

March 15, 2021

VIA IBFS

Marlene H. Dortch
Secretary
Federal Communications Commission
45 L Street NE
Washington, DC 20554

Re: *Space Exploration Holdings, LLC, Application for Modification of Authorization for the SpaceX NGSO Satellite System*, IBFS File No. SAT-MOD-20200417-00037

Dear Ms. Dortch:

WorldVu Satellites Limited (“OneWeb”) submits this correspondence to highlight the significant interference issues presented by the above-captioned application for modification filed by Space Exploration Holdings, LLC (“SpaceX”)—issues that SpaceX has failed to successfully resolve or even comprehensively address in the record to date.¹

As numerous satellite operators have pointed out, the Third SpaceX Modification effectively constitutes an entirely new satellite system: SpaceX proposes to drastically lower the altitude of two-thirds of its authorized satellites, materially modify the antennas and the associated power flux density (“PFD”) contours of all the Starlink satellites, and significantly lower the minimum elevation angle of its associated ground stations.² In other words, SpaceX’s proposed constellation architecture is nearly unrecognizable from its currently authorized system.³ As a

¹ Comments of OneWeb, IBFS File No. SAT-MOD-20200417-00037 (filed Jul. 13, 2020) (“OneWeb Comments”); Reply of OneWeb, IBFS File No. SAT-MOD-20200417-00037 (filed Aug. 7, 2020) (“OneWeb Reply”); Letter from Brian D. Weimer, Counsel to OneWeb, to Marlene H. Dortch, Secretary, FCC, IBFS File No. SAT-MOD-20200417-00037 (filed Feb. 10, 2021) (“OneWeb Feb. 10 Letter”); Letter from Brian D. Weimer, Counsel to OneWeb, to Marlene H. Dortch, Secretary, FCC, IBFS File No. SAT-MOD-20200417-00037 (filed Feb. 17, 2021); Letter from Brian D. Weimer, Counsel to OneWeb, to Marlene H. Dortch, Secretary, FCC, IBFS File No. SAT-MOD-20200417-00037 (filed Feb. 25, 2021).

² See *Space Exploration Holdings, LLC, Application for Modification of Authorization for the SpaceX NGSO Satellite System*, IBFS File No. SAT-MOD-20200417-00037; Call Signs S2983 and S3018 (filed Apr. 17, 2020) (“Third SpaceX Modification”).

³ OneWeb Comments at 1–2; see also Letter from Mariah Dodson Shuman, Corporate Counsel, Kuiper Systems LLC, to Marlene H. Dortch, Secretary, FCC, IBFS File No. SAT-MOD-20200417-

result, OneWeb previously requested the Commission process the Third SpaceX Modification as part of the Commission's ongoing Second Processing Round for non-geostationary orbit, fixed-satellite service systems ("NGSO FSS").⁴ This correspondence augments these prior submissions and provides additional analyses reinforcing OneWeb's previous conclusion that any full grant of the Third SpaceX Modification would substantially degrade the NGSO FSS sharing environment and, therefore, can only be processed in the ongoing Second Processing Round if it is to remain consistent with well-established Commission precedent.

In addition, SpaceX's apparent clandestine antenna redesign of the previously authorized and operating satellites should be clarified. The Commission should, at a minimum, require SpaceX to (1) confirm whether all satellites at 550 km use phased array antennas or (2) whether some (and how many) or all of the currently deployed satellites use parabolic antennas.

I. SPACEX MUST CLARIFY THE INCONSISTENT STATEMENTS IN THE RECORD REGARDING THE TECHNICAL CHARACTERISTICS OF ITS KA-BAND SATELLITE ANTENNA

The Technical Narrative included as part of the Third SpaceX Modification indicated that SpaceX proposed "to relocate the satellites that are currently authorized to operate at altitudes from 1,110 km to 1,325 km down to altitudes ranging from of 540 km to 570 km, and to make related changes to the operations of the satellites in these new lower shells of the constellation."⁵ SpaceX also certified "that all other technical information provided in its previous Ku/Ka-band applications, as modified, remains unchanged."⁶ The Technical Narrative contains no mention of SpaceX shifting from phased array antennas on its satellites to a more parabolic-like antenna technology for Ka-band links.⁷ More recently, SpaceX appeared to confirm the Starlink satellites that are part of the Third SpaceX Modification will deploy "parabolic" antennas to communicate

00037, at 1 (filed Aug. 18, 2020) ("SpaceX's proposed modification...is an entire system redesign that involves every SpaceX satellite...The configuration...bears little resemblance to the original constellation proposed by SpaceX...").

⁴ OneWeb Feb. 10 Letter at 2; see also *Cut-Off Established For Additional NGSO FSS Applications Or Petitions For Operations In the 10.7-12.7 GHz, 12.75-13.25 GHz, 13.8-14.5 GHz, 17.7-18.6 GHz, 18.8-20.2 GHz, and 27.5-30 GHz Bands*, Public Notice, 35 FCC Rcd 2881 (2020) (establishing the 2020 Ku-/Ka-band NGSO processing round or "Second Processing Round").

⁵ Third SpaceX Modification, Attachment A at 1.

⁶ *Id.* at 2; see also Third SpaceX Modification, Legal Narrative at 1 (noting that with the exception of the changes identified in the application identified by SpaceX, "all other information provided in its Ku/Ka-band applications...remains unchanged.").

⁷ *Space Exploration Holdings, LLC*, IBFS File No. SAT-LOA-20161115-00118, Attachment A, Technical Information, at 2, 6-7, 9, 13, 40 (filed Nov. 15, 2016); *Space Exploration Holdings, LLC*, IBFS File No. SAT-LOA-20170726-00110, Attachment A, Technical Information, at 5-6, 11, 20 (filed Jul. 26, 2017); *Space Exploration Holdings, LLC*, IBFS File No. SAT-MOD-20181108-00083, Attachment A, Technical Information, at 6 (filed Nov. 8, 2018) ("First SpaceX Modification") (referencing the use of phased array antennas only).

with gateway earth stations and provided the associated antenna pattern reproduced in Figure 1 below.”⁸

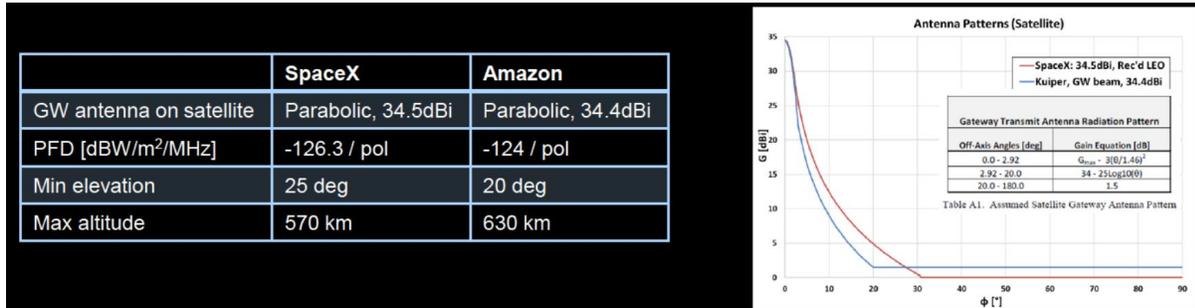


Figure 1: new SpaceX satellite gateway antenna pattern

In addition, SpaceX provided the following PFD contours (reproduced in Figure 2 below) generated by a satellite at an altitude of 550 km for an elevation of 25°.⁹

⁸ Letter from Gardner Foster, Principal, Satellite Policy, SpaceX, to Marlene H. Dortch, Secretary, FCC, IBFS File No. SAT-MOD-20200417-00037, at 14 (filed Jan. 19, 2021) (“SpaceX Jan. 19 Letter”).

⁹ Letter from David Goldman, Director of Satellite Policy, SpaceX, to Marlene H. Dortch, Secretary, FCC, IBFS File No. SAT-MOD-20200417-00037, at 20 (filed Feb. 22, 2021) (“SpaceX Feb. 22 Letter”).

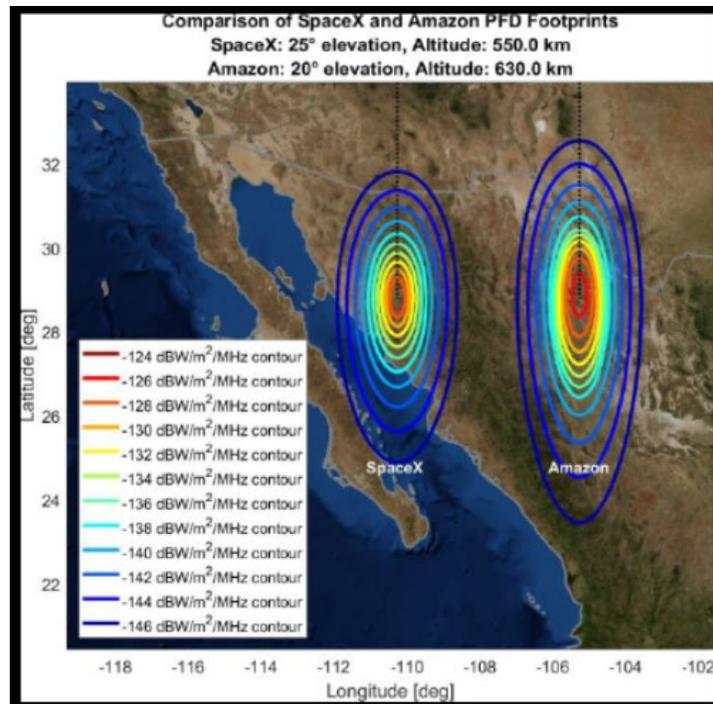


Figure 2: PFD contours produced by a SpaceX satellite at 550 km

These PFD contours are representative of the antenna pattern—*i.e.*, a parabolic antenna—associated with the 2,824 satellites that are part of the Third SpaceX Modification. Although it certified¹⁰ in the Third SpaceX Modification that no changes were made to the technical characteristics provided for the previously authorized satellites (operating at an altitude of 550 km), SpaceX appears to have replaced the phased array antennas of these satellites being currently deployed at 550 km with parabolic antennas.

Other satellite operators have also highlighted SpaceX's apparent clandestine antenna redesign. For example, OneWeb agrees with SES/O3b's observation that "significant signals point to the possibility that SpaceX is relying on parabolic, rather than phased array, antennas onboard its satellites for the Ka-band gateway links" and that there is "no mention of the parabolic antennas or description of their operating characteristics anywhere in the series of SpaceX submissions to the Commission describing its system."¹¹ Similarly, several submissions by Amazon Kuiper in this proceeding have also highlighted SpaceX's apparent satellite antenna redesign.¹²

¹⁰ See *supra* n. 6.

¹¹ Reply of SES Americom, Inc. and O3b Limited, IBFS File No. SAT-MOD-20200417-00037, at 12, 14 ("SES Reply") (filed Aug. 7, 2020).

¹² See, *e.g.*, Letter from Mariah Dodson Shuman, Corporate Counsel, Kuiper Systems LLC, to Marlene H. Dortch, Secretary, FCC, IBFS File No. SAT-MOD-20200417-00037, at 12 (filed Sep. 24, 2020) ("Amazon Sep. 24 Letter") (noting a Ka-band PFD increase resulting from SpaceX's antenna re-design); Letter from Mariah Dodson Shuman, Corporate Counsel, Kuiper Systems

Given these apparent discrepancies, and setting aside the potential inaccuracies contained in previous SpaceX submissions,¹³ the Commission should, at a minimum, require SpaceX to (1) confirm whether all satellites at 550 km use phased array antennas—consistent with the current SpaceX space station license—or (2) whether some (and how many) or all of the currently deployed satellites use parabolic antennas. As explained in Sections II and III below, any full grant of the Third SpaceX Modification remains premature absent SpaceX comprehensively addressing these issues in the record.

II. SPACEX’S APPARENT CHANGE IN KA-BAND ANTENNA TECHNOLOGY MATERIALLY IMPACTS THE PFD LEVELS PRODUCED BY SATELLITES OPERATING AT 550 KM

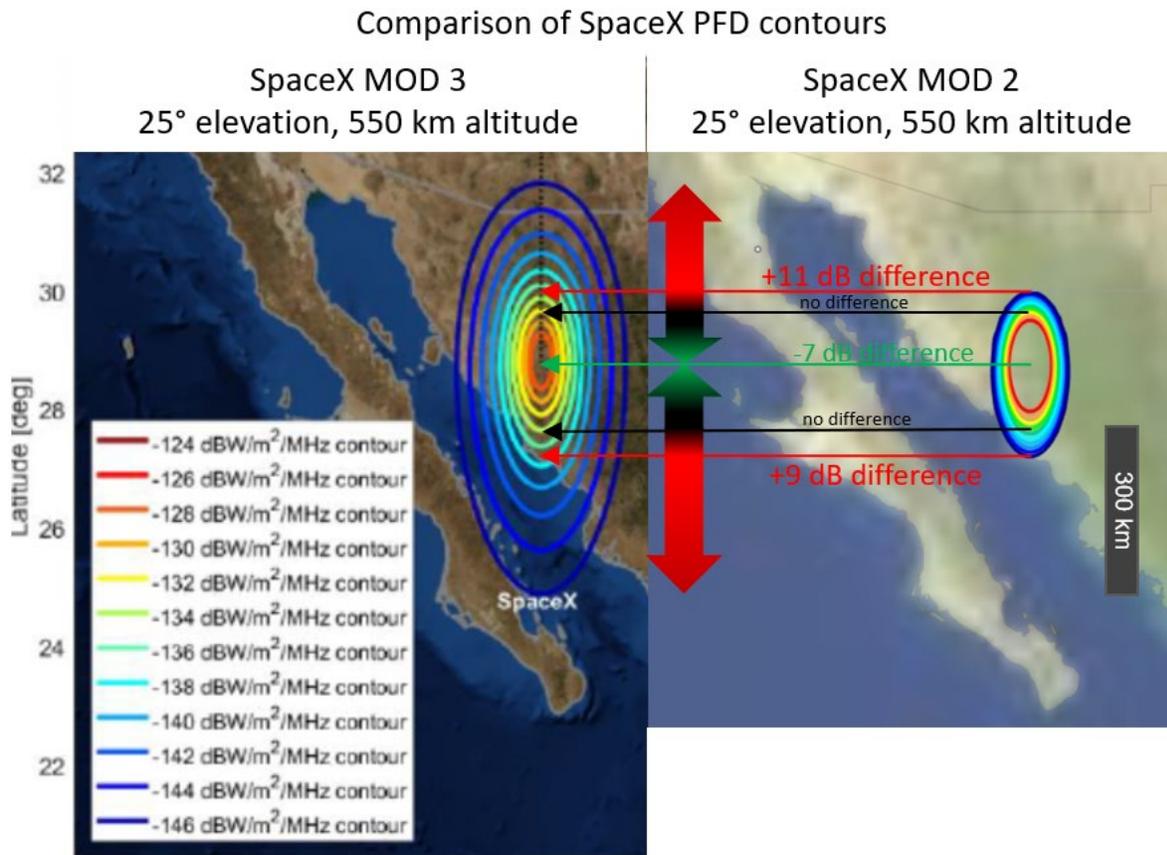
SpaceX’s apparent undisclosed change in antenna technology for SpaceX satellites at the 550 km operating altitude would materially impact the PFD produced on the ground. In Figure 3 below, OneWeb compares the PFD contours produced by a SpaceX beam at an elevation of 25° by an authorized phased array antenna (“SpaceX MOD2” on the right) and the PFD produced using a parabolic antenna as illustrated by SpaceX in the Third SpaceX Modification (or “SpaceX MOD3” on the left).¹⁴ OneWeb generated the phased array antenna PFD contours using the GXT files provided by SpaceX in the First SpaceX Modification and Second SpaceX Modification modifications.¹⁵

LLC, to Marlene H. Dortch, Secretary, FCC, IBFS File No. SAT-MOD-20200417-00037, at 1, 5, 9 (filed Feb. 11, 2021) (“Amazon Feb. 11 Letter”); Letter from Mariah Dodson Shuman, Corporate Counsel, Kuiper Systems LLC, to Marlene H. Dortch, Secretary, FCC, IBFS File No. SAT-MOD-20200417-00037, at 1, 5 (filed Feb. 22, 2021) (“Amazon Feb. 22 Letter”).

¹³ See *supra* n. 7; see also 47 C.F.R. § 1.17 (requiring truthfulness and accuracy in submissions to the Commission).

¹⁴ SpaceX Feb. 22 Letter at 20.

¹⁵ See First SpaceX Modification; see also *Space Exploration Holdings, LLC, Application for Modification of Authorization for the SpaceX NGSO Satellite System*, IBFS File No. SAT-MOD-20190830-00087 (“Second SpaceX Modification”) (filed Aug. 30, 2019).



While the PFD produced by a parabolic antenna is slightly lower in the area close to the center of the beam—due to the proposed reduction of PFD in the Third SpaceX Modification—it is significantly higher as the distance from the center of the beam increases, by up to at least 9 dB. OneWeb notes it was not possible to assess the difference outside the outer contour of the footprint on the right because SpaceX provided no gain contours beyond the -20 dB contour for the phased array antenna. It is, however, reasonable to expect that the differential would be *even higher* than the 9 dB and 11 dB indicated in Figure 3 considering the fast roll-off expected from SpaceX’s previously authorized phased array antenna.

OneWeb performed a similar comparison (shown in Figure 4 below) to illustrate the PFD contours produced by beams at an elevation of 90° (Nadir).

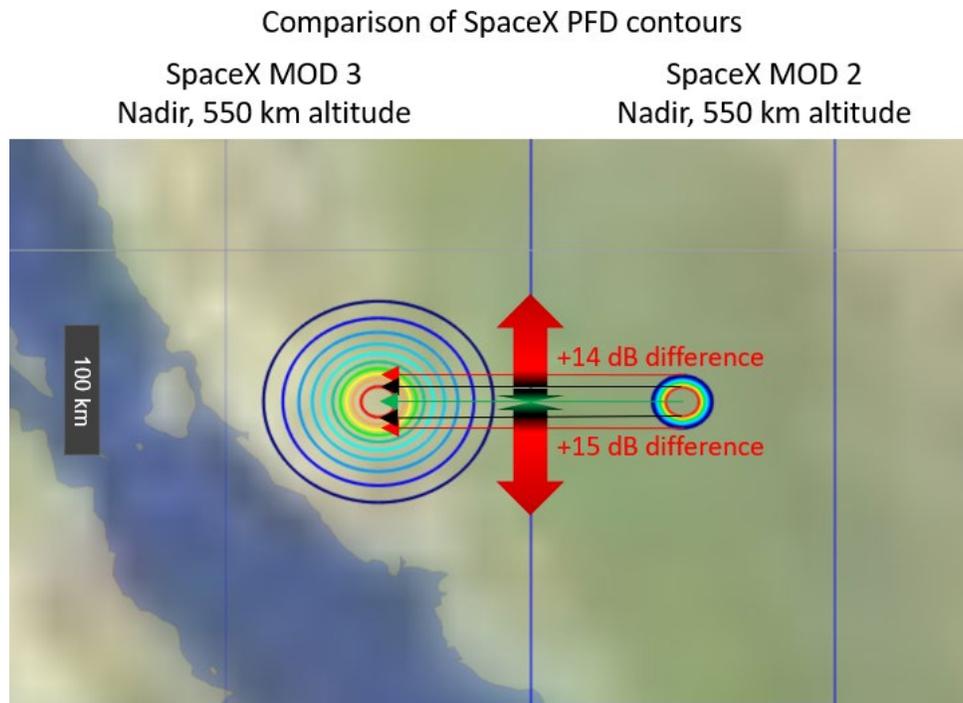


Figure 4: comparison between PFD produced by a satellite at 550 km using a parabolic antenna (left) and a phased array antenna (right) at 90° elevation

This figure again shows that outside of the small area close to the center of the beam, the PFD produced by a parabolic antenna will be significantly higher than the PFD produced by SpaceX's currently authorized phased array antenna as the distance from the center of the beam increases, by up to at least 14 dB.

These comparisons demonstrate that for all elevation angles, SpaceX's apparent undisclosed change in Ka-band antenna technology for the satellites at the 550 km operating altitude would materially modify the PFD produced on the ground and dramatically increase it over extensive geographical areas.

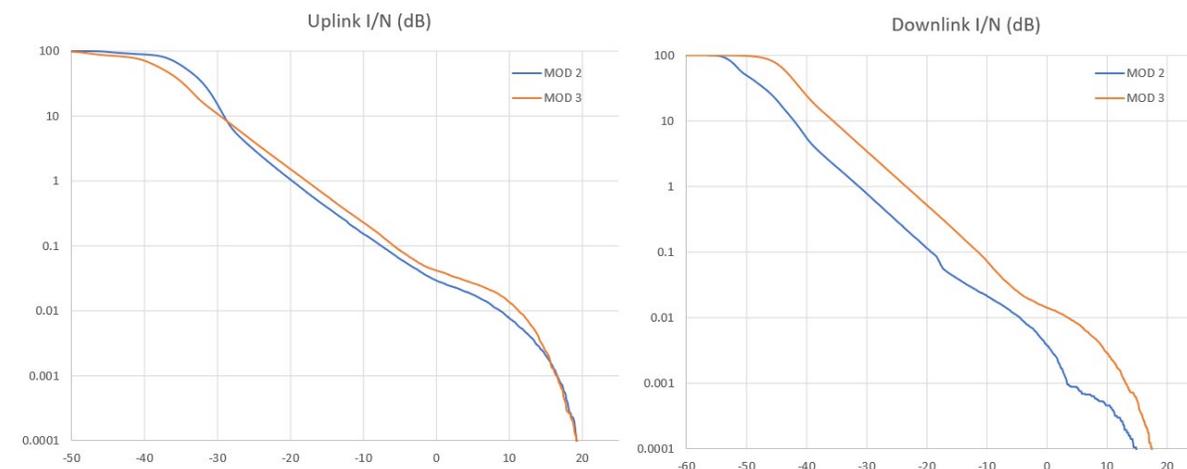
III. ANY FULL GRANT OF THE THIRD SPACEX MODIFICATION WILL SIGNIFICANTLY DEGRADE THE KA- BAND INTERFERENCE ENVIRONMENT

In addition to the apparent undisclosed shift of antenna technology for the satellites at the 550 km operating altitude, SpaceX ostensibly also decided to similarly change the antenna technology for the 2,824 remaining satellites that are part of the Third SpaceX Modification. As explained in Section II above, this shift from phased array to parabolic antenna technology will reduce the PFD levels in the small area close to the boresight but will *dramatically* increase these PFD levels as the distance from the boresight grows greater. Accordingly, OneWeb anticipates this antenna change will degrade the interference environment when there is geographical separation between the Ka-band gateways of two satellite operators.

In order to assess the impact of this change in a real-world scenario, OneWeb performed an interference analysis for the OneWeb Santa Paula Gateway¹⁶ and the SpaceX Hawthorne Gateway.¹⁷ Both gateways are located in California, approximately 86.8 km apart. OneWeb compared the Interference-to-Noise (“I/N”) ratio values for the SpaceX Hawthorne Gateway communicating with the currently authorized SpaceX constellation (in blue, below) to the constellation described in the Third SpaceX Modification (in orange, below), taking into account the antenna technology change for all altitudes and the reduction in altitude for the 2,824 satellites that are part of the Third SpaceX Modification. OneWeb produced interference results—presented as a cumulative distribution function of the I/N ratio for varying percentages of time—in both the uplink and downlink directions. This analysis first considered the OneWeb system as the victim and then considered the SpaceX system as the victim. The results are presented in turn below.

OneWeb as Victim Scenario

While there is no significant change in the uplink direction, interference into the OneWeb Santa Paula Gateway in the downlink direction will significantly increase (the orange curve is always well above the blue curve) in this operational scenario. For most percentages of time, interference will increase by approximately 5 to 9 dB. In other words, interference into the OneWeb system will increase significantly as a result of the higher PFD produced (at a distance of 86.8 km) by the parabolic, satellite-based Ka-band antenna that SpaceX ostensibly plans to deploy across its constellation.

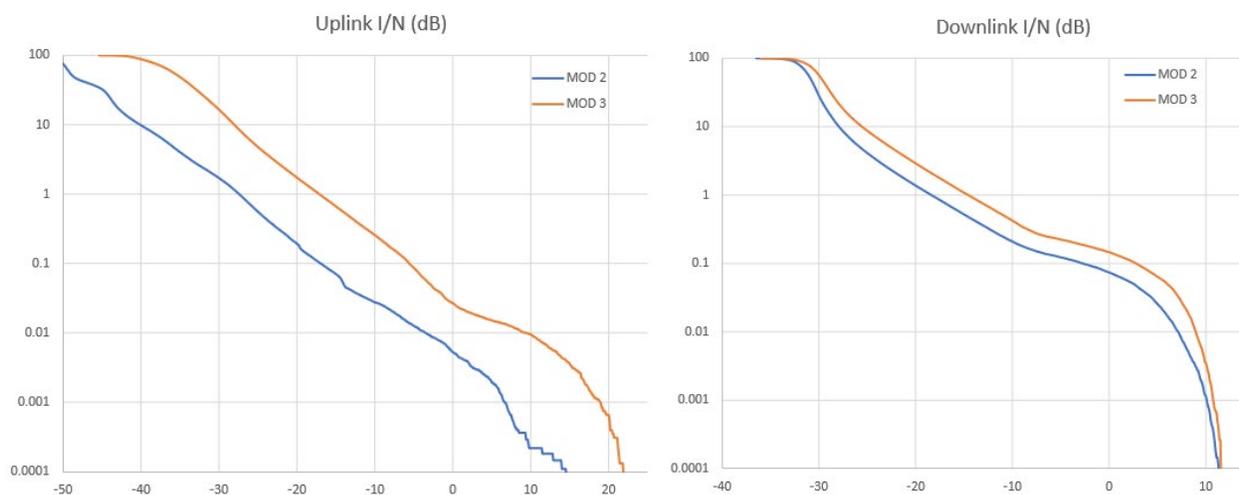


¹⁶ See *WorldVu Satellites Limited*, Application for Gateway Earth Station, IBFS File No. SES-LIC-20190422-00538, (filed Apr. 22, 2019) (“Santa Paula Gateway”).

¹⁷ See *SpaceX Services, Inc.*, Grant of Authority, IBFS File No. SES-LIC-20200210-00150, Call Sign E200455 (granted Dec. 18, 2020) (“Hawthorne Gateway”).

SpaceX as Victim Scenario

In the downlink direction, interference increases for all percentages of time, by up to 3 dB. In the uplink direction, the interference received by SpaceX *significantly* increases (the orange curve is shifted to the left by approximately 10 to 13 dB for all percentages of time). This significant difference is the result of the limited off-axis discrimination of the parabolic antenna first introduced in the Third SpaceX Modification, as compared to the fast roll-off of the previously authorized phased array antenna.



SpaceX has stated that they will accept any increase of interference to its NGSO system resulting from a grant of the Third SpaceX Modification,¹⁸ but it is unclear how SpaceX—or any other NGSO operator—could accept the operational implications of an increase in interference of 10-13 dB as calculated in this example. Moreover, this purported acceptance does not fully address the impact of the Third SpaceX Modification on the NGSO interference environment. The coordination process relied upon by NGSO operators does not follow a simplistic, fixed structure in terms of protection and methodology as suggested by SpaceX. As OneWeb previously explained, “[t]he conditions agreed to during inter-operator coordination negotiations...depend on the levels and associated probability of interference experienced between the systems—not simply the percentage of time associated to -12.2 dB of I/N—and their associated protection requirements.”¹⁹ Coordination conditions and operational limitations agreed to by SpaceX and another NGSO operator concerning the currently authorized SpaceX system would be fundamentally different from the conditions arising from the coordination of a more interference-

¹⁸ See Consolidated Opposition to Petitions and Response to Comments of SpaceX, IBFS File No. SAT-MOD-20200417-00037, at 23 (filed July 27, 2020) (“SpaceX is willing to accept...any additional interference to its uplinks from other NGSO systems authorized in the 2016 processing round resulting from [the Third SpaceX Modification] compared to its current authorization”).

¹⁹ OneWeb Reply at 16.

sensitive system, such as the system proposed by SpaceX in the Third SpaceX Modification. It is therefore unclear how SpaceX's acceptance of any increase of interference would be implemented in practice.

This modeling demonstrates that any grant by the Commission of the remaining portion of the Third SpaceX Modification will have a significant and adverse impact on the NGSO FSS interference environment in the Ka-band. Notably, it will significantly increase both the downlink interference into the OneWeb Santa Paula Gateway and the uplink interference into the SpaceX Hawthorne Gateway even when these gateways are geographically separated. This analysis also aligns with the submissions of other NGSO FSS operators, whose analyses reached similar conclusions regarding the worsening of the Ka-band interference environment as a result of any full grant of the Third SpaceX Modification.²⁰

Consistent with this emerging consensus regarding the Ka-band interference environment for NGSO FSS operators, OneWeb respectfully urges the Commission to keep in mind the inherently broad impacts on the coexistence of gateway operations that would result from any grant of the remaining portion of the Third SpaceX Modification. SpaceX has submitted applications for approximately 50 gateway earth stations and associated requests for special temporary authority at locations across the United States, potentially enabling the undesirable interference scenarios illustrated above to unfold on an aggregated, nationwide level. Accordingly, even other NGSO FSS operators with existing or planned gateway or user terminal operations planning to rely on geographical separation from a SpaceX gateway earth station—which, given the breadth of SpaceX's earth station applications, constitutes a large part of the United States—will likely experience a worsened interference environment as a result of a full grant of the Third SpaceX Modification. Such an outcome would be inconsistent with both the Commission's well-established *Teledesic* precedent governing treatment and the Commission's public interest standard.²¹

These real-world impacts resulting from any full grant of the Third SpaceX Modification cast doubt on the credibility of SpaceX's previous pronouncements that “[t]here is no incentive for NGSO operators to collocate gateways” and “[g]ateway separation is a very effective way to mitigate interference.”²² As SES/O3b correctly observes, SpaceX has frequently touted the capabilities of its phased array antennas, begging the question of how SpaceX will “provide comparable interference mitigation if it is employing such [parabolic] antennas for Ka-band gateway links.”²³ While OneWeb remains committed to gateway separation as an integral component of NGSO spectrum sharing, a full grant of the SpaceX Third Modification, as shown above, undermines the effectiveness of such efforts.

²⁰ See, e.g., Amazon Sep. 24 Letter; Amazon Feb. 11 Letter; Amazon Feb. 22 Letter.

²¹ *Teledesic LLC*, Order and Authorization, 14 FCC Rcd 2261 ¶ 5 (1999) (explaining that if a modification application “present[ed] significant interference problems” it would be treated “as a newly filed application and [the Commission] would consider the modification application in a subsequent satellite processing round.”).

²² SpaceX Feb. 22 Letter at 20; SpaceX Jan. 19 Letter at 14.

²³ SES Reply at 15.

At bottom, SpaceX has sought authority for what amounts to an entirely new system and proposes to move a vast number of satellites, *i.e.*, 64% of its constellation, to much lower altitudes.²⁴ The analysis contained herein simply confirms an otherwise common sense conclusion—that such a drastic modification stands to fundamentally upend the NGSO interference environment for other co-frequency operators.

* * * * *

For the foregoing reasons, OneWeb respectfully requests the Commission require SpaceX comprehensively address the above-referenced discrepancies concerning previously authorized and operating satellites, the significant interference issues demonstrated above, and that as constituted, the Third SpaceX Modification be processed as part of the Commission's Second Processing Round.

Kindly refer any questions regarding this matter to the undersigned.

Respectfully submitted,

/s/ Brian D. Weimer

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²⁴ See *supra* n. 3.