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Marlene H. Dortch
Secretary
Federal Communications Commission
445 12th Street, S.W.
Washington, DC 20554

Re: *Update to Parts 2 and 25 Concerning Non-Geostationary, Fixed-Satellite Service Systems and Related Matters*, IB Docket No. 16-408

Dear Ms. Dortch:

In this proceeding, Space Exploration Technologies Corp. ("SpaceX") has shown that the equivalent power flux-density ("EPFD") limits adopted by the International Telecommunications Union ("ITU") are more than adequate to protect modern geostationary orbit ("GSO") satellites against interference from non-geostationary orbit ("NGSO") satellite systems.[1] In its Reply, Viasat, Inc. ("Viasat") briefly called one aspect of SpaceX's argument into question.[2] Below, we explain in greater detail the analysis previously presented to demonstrate that Viasat's criticism is unfounded.

As SpaceX previously explained, the ITU developed its $EPFD_{\uparrow}$ limits based on certain prescribed parameters. Specifically, Table 22-2 in the ITU Radio Regulations identifies the reference antenna beamwidth and the reference antenna pattern to be used to determine the potential impact of NGSO uplink transmissions on a GSO satellite in each frequency band.[3] The relevant ITU Recommendation further provides that the GSO service area to be considered in this analysis is defined as the area within the 15 dB gain contour of this reference antenna pattern.[4] Using those inputs, the 15 dB gain contour for the peak gain of the reference pattern (40.7 dBi) is reached at an angle of 7.75º from boresight. Assuming that the GSO satellite beam points to nadir, that 15 dB contour encompasses an area of about 110 million square kilometers.

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1 *See* Space Exploration Technologies Corp. Response to Petitions for Reconsideration, IB Docket No. 16-408, at 10-13 (Feb. 20, 2018) ("SpaceX Response").

2 *See* Reply of Viasat, Inc., IB Docket No. 16-408, at 4 (Mar. 5, 2018) ("Viasat Reply").

3 For the Ka-band uplink frequencies at issue here, the specified reference beamwidth is 1.55º and the reference antenna pattern is Recommendation ITU-R S.672-4 (1997) with *Ls*=-10 (*Ls* is the first sidelobe level). The peak gain for this reference antenna is 40.7 dBi. *See* Recommendation ITU-R S.1503-3, Table 16 (2018).

4 *See* Recommendation ITU-R S.1503-3, § D5.2.5.

The $EPFD_{\uparrow}$ calculation aggregates the inference produced by all NGSO earth stations inside this 15 dB contour, which is likely to be large for a large NGSO constellation. For example, SpaceX conservatively estimates that the average number of earth stations transmitting with overlapping frequencies per square kilometer when its system is fully deployed will be 0.00003,[5] which corresponds to 3,300 earth stations in a service area of 110 million square kilometers. Assuming that each of these earth stations is operating at the EPFD limit of -162 $dBW/m^2/40$ kHz, the worst case interference for the reference antenna would be negligible – *i.e.*, I/N of -19.5 dB, or a mere 1.1% $\Delta T/T$. Moreover, even assuming that five similar NGSO systems were all operating at the EPFD limit and all reach that limit at exactly the same time, the aggregate interference would still be very reasonable – *i.e.*, I/N of -12.5 dB, or 5.6% $\Delta T/T$ (less than the ITU trigger for coordination).[6]

Viasat claims that its own, more advanced satellites will experience much greater interference from NGSO earth stations, suffering a data rate reduction of 26% corresponding to signal degradation of 3.5 dB.[7] But as SpaceX explained, Viasat has apparently misapplied the relevant antenna pattern. Viasat indicates that its next-generation satellites have a G/T as high as 30.9 dB/K,[8] which is consistent with a peak gain of 61 dBi and a system temperature of 1050 K.[9] Using this peak gain and the antenna pattern described by the relevant ITU Recommendation,[10] the relative gain of 15 dB is reached at 0.155º from boresight. (Although Viasat has not provided the 15 dB beamwidth measured for its actual antenna, there is no reason to believe it would be dissimilar.) Assuming that the GSO satellite beam points to nadir, that 15 dB contour encompasses an area of about 29,200 square kilometers.

Thus, the area from which Viasat's higher-gain antenna will potentially receive uplink interference is much smaller than the area assumed in the ITU reference situation. Indeed, the area assumed in the ITU reference situation is 3,767 times larger than the area covered by Viasat's antenna.[11] This far smaller area likely corresponds to a far smaller number of earth stations, which

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5 *See* IBFS File No. SAT-LOA-20161115-00118, Technical Attachment at Annex 2-7 (Nov. 15, 2016).

6 Note that such a scenario is very unlikely given the different orbits and operating characteristics of NGSO systems, and ignores the effects of atmospheric attenuation. The calculation assumes a GSO system temperature of 1050 K.

7 Petition for Reconsideration of Viasat, Inc., IB Docket No. 16-408, Exhibit A at 3 (Jan. 17, 2018).

8 *See id.*, Exhibit A at Table 1. Note that all of the satellites listed in this table with lower G/T values will be less likely to be affected by any interference from NGSO earth stations. *Id.* at n.2.

9 A Viasat *ex parte* filing appears to confirm these values. *See* Letter from John P. Janka to Marlene H. Dortch, GN Docket No. 14-177, *et al.*, Attachment at 1 (Apr. 21, 2016).

10 For this purpose, we used *Ls*=-20 with the Recommendation ITU-R S.672-4 pattern in order to reflect the higher antenna gain.

11 The ratio is 110,000,000/29,200. Viasat indicates that the 3 dB beamwidth of its antenna is 0.21º, and compares this to the 3 dB beamwidth of the reference antenna (1.55º) to conclude that its beam covers approximately 1/55 of the area covered by the ITU reference antenna $(0.21/1.55)^2$). *See* Viasat Reply at 4 n.11. However, this calculation is irrelevant because the 3 dB spot area does not scale linearly with the 15 dB service area as used for EPFD calculations.

would likely more than offset the increased peak gain of Viasat's antenna. Specifically, again using the parameters of the system proposed by SpaceX, there is likely to be, on average, less than one SpaceX gateway earth station in view of a second-generation Viasat GSO satellite at any given time (*i.e.*, there will typically be zero earth stations in view, and rarely more than one). Even assuming a worst case in which a SpaceX earth station is right at the boresight of the Viasat GSO antenna and emitting at the maximum planned EIRP toward the GSO arc, interference to Viasat should not exceed an I/N of -29.25 dB. Recall that the interference contemplated under the ITU reference situation discussed above was -19.5 dB, or almost 10 dB greater – yet still negligible.[12]

Accordingly, although the ITU may not have contemplated a system with the characteristics of Viasat's second-generation GSO satellites when it developed the current EPFD limits, the disparity actually works in Viasat's favor as the EPFD limits are actually *more protective* of the new generation of satellites than those the rules were originally designed to protect.

Respectfully submitted,

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[12] It is theoretically possible that a single NGSO earth station operating at very high power, with poor sidelobe rejection, or with little angular separation to the GSO arc could interfere straight into the boresight of a GSO satellite receive antenna. However, this scenario is inconsistent with the design of LEO constellations, which use a large number of low-power earth stations. Indeed, no LEO constellation proposed to date operates in such a manner.