EXHIBIT B

Attachment 1

Technical Response to SpaceX Opposition

The following responds to technical arguments in SpaceX's Opposition, filed on December 26, 2017, to Viasat's petition requesting reconsideration of a condition in Viasat's earth station blanket license, Call Sign, E170088 ("Petition").

I. VIASAT HAS PROVIDED SPACEX WITH THE PARAMETERS AND ASSUMPTIONS USED IN VIASAT'S ANALYSIS

In its Opposition, SpaceX argues that the technical demonstration in Viasat's Petition is insufficient because Viasat has not delineated certain technical parameters and assumptions used in the underlying simulations. Below, Viasat details the inputs and assumptions used in its simulations, which further demonstrates that SpaceX's NGSO operations in the 28.6-29.1 GHz band would not experience significant interference from Viasat's earth station operations in this band segment.

As an initial matter, the following underlying inputs and assumptions were used in the simulations in the Petition:

- Technical parameters from Viasat's blanket license earth station application and SpaceX's FCC license application, as detailed in the Tables below.
- A single Viasat earth station co-located with a SpaceX earth station within CONUS, with other locations 0.25° - 2.0° latitude away from SpaceX earth station also tested as noted below.
- The EIRP and EIRP density were, as noted below in Tables 1 and 2, taken from Viasat's FCC license application for 80 MBd and 160 MBd carriers for the 75 cm and 1.8 m antennas respectively, each representative of edge of coverage operation in clear sky for the respective antennas.

- The analysis considered both the 75 cm and the 1.8 m antennas. Each was analyzed in its own separate Visualyse simulation.

As discussed in more detail below, Viasat utilized these parameters and data provided in its ongoing coordination discussions with SpaceX. Viasat and SpaceX have exchanged technical information about their respective systems, which Viasat has used as the basis for the simulations in the Petition and in the analysis below. Viasat provided this information to SpaceX many months ago, but SpaceX's filings with the Commission continue to disregard this information.

II. SPACEX'S ANALYSIS IS BASED ON UNREALISTIC ASSUMPTIONS AND INCORRECT DATA

In its Opposition, SpaceX continues to rely on its analysis in its June 26, 2017 submission to Viasat's blanket license earth station application ("June 26 Reply") to claim that Viasat's operations would have a "large potential impact on NGSO operations." See Opposition at 3. SpaceX claims that the ΔT/T impact into its NGSO system, calculated for transmissions by Viasat earth stations, would range from 15% to 452% with 20 degrees of orbital isolation and from 6% to 164% with 30 degrees of orbital isolation. See Opposition at 2. SpaceX's analysis, however, does not reflect the actual geometry of the earth stations and the GSO and SpaceX orbits and does not use the correct operating parameters for Viasat earth stations. The following discussion reconciles Viasat's analysis and underlying simulations provided in the Petition with SpaceX's unrealistic and unsubstantiated calculations.

SpaceX's June 26 Reply presents ΔT/T calculations based on two assumed in-line scenarios. In Scenario 1, a SpaceX NGSO satellite is in the main beam of the Viasat GSO earth station uplink. In Scenario 2, a SpaceX earth station is collocated with a Viasat earth station, and their respective satellites are at the edge of an in-line event. SpaceX's analysis considers orbital isolation angles of 10°, 20°, and 30° in two different geometrical configurations for each of the two scenarios.

A. Scenario 1

Scenario 1, in which a SpaceX satellite would operate when directly in-line with Viasat's GSO satellite, would not occur if SpaceX operates its proposed NGSO network under the terms of its FCC license application. SpaceX specifies a minimum orbital isolation of 22 degrees in both its discussion of GSO arc avoidance in that application, and in a letter to Viasat dated June 9, 2017 where GSO arc avoidance is also discussed for purposes of coordination.

In its FCC application narrative, SpaceX states:

> "Specifically, SpaceX will turn off the transmit beam on the satellite and user terminal whenever the angle between the boresight of a GSO earth station (***assumed to be collocated with the SpaceX user***) and the direction of the SpaceX satellite transmit beam is 22 degrees or less. Because of the number and configuration of satellites in the SpaceX System, there will be ample alternate satellites in view to provide uninterrupted service to a user from satellites operating outside of the exclusion zone around the GSO arc." (emphasis added)

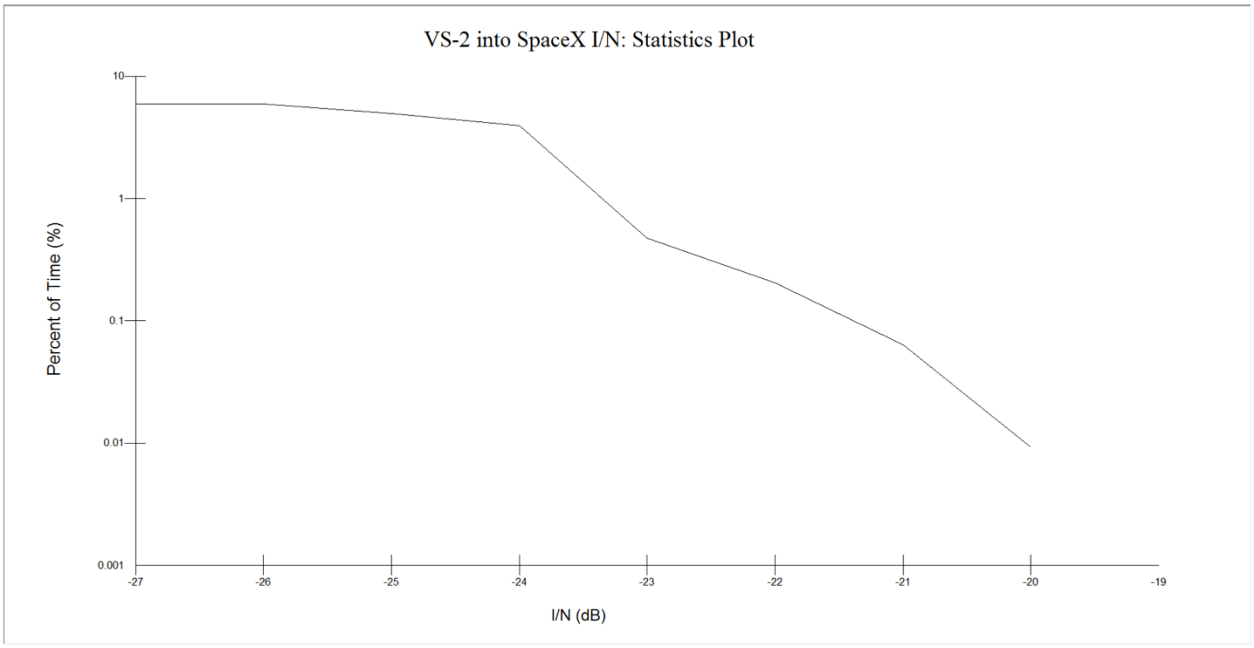
The nature of the SpaceX network operations described in its FCC license application therefore precludes the type of in-line event described in Scenario 1, because no SpaceX satellite will operate within 22° of the GSO arc. This impossibility of Scenario 1 ever arising was confirmed in the June 9, 2017 letter, where SpaceX confirmed that it will also maintain a ±22-degree separation angle from the GSO arc in the 28.6-29.1 GHz band segment (among others).

B. Scenario 2

In SpaceX's Scenario 2, the SpaceX and Viasat earth stations are collocated in the same manner assumed in Viasat's analysis in the Petition. SpaceX asserts that at a 30º isolation angle, SpaceX's calculation yields a 6% ΔT/T for a 75 cm earth station and 11% for a 1.8 m earth station, but does not provide any time statistics for how frequently it expects these events to occur. SpaceX also identified its calculations for 10º and 20º isolation angles, but as discussed above, isolation angles of less than 22º would not occur according to SpaceX.

As noted in Viasat's Petition, an analysis using the 22° isolation angle from GSO that SpaceX specifies in its application and letter produced a worst case I/N of about -19 dB, which equates to a ΔT/T of only 1.2% over a 24 hour orbital simulation run. The cumulative distribution function (CDF) plot of the run in Figure 1 below shows just how infrequently this occurs.

Figure 1: Plot of I/N as a Percent of Time for 75 cm earth station



The plot shows that 99.99% of the time the I/N is less than -20 dB and less than a 1% ΔT/T. Normally, between GSO networks, a coordination trigger of 6% ΔT/T is used. Due to the static nature of the alignments between earth stations and satellites in GSO networks, it is assumed that the 6% ΔT/T would be present 100% of the time. In the case of GSO vs NGSO networks, the alignments are not static, especially for LEO NGSOs having shorter duration alignments. Therefore, consideration of the magnitude, duration, and frequency of I/N events is necessary and appropriate.

There are several deficiencies in SpaceX's ΔT/T calculations. The technical Exhibit A in the SpaceX June 26 Reply does not indicate how the asserted ΔT/Ts were calculated, what underlying data was used, where the various input values came from, or how they were derived. For example, SpaceX does not indicate which Viasat emission designator is being analyzed, or how much antenna gain is assumed at the various off-axis angles. Moreover, some of the input values appear muddled, such as using a value for EIRP when it seems SpaceX may have intended EIRP density, and the provided mathematical formula lacks an entry for the bandwidth for either system. In addition, SpaceX's Opposition indicates that it based its initial calculations on Viasat earth station EIRPs in a 40 kHz bandwidth, which SpaceX has since corrected to reflect the EIRPs actually specified by Viasat in a 4 kHz bandwidth.

In addition, SpaceX's analysis shows a fundamental misunderstanding of the Viasat's technology and operating parameters. First, SpaceX uses higher power density emissions which are intended for use only in faded conditions. SpaceX ignores clarifying information that Viasat provided in a June 15, 2017 call with SpaceX to discuss Viasat's earth station operations. During this call, Viasat engineers clearly identified that most of the emission designators would only be used during faded conditions, and that it was simply the Viasat practice to list the various emission designators and use the maximum EIRP and EIRP density for each that complies with Section 25.138, and that the 160 MBd symbol rate was the nominal clear sky emission designator for the 75 cm earth station and that the 320 MBd symbol rate was nominally used for the 1.8 m earth station. Further, in some cases, one step down, i.e. 80 MBd and 160 MBd, might be used in edge of coverage for the 75 cm and 1.8 m antennas respectively. Nevertheless, SpaceX generally used values intended for rain fade conditions in its June 26 Reply even though, as discussed with SpaceX in the case of faded operation and a near in-line event, these carriers would be faded for both Viasat and SpaceX receivers.

The purpose of the emissions to be used during faded operations is to compensate for rain and atmospheric attenuation in the path of the link to the satellite. The choice of emission and amount of power increase corresponds directly to the actual attenuation in the path due to the fading event. When higher power densities are used to offset the effects of rain fade and atmospheric attenuation, the Viasat satellite receiver sees the same power density during the fade as would normally be received in clear sky conditions. Because the SpaceX analysis is considering a near in-line event, the path through the atmosphere between the earth station and space will be attenuated equally for both the Viasat and SpaceX satellite receivers.

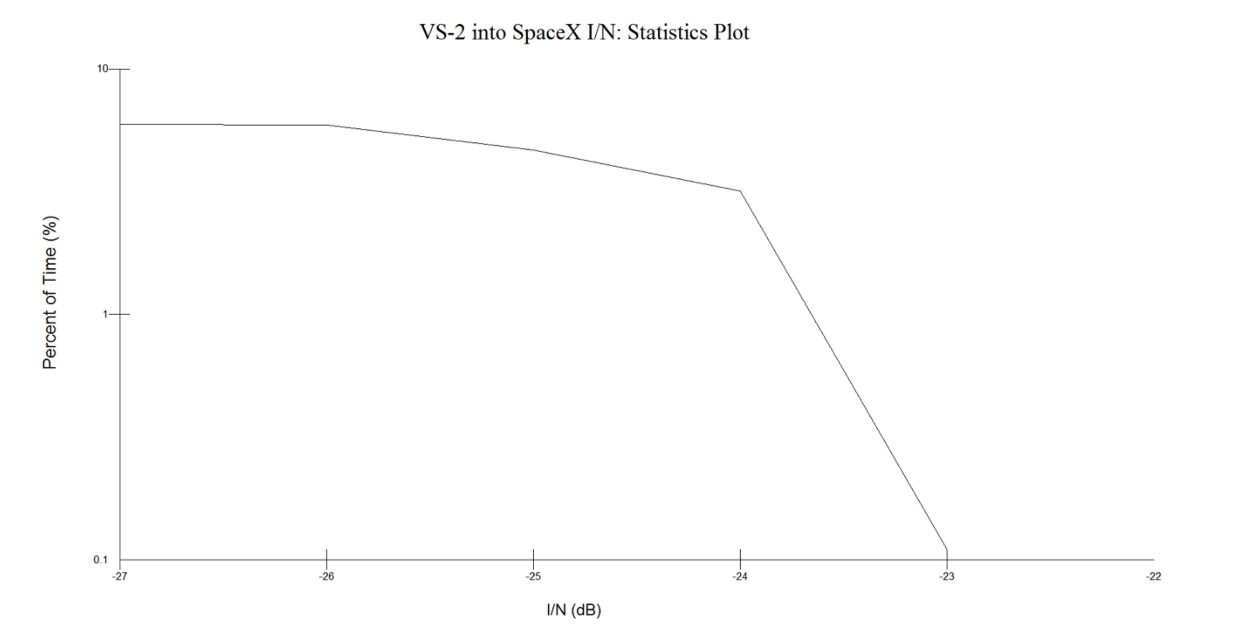
Second, SpaceX does not use the correct bandwidth for each system when performing its interference analysis. FCC and ITU filings include emission designators and EIRP density specifically for this reason so that carriers of different sizes can be evaluated with respect to each other. In its analysis, SpaceX converts the Viasat transmitted power to a per hertz value and then assumes that that this same power density will be received uniformly across the entire 500 MHz receive channel bandwidth of the SpaceX system. This method leads to erroneous conclusions for several reasons.

Viasat earth stations use MF-TDMA and only one station may transmit at a time on a given frequency within a satellite beam, but, a given earth station may in the next burst transmit on any other available frequency channel in the 28.6-29.1 GHz band or in any other sub-band available within the beam footprint as assigned by the MF-TDMA scheduler. Because Viasat earth stations are spread throughout its satellite beam, it is unlikely that there will be multiple earth stations co-located with the SpaceX earth station that will transmit, both at the same time, and on adjacent frequency channels within the 500 MHz channel bandwidth of the SpaceX receiving beam. Rather, it is more likely that the other Viasat earth stations within the same Viasat beam will be at different locations reasonably removed from the SpaceX earth station and will not have the same near in-line alignment as the instant earth station being considered. These transmissions of these stations will be further reduced by the off-axis gain reduction of the SpaceX satellite receiving beam.

By choosing to use only the worst case faded carrier in their analysis and not accounting for the differences in the channel bandwidth, SpaceX is not accounting for the fact that only one, or a small handful, of 5 MHz wide carriers will be operating within their 500 MHz receive channel. Basically, they are assuming 100 times the power of an un-faded Viasat earth station will be operating in the 500 MHz SpaceX receiving channel.

Because Viasat's simulation for the SpaceX network yielded a $\Delta T/T$ of less than 6% at the minimum 22º isolation angle more than 99.99% of the time, Viasat did not provide the results of the simulation for a 30º isolation angle, because a greater isolation angle would result in an even lower $\Delta T/T$ with an even greater percentage of time not exceeding 6% $\Delta T/T$ – in fact, 100% of the time an I/N of -22 dB was never exceeded – see Figure 2.

Figure 2: 30° Isolation I/N vs Percentage of Time for 75 cm earth station



However, to respond to SpaceX's Opposition, Viasat provides an analysis of the 30 degree case. SpaceX does not provide a representative ΔT/T calculation for the 30° separation case of Scenario 2 but rather simply asserts that the calculated ΔT/T is 6% for a 75 cm earth station and 11% for a 1.8 m earth station. In Viasat's calculation here, values are used from the Viasat blanket license application and SpaceX license application as identified in the Tables below:

Table 1: 75 cm Antenna ΔT/T Analysis at ~30° Separation Angle

75 cm Antenna			
Item	Value	Unit	FCC Form 312 question or Comment text
Frequency	28850.0	MHz	(E43)
Antenna diameter	0.745	m	(E33)
Antenna gain	44.0	dBi	(E41)
Input power	25.0	W	(E38)
Emission bandwidth	80.0	MHz	(E47)
EIRP per carrier	57.9	dBW	(E48)
EIRP density	14.9	dBW/4 kHz	(E49)
Off-axis angle to SX satellite	29.0	degrees	As calculated from Visualyse look angles for VS and SX ES
Off-axis gain reduction	51.8	dBc	As calculated by Visualyse (actual VS ant patterns are 55 dBc)
EIRP density toward SX sat	-37.0	dBW/4 kHz	Calculated from EIRP density and off-axis gain reduction
Slant range to SX satellite	1347.0	km	As calculated by Visualyse (sat 490 of planes 1-32 in the simulation)
Path & atm loss to SX satellite	184.9	dB	As calculated by Visualyse
SX satellite receive gain	41.0	dBi	From SX Schedule S for receiving beam GU3/GU7
SX satellite G/T	13.7	dB/K	From SX Schedule S for receiving beam GU3/GU7
SX satellite receiver noise	537.0	K	Calculated from SX Rx Gain and G/T
SX Rx channel bandwidth	500.0	MHz	From SX Schedule S receiving channel CGU7
SX Receiver noise power	-114.3	dBW	Calculated using N=ktB equation and SX noise and bandwidth values
VS received power	-137.8	dBW	Calculated using VS off-axis EIRP density, path loss, and SX Rx gain
I/N	-23.5	dB	Calculated by subtracting SX Rx noise from VS Rx power
Delta T/T	0.447	%	Calculated by standard formula 10^(x/10)*100

In Table 1 above for a 75 cm antenna, the resulting ΔT/T value of 0.45% calculated for a 30° isolation angle is over twelve times lower than the 6% ΔT/T SpaceX reported for the 75 cm earth station using rain-faded EIRP density values (but apparently not accounting for atmospheric attenuation). See SpaceX June 26 Reply at 6.

Table 2 1.8 m Antenna ΔT/T Analysis at ~30° Separation Angle

1.8 m Antenna			
Item	Value	Unit	FCC Form 312 question or Comment text
Frequency	28850.0	MHz	(E43)
Antenna diameter	1.8	m	(E32)
Antenna gain	53.0	dBi	(E41)
Input power	25.0	W	(E38)
Emission bandwidth	160.0	MHz	(E47)
EIRP per carrier	67.0	dBW	(E48)
EIRP density	21.0	dBW/4 kHz	(E49)
Off-axis angle to SX satellite	29.0	degrees	As calculated from Visualyse look angles for VS and SX ES
Off-axis gain reduction	57.5	dBc	As calculated by Visualyse
EIRP density toward SX sat	-36.4	dBW/4 kHz	Calculated from EIRP density and off-axis gain reduction
Slant range to SX satellite	1347.9	km	As calculated by Visualyse (sat 493 of planes 1-32 in the simulation)
Path & atm loss to SX satellite	184.9	dB	As calculated by Visualyse
SX satellite receive gain	41.0	dBi	From SX Schedule S for receiving beam GU3/GU7
SX satellite G/T	13.7	dB/K	From SX Schedule S for receiving beam GU3/GU7
SX satellite receiver noise	537.0	K	Calculated from SX Rx Gain and G/T
SX Rx channel bandwidth	500.0	MHz	From SX Schedule S receiving channel CGU7
SX Receiver noise power	-114.3	dBW	Calculated using N=ktB equation and SX noise and bandwidth values
VS received power	-134.3	dBW	Calculated using VS off-axis EIRP density, path loss, and SX Rx gain
I/N	-20.0	dB	Calculated by subtracting SX Rx noise from VS Rx power
Delta T/T	1.01	%	Calculated by standard formula 10^(x/10)*100

Likewise, in Table 2 above for a 1.8 meter antenna, the 1.01% ΔT/T value calculated for a ~30° isolation angle by Viasat is ten times lower than the 11% value calculated by SpaceX.

It is important to note several assumptions related to the ΔT/T value calculated by Viasat. First, the symbol rates used in each case are the lowest to be used for normal clear sky operation representing an earth station located at the edge of beam coverage. Nominally, for the 75 cm antenna and the 1.8 m antenna the typical operating symbol rate will be one step higher. The terminal bursts at the same maximum 25 W power output and maximum EIRP, but at twice the bandwidth so the EIRP density is reduced by 3 dB, thereby also reducing the I/N by 3 dB. The ΔT/T however, is unchanged. This is because while the EIRP density is reduced by 3 dB, the transmitted bandwidth now being received by the SpaceX receiver is now doubled so the net Viasat power in the SpaceX receiver is unchanged. Similarly, if the operating symbol rate is reduced, the terminal still transmits at the same EIRP, but the EIRP density is now increased by

3 dB. However, the transmitted bandwidth now being received by the SpaceX receiver is halved, and again the resulting $\Delta T/T$ is unchanged. It is important to note here, as was also noted above, that SpaceX in their formula for I/N in Exhibit A of the June 26 filing does not include a bandwidth component, assuming wrongly that the received power density from a single Viasat uplink can be applied uniformly across the entire 500 MHz SpaceX receive channel. As described below, this is not the case.

In this simulation, the Viasat earth station and the SpaceX earth stations are assumed to be co-located and that the SpaceX satellite's receiving beam boresight is pointed at both the Viasat and SpaceX earth stations. The Visualyse simulation was configured to use a 41 dBi gain for the SpaceX satellite per the Schedule S filing. Visualyse has options for the antenna gain roll-off and in this case an ITU-R S.1528 recommendation was used with L = -15 dB.

As SpaceX stated in their FCC license application, in the Ka band, usage is limited to communications with SpaceX gateway earth stations. Accordingly, the receiving beams will be tightly focused on the gateways and only operated at elevation angles above 40° above the local horizon. If the Viasat earth station is not co-located with or very near by the SpaceX gateway earth station, the effective gain in the direction of the Viasat earth station is reduced and the I/N drops. In the Visualyse simulation, using the ITU-R roll-off model noted above, moving the Viasat earth station north in latitude by 0.25°, 0.5°, 1°, and 2° result in reductions of 1.2 dB, 8.9 dB, 13.2 dB, and 18.8 dB I/N, respectively.

Like the SpaceX example, the Viasat simulation uses only a single earth station for Viasat and for SpaceX, and separate simulations were performed for the 75 cm and 1.8 m antenna cases. This is reasonable and appropriate given that the Viasat network operates using MF-TDMA such that only a single earth station transmits within a given Viasat satellite beam on a given frequency at a time. Thus, as discussed above, it is unlikely that multiple earth stations will be co-located near the SpaceX earth station and in the center of the SpaceX receiving beam and transmitting on adjacent frequencies within the 500 MHz receive channel bandwidth of the SpaceX receiver at the same time. Rather, it is realistic to expect that various Viasat earth stations transmitting within the 500 MHz SpaceX receive channel bandwidth will be spread around within Viasat's overall coverage area and most of them will have a larger isolation angle than the 30° assumed for the earth station in the simulation. Also, these earth stations will be further from the SpaceX beam center and as noted above will see a further reduction in the received I/N.

However, even in the worst case where for some brief time several Viasat earth stations transmitted on adjacent channels at the same time such that the entire 500 MHz SpaceX receive channel had Viasat carriers overlapping, the resulting $\Delta T/T$ as calculated above in Tables 1 and 2 would increase at worst by 500 MHz/80 MHz = 6.25 times or to 2.8% in the case of the 75 cm antenna, and 500 MHz/160 MHz = 3.14 times or to 3.14% in the case of the 1.8 m antenna.

Finally, it is worth noting that with respect to the I/N calculations, these are based on a snapshot alignment and do not in any way reflect the percentage of time such alignments might occur in the normal operation of the networks. The majority of the time, in any of the available tracking modes in Visualyse the isolation angle is much larger than 30°, especially given the 40° minimum elevation operational parameters that SpaceX identified in its FCC license application for its Ka band gateways. To even get Visualyse to produce a 30° isolation angle snapshot for analysis required that the range of pointing angles for the SpaceX earth station be limited in such a way as to artificially force the software to generate an alignment. Importantly, in any given 24 hour simulation run, a -12.2 dB I/N value was never observed and the highest value seen was -22 dB which equates to a ΔT/T of 0.6%.

III. OPERATION OF THE EARTH STATIONS WITH VIASAT-1 DOES NOT CHANGE THE ANALYSIS

SpaceX has noted that Viasat's analysis addressed earth stations communicating with ViaSat-2 and suggests that the analysis should also consider ViaSat-1 as well. As the Viasat earth stations would operate within the limits of the licensed parameters, the EIRP density of the earth stations will be no higher when communicating with ViaSat-1 than with ViaSat-2. A separate Visualyse simulation was performed using the earth station operating parameters as indicated above, except that the satellite point of communication was changed from ViaSat-2 at 69.6° W.L. to ViaSat-1 at 115.1° W.L. No change in I/N values or percentage of time for these values was observed in this alternative simulation.

DECLARATION

I hereby declare that I am the technically qualified person responsible for preparation of the engineering information contained in this Reply of Viasat, Inc. ("Reply"), 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 Reply, 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.
Chief Technology Officer, Regulatory Affairs
Viasat, Inc.
6155 El Camino Real
Carlsbad, CA 92009

January 8, 2018