</td><td>22.4</td><td>22.4</td></tr>
<tr><td>4</td><td>19.2</td><td>19.2</td><td>19.2</td><td>23.0</td><td>23.0</td><td>23.0</td><td>23.0</td><td>23.0</td></tr>
</table>

Table A.9-5. Summary of the C/I margins (dB); JUPITER 77W interfering into VIASAT-3.

		Interfering Carriers			
	Carrier ID	1	2	3	4
Wanted Carriers	5	3.8	6.0	6.0	6.0
	6	2.1	4.0	4.1	4.1
	7	8.4	10.4	10.4	10.4
	8	12.5	18.0	18.0	18.0
	9	15.3	19.3	19.4	19.4
	10	21.2	24.3	24.4	24.4
	11	22.6	25.6	25.6	25.6
	12	10.5	12.8	12.8	12.8

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

In the U.S., the 28.1-28.35 GHz band is allocated to LMDS on a primary basis and it is allocated to the FSS on a secondary basis. §2.105(c)(2) states, in part, that stations of a secondary service:

> (i) Shall not cause harmful interference to stations of primary services to which frequencies are already assigned or to which frequencies may be assigned at a later date;
>
> (ii) Cannot claim protection from harmful interference from stations of a primary service to which frequencies are already assigned or may be assigned at a later date;

Regarding §2.105(c)(2)(i), uplinks from gateway-type 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 LMDS station. Technical compatibility will be accomplished through geographic separation between the gateway-type antennas and the LMDS stations and shielding as necessary. Regarding §2.105(c)(2)(ii), transmitting LMDS stations cannot cause harmful interference into an earth station since the earth station does not receive transmissions in the 28.1-28.35 GHz band. Harmful interference occurring from the aggregation of transmitting LMDS stations into a receiving spot beam of the VIASAT-3 satellite is considered to be unlikely, however ViaSat undertakes to accept this risk and will not seek protection from such interference in the event it occurs.

The antennas deployed in this band segment will operate in the A-Type Spot Beams and the B-Type Spot Beams. The locations for these antennas have not yet been selected.

The applications for those earth stations 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.

Currently there are no operational NGSO systems authorized by the Commission to use the 28.1-28.35 GHz band, nor are there any pending applications before the Commission for use of the 28.1-28.35 GHz band by a NGSO system. O3b Limited ("O3b") has received a license from the Commission for a gateway earth station located in Hawaii to communicate with O3b's constellation of NGSO satellites using the 28.1-28.35 GHz band on a secondary basis.[3] The analysis in the following section regarding the compatibility of VIASAT-3 operations in the United States with those authorized operations of that O3b gateway in the 28.6-29.1 GHz and 18.8-19.3 GHz bands is equally applicable to the 28.1-28.35 GHz band segment.

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

In the United States, the 28.6-29.1 GHz band is allocated to NGSO FSS on a primary basis and it is allocated to GSO FSS on a secondary basis. Stations operating in a secondary service cannot cause harmful interference to or claim protection from harmful interference from stations of a primary service. ViaSat's proposed U.S. operations will be consistent with the obligations of a

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3 *See* SES-LIC-20100723-00952.

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 parameters of the NGSO FSS networks, their earth station locations, and their interference criteria.

O3b has received a license from the Commission for a gateway earth station located in Hawaii authorized to communicate with O3b's constellation of NGSO satellites using the 28.6-29.1 GHz and 18.8-19.3 GHz bands.[4] Interference analysis provided herein demonstrates that no harmful interference will occur between O3b's gateway operations in Hawaii, and the operations of the VIASAT-3 satellite network in the United States.

Currently there are no NGSO satellite networks 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 VIASAT-3 satellite network would protect HEO satellite systems with

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[4] *See* SES-LIC-20100723-00952.

the characteristics of those previously licensed to ATCONTACT and NGST from harmful interference.

A.11.1 Compatibility with O3b

O3b has Commission authorization to communicate with its NGSO network using a gateway earth station located in Hawaii. The following analysis addresses compatibility of VIASAT-3 operations in the United States with that O3b earth station. The O3b constellation will use eight satellites in a medium earth orbit with an altitude of 8062 km and an inclination of zero degrees (i.e., an equatorial orbit). The satellites have steerable spot beams which are maintained on the gateway location as the satellites traverse their orbit until a minimum elevation angle is no longer met. Table A.11-1 shows the pertinent 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
Minimum Operational Elevation Angle		3°
Earth Station Uplink Input Power Density	-56.6 dBW/Hz	-53.4 dBW/Hz
Satellite Rx Antenna Gain	53.2 dBi	34.5 dBi
Satellite Rx System Noise Temp	1349 K	1000 K
Satellite Tx EIRP Density	-20 dBW/Hz	-28.32 dBW/Hz
Earth Station Rx System Noise Temperature	224 K	225 K

The minimum elevation angle for service to the Hawaiian gateway is stated as being 3 degrees. From this we can determine the eastern-most location of an O3b satellite, just before it can no longer communicate with the Hawaiian gateway, as being at 99.67° W.L. This orbital location provides the smallest angular separation with respect to the VIASAT-3 network. Any location of an O3b satellite further west will necessarily create a larger angular separation with respect to the VIASAT-3 network.

The O3b system has an equatorial orbit. From the perspective of sharing with a GSO network, this means that the location of a GSO network's transmitting earth station that causes the most interference to the O3b system would be a location closest to the equator, or in the case of the VIASAT-3 network, an earth station located at a southerly location. Similarly, a GSO network's receiving ground antenna located closest to the equator would receive the most interference from the O3b system. Of course, in both cases, the location of the O3b gateway antenna also plays a role in the mutual interference environment.

For interference calculation purposes, the location of the VIASAT-3 earth station antenna was chosen to be both southerly and westerly (within CONUS) since it was found that such a location causes a higher potential for a mutual interference environment.

Given these antenna locations and with the O3b satellite assumed to be at a static 99.67° W.L. location, the angular separation (off-axis angle) at the relevant earth station can be calculated. In addition, the calculations take into account the fact that the VIASAT-3 satellite provides at least 20 dB of satellite antenna discrimination towards Hawaii in both uplink and downlink directions and the O3b satellites communicating with the Hawaiian gateway provide at least 20 dB of satellite antenna discrimination towards the service area of the VIASAT-3 satellite network in both uplink and downlink directions.

Table A.11-2 shows the predicted interference degradations to the O3b system due to operation of the VIASAT-3 network and vice versa. The results show that the O3b system is adequately protected. The calculated $\Delta T/T$ values in all cases are extremely small, indicating the technical compatibility of the VIASAT-3 satellite network with the authorized operation of the O3b gateway in Hawaii.

The preceding demonstrates that the VIASAT-3 satellite network is compatible with O3b's authorized operations of a gateway earth station located in Hawaii.

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

Victim network		O3b (Hawaii)	VIASAT-3
Interfering network		VIASAT-3	O3b (Hawaii)
E/S Latitude	degrees	21.67	34.5
E/S Longitude	degrees	-158.03	-120.5
Uplink:			
Frequency band	GHz	28.85	28.85
Interfering uplink input power density	dBW/Hz	-56.6	-53.4
Angular separation between interfering E/S and victim satellite	degrees	20.6	7.1
Slant range (Interfering path)	km	10359	41483
Free space path loss (Interfering path)	dB	202.0	214.0
Atmospheric losses	dB	1.2	1.2
Victim satellite receive antenna gain	dBi	34.5	53.2
Victim Satellite's Antenna Discrimination towards Interfering E/S	dB	20	20
Victim satellite Rx system noise temperature	K	1000	1349
No	dBW/Hz	-198.6	-197.3
Io	dBW/Hz	-246.1	-227.4
Io/No	dB	-47.5	-30.1
ΔT/T	%	0.0018	0.0972
Downlink:			
Frequency band	GHz	19.05	19.05
Interfering satellite downlink EIRP density	dBW/Hz	-20.0	-28.32
Slant range (Interfering path)	dB	41483	10359
Free space path loss (Interfering path)	dB	210.4	198.3
Atmospheric & scintillation losses	dB	1	1
Angular separation between interfering satellite and victim E/S	degrees	7.1	20.6
Interfering Satellite's Antenna Discrimination towards Victim E/S	dB	20	20
Victim Rx earth station system noise temperature	K	225	224
No	dBW/Hz	-205.1	-205.1
Io	dBW/Hz	-243.4	-248.5
Io/No	dB	-38.3	-43.4
ΔT/T	%	0.0147	0.0046

A.11.2 Sharing with HEO Systems

This section analyzes compatibility of VIASAT-3 with HEO systems. Table A.11-3 summarizes the salient parameters of the GESN and ATCONTACT HEO satellite networks. These 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.[5] It can be seen that the two networks'

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

orbital and transmission parameters are identical, which allows a single interference analysis to be performed.

Table A.11-3. GESN and ATCONTACT HEO satellite characteristics.

	GESN	ATCONTACT
Orbital parameters • # of satellites • # of planes • # of satellites per plane • Inclination • Apogee • Perigee • Minimum Tx altitude	 3 3 1 63.4° 39352 km 1111 km 16000 km	 3 3 1 63.4° 39352 km 1111 km 16000 km
Satellite Rx gain	46.5 dBi	46.5 dBi
Satellite Rx system noise temp.	504 K	504 K
Earth station uplink input power density	-63.45 dBW/Hz	-63.45 dBW/Hz
Satellite downlink EIRP density	-18 dBW/Hz	-18 dBW/Hz
E/S Rx system noise temperature	315 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 would 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.

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 very small, indicating the technical compatibility of the VIASAT-3 satellite 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. Worst case interference calculations.

Victim network Interfering network		GESN / ATCONTACT VIASAT-3	VIASAT-3 GESN / ATCONTACT
Uplink:			
Frequency band	GHz	29	29
Interfering uplink input power density	dBW/Hz	-56.6	-63.45
Angular separation	degrees	27.4	27.4
Slant range (Interfering path)	km	21046	40586
Space loss (Interfering path)	dB	208.2	213.9
Atmospheric & scintillation losses	dB	1.2	1.2
Victim satellite receive antenna gain	dBi	46.5	53.2
Victim satellite Rx system noise temperature	K	504	1349
No	dBW/Hz	-201.6	-197.3
Io	dBW/Hz	-226.4	-232.3
Io/No	dB	-24.9	-35.0
ΔT/T	%	0.3260	0.0317
Downlink:			
Frequency band	GHz	19	19
Interfering satellite downlink EIRP density	dBW/Hz	-20.0	-18
Slant range (Interfering path)	dB	40586	21046
Space loss (Interfering path)	dB	210.2	204.5
Atmospheric & scintillation 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	-238.2	-230.5
Io/No	dB	-34.6	-25.4
ΔT/T	%	0.0350	0.2893

A.12 ORBITAL DEBRIS MITIGATION PLAN

The spacecraft manufacturer for the VIASAT-3 satellite has not yet been selected and therefore ViaSat's Orbital Debris Mitigation Plan is necessarily forward looking. ViaSat will incorporate the material objectives of §25.114(d)(14) of the Commission's Rules into the design of the satellite through the satellite's Technical Specifications, Statement of Work and Test Plans. 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. During this process, some changes to the Orbital Debris Mitigation Plan may occur and ViaSat will provide the Commission with updated information, as appropriate.

A.12.1 Spacecraft Hardware Design

Although the VIASAT-3 satellite has not been fully designed, ViaSat does not expect that the satellite will undergo any release of debris during its operation. Furthermore, all separation and deployment mechanisms, and any other potential source of debris are expected to be retained by the spacecraft or launch vehicle.

ViaSat will assess and limit 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 will take steps to limit the effects of such collisions through shielding, the placement of components, and the use of redundant systems. ViaSat will incorporate a rugged TT&C system with regard to meteoroids smaller than 1 cm through redundancy, shielding, separation of components and physical characteristics. The VIASAT-3 satellite will include two near omni-directional antennas mounted on opposite sides of the spacecraft. These antennas will be extremely rugged and capable of providing adequate coverage even if struck, bent or otherwise damaged by a small or medium sized particle. ViaSat plans to locate the command receivers and decoders and telemetry encoders and transmitters within a shielded area and provide redundancy and physical separation for each component. The VIASAT-3 satellite will carry a rugged propulsion system capable of withstanding collision with small debris.

A.12.2 Minimizing Accidental Explosions

ViaSat and its spacecraft manufacturer will assess and limit the probability of accidental explosions during and after completion of mission operations. The satellite will be designed to ensure that debris generation will not result from the conversion of energy sources on board the satellite into energy that fragments the satellite. The propulsion subsystem pressure vessels will be designed with high safety margins. Bipropellant mixing is prevented by the use of valves that prevent backwards flow in propellant lines and pressurization lines. All pressures, including those of the batteries, 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 all fuel line valves open, venting the pressure vessels and the batteries will be left in a permanent state of discharge.

A.12.3 Safe Flight Profiles

In considering current and planned satellites that may have a station-keeping volume that overlaps the VIASAT-3 satellite, ViaSat has reviewed the lists of FCC licensed satellite networks, as well as those that are currently under consideration by the FCC. In addition, networks for which a request for coordination has been published by the ITU within ±0.15° of 79.3° W.L. have also been reviewed.

Based on these reviews, there are no operational satellites within ±0.15 ° 0f 79.3° W.L., there are no pending applications before the Commission to use an orbital location within ±0.15° of 79.3° W.L and there are no published ITU networks within ±0.15° of 79.3° W.L. Accordingly, ViaSat concludes that physical coordination of the VIASAT-3 satellite with another party is not required at the present time.

A.12.4 Post-Mission Disposal

At the end of the operational life of the VIASAT-3 satellite, ViaSat will maneuver the satellite to a disposal orbit with a minimum perigee of 300 km above the normal GSO operational orbit. The post-mission disposal orbit altitude is based on the following calculation, according to §25.283:

Total Solar Pressure Area "A" = 105.1 m^2

"M" = Dry Mass of Satellite = 3168 kg

"C_R" = Solar Pressure Radiation Coefficient = 1.9

Therefore the Minimum Disposal Orbit Perigee Altitude:

= 36,021 km + 1000 x C_R x A/m

= 36,021 km + 1000 x 1.9 x 105.1/3168

= 36,084 km

= 298 km above GSO (35,786 km)

Adequate margin has already been accounted for in the calculation of the disposal orbit of 300 km. This will require 11 kg of propellant that will be reserved, taking account of all fuel measurement uncertainties, to perform the final orbit raising maneuver.

A.13 PREDICTED RECEIVER AND TRANSMITTER CHANNEL FILTER RESPONSE CHARACTERISTICS

The predicted receiver and transmitter frequency responses of each 500 MHz or 1000 MHz channel, as measured between the receive antenna input and transmit antenna, fall within the limits shown in Table A.13-1 below. In addition, the frequency tolerances of §25.202(e) and the out-of-band emission limits of §25.202(f) (1), (2) and (3) will be met.

Table A.13-1: Predicted Channel Receiver and Transmitter Frequency Responses

Frequency Rx/Tx (MHz)	Receiver Frequency Response (dB) (without NGSO)	Receiver Frequency Response (dB) (with NGSO)	Transmit Frequency Response (dB) (without NGSO)	Transmit Frequency Response (dB) (with NGSO)
28000/18200	<-20.0	<-20.0	<-20.0	<-20.0
28100/18300	> -3.0	>-3.0	>-3.0	>-3.0
28200/18400	> -1.7	>-2.0	>-1.5	>-1.5
28300/18500	> -1.5	>-1.7	>-0.75	>-0.75
28400/18600	>-1.5	>-1.5	>-0.5	>-0.5
28500/18700	>-1.7	>-1.5	>-0.5	>-0.5
28600/18800	>-3.0	>-1.5	>-0.5	>-0.5
28700/18900	<-20.0	>-1.5	>-0.5	>-0.5
28800/19000	<-20.0	>-1.5	>-0.5	>-0.5
28900/19100	<-20.0	>-1.7	>-0.5	>-0.5
29000/19200	<-20.0	>-2.0	>-0.5	>-0.5
29100/19300	<-20.0	>-3.0	>-0.5	>-0.5
29200/19400	<-20.0	<-20.0	N/A	N/A
29300/19500	<-20.0	<-20.0	N/A	N/A
29400/19600	<-20.0	<-20.0	N/A	N/A
29500/19700	>-3.0	<-20.0	>-0.5	>-0.5
29600/19800	>-1.7	<-20.0	>-0.5	>-0.5
29700/19900	>-1.5	<-20.0	>-0.5	>-0.5
29800/20000	>-1.5	<-20.0	>-0.75	>-0.75
29900/20100	>-1.7	<-20.0	>-1.5	>-1.5
30000/20200	>-3.0	<-20.0	>-3.0	>-3.0
30100/20300	<-20.0	<-20.0	<-20.0	<-20.0

Note: "N/A" indicates that transmit frequency response is not applicable because signal is attenuated by the input frequency response.

A.14 SPACECRAFT LIFETIME AND RELIABILITY

The VIASAT-3 satellite will be designed for a 15 year life once on station. The probability of the entire satellite successfully operating throughout this period is 0.55 with the probability of the payload and bus operating throughout this period is 0.71 and 0.77, respectively. These numbers are based on documented failure rates of all critical components in the satellite bus and payload.

A.15 SCHEDULE S SECTION S7(N)

In response to section S7 (n) of the Schedule S form, the receive system noise temperature is 218776 K for beams TCR and TCL (on-station telecommand) and 416869 K for beam BNR (autotrack beacon). The Schedule S software does not allow a receive system noise temperature of greater than approximately 32800 K to be entered into the form. Because the receive system noise temperatures for receive beams TCR, TCL and BNR are greater than 32800 K, the Schedule S fields for the receive system noise temperatures of these beams have been left blank.

A.16 WAIVER REQUEST

ViaSat requests a waiver of the requirement in Section 25.210(i) of the Commission's Rules, 47 C.F.R. § 25.210(i), which 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 uplink spot beam receive antennas (both A-Type and B-Type Spot Beams) provide a minimum cross-polarization of 26 dB. In support of its requested waiver, ViaSat notes that the small cross-polarization shortfall is in the uplink direction only and therefore will have no adverse effect on adjacent satellite networks.[6] Further, the satellite's cross-polarization isolation performance has been fully taken into account in the design of the link budgets for the

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[6] Receive cross-polarization interference is an intra-system design issue, and does not affect adjacent satellite networks.

services that the satellite will provide. The link budgets are sufficiently robust to compensate for the negligible degradation caused by the slightly reduced cross-polarization isolation performance. Grant of the requested waiver is also consistent with prior Commission decisions granting similar waivers of Section 25.210(i).[7]

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[7] *See, e.g.*, ViaSat, Inc., File Nos. SAT-LOI-20080107-00006, SAT-AMD-20080623-00131, SAT-AMD-20090213-00023, Call Sign S2747, Attachment – Conditions for Letter of Intent at ¶ 5 (granted Aug. 18, 2009).

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.

/s/
____

Stephen D. McNeil
Telecomm Strategies Canada, Inc.
Ottawa, Ontario, Canada
(613) 270-1177