Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
	)	
Space Exploration Holdings, LLC	)	Call Signs S2983 and S3018
	)	
Application for Modification of	)	File No. SAT-MOD-20181108-00083
Authorization for the SpaceX NGSO	)	
Satellite System	)	

REPLY OF WORLDVU SATELLITES LIMITED

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INTRODUCTION AND SUMMARY

In its Further Opposition, SEH fundamentally fails to address the serious concerns—raised by OneWeb and other interested parties—created by the major changes proposed in the SEH Modification Application.[1] The Commission appears to have recognized some of these very serious concerns by issuing a request for further information to SEH.[2] The Commission is rightly focused on the risk of physical collisions presented by the Modification Application.

Until SEH fully addresses the serious concerns raised by OneWeb, the Commission itself, and all other interested parties, the Commission should withhold grant of the Modification Application. Hasty action by the Commission at this very important juncture in the development of real satellite systems like OneWeb—which successfully launched its first six satellites just last week—and the many existing small satellite constellations could be nothing short of catastrophic.

Notably, no commenter or petitioner has stated or even suggested any level of comfort with the Commission granting the Modification Application in its current form.[3] To the contrary, the record in this proceeding demonstrates widespread industry opposition to SEH's proposed modifications and reinforces OneWeb's prior determination that the Commission should not grant the Modification Application. OneWeb respectfully restates its request that the

[1] *See* Space Exploration Holdings, LLC, Further Consolidated Opposition to Petitions and Response to Comments of Space Exploration Holdings, LLC, IBFS File No. SAT-MOD-20181108-00083 (filed Feb. 21, 2019) ("Further Opposition").

[2] *See* Letter from Jose P. Albuquerque, Chief, Satellite Division, to William M. Wiltshire and Paul Caritj, Counsel to SpaceX, IBFS File No. SAT-MOD-20181108-00083 (Feb. 26, 2019) ("Commission Letter").

[3] *See generally* IBFS File No. SAT-MOD-20181108-00083.

Commission deny the Modification Application or, at a minimum, consider it only within the context of a subsequent NGSO FSS processing round.

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REPLY OF WORLDVU SATELLITES LIMITED

WorldVu Satellites Limited ("OneWeb") submits this reply to the Further Opposition filed by Space Exploration Holdings, LLC ("SEH") and other comments and petitions submitted regarding SEH's application to modify the license for its non-geostationary, fixed-satellite service ("NGSO FSS") system to move 1,584 satellites from an authorized altitude to 550 km and increase *actual* interference to current and future NGSO FSS systems by, among other things, utilizing the Ku-band for both gateway and user links.[4]

I. SEH'S UPDATED INTERFERENCE ANALYSIS IS CRITICALLY FLAWED AND FAILS TO ADDRESS THE SUBSTANTIAL INTERFERENCE CONCERNS RAISED IN THE RECORD

In its Petition to Deny or Defer, OneWeb identified serious analytical flaws inherent to SEH's technical analysis, which incorrectly claimed the Modification Application would not increase interference to other NGSO FSS systems.[5] In the Further Opposition, SEH doubles down on the ill-conceived notion that its original technical analysis—claiming to demonstrate the impact of the Modification Application against a paper constellation[6] not authorized in the current processing rounds—is somehow sufficient to show a lack of increased interference to other co-frequency NGSO FSS systems authorized or under review pursuant to the current NGSO FSS processing round.[7] Nevertheless, SEH grudgingly supplies new analyses of the

[4] *See* Further Opposition.

[5] *See* OneWeb, Petition to Deny or Defer of WorldVu Satellites Limited, IBFS File No. SAT-MOD-20181108-00083, at 2-8 (filed Feb. 8, 2019) ("OneWeb Petition").

[6] IK-NGSO-A10K-1.

[7] *See* Further Opposition at 4.

interference impact to the SES/O3b and OneWeb systems (the "New Interference Analysis") in the Further Opposition.[8]

However, the New Interference Analysis SEH reluctantly pulled together opens up many new issues, including misleading operational assumptions, an incomplete analysis parameter set, and highly misleading conclusions with respect to the interference caused to other NGSO FSS systems.[9] Nothing contained in the New Interference Analysis alters OneWeb's prior conclusion that a grant of the Modification Application will result in increased interference to OneWeb and other NGSO FSS systems.

In its New Interference Analysis, SEH carefully crafts a dubious artificial scenario which is unlikely to occur and unjustifiably biases results in its favor. OneWeb is not the only Ku-band operator to have noticed these severe analytical flaws; Kepler properly concludes SEH's claim that the modification "will cause no additional interference at all" is "not supported by adequate evidence."[10]

This New Interference Analysis is critically flawed for at least two reasons.

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[8] *Id.* at A-1 – A-5.

[9] SEH's continued reliance on *Teledesic* for the proposition that a reduction in satellites and power is on its face evidence of reduced interference is likewise misleading. The Teledesic modification was granted in an environment in which nascent NGSO systems were less advanced and ultimately failed to successfully launch. Today's NGSO interference environment is much more technically complex and includes two operators (O3b and OneWeb) who have launched and placed into orbit components of their authorized systems. The factors recognized in *Teledesic* cannot be solely relied on in determination of whether a modification will present "significant interference" to the current NGSO environment. *See Teledesic LLC*, 14 FCC Rcd. 2261 (IB 1999).

[10] Kepler Communications, Inc., Reply Comments of Kepler Communications, Inc. to Consolidated Opposition of Space Exploration Holdings, LLC, IBFS File No. SAT-MOD-20181108-00083, at 4 (filed Feb. 24, 2019) ("Kepler Reply Comments").

First, in the New Interference Analysis SEH attempts to portray an interference environment in which the absolute I/N values are maximized, claiming this to be a worst-case scenario. SEH appears to misunderstand that the purpose of the required analysis is to identify the worst-case *difference* in I/N statistics between SEH's previously licensed operational envelope and its proposed modified operations. This means the absolute values are irrelevant to the conclusion SEH is straining to demonstrate. In fact, the absolute worst-case method of simulation serves to bias results in favor of SEH.

To illustrate this point, consider a victim earth station (shown as an antenna receive pattern) that can receive interference from four SEH satellites (A, B, C, D) coming from various directions.

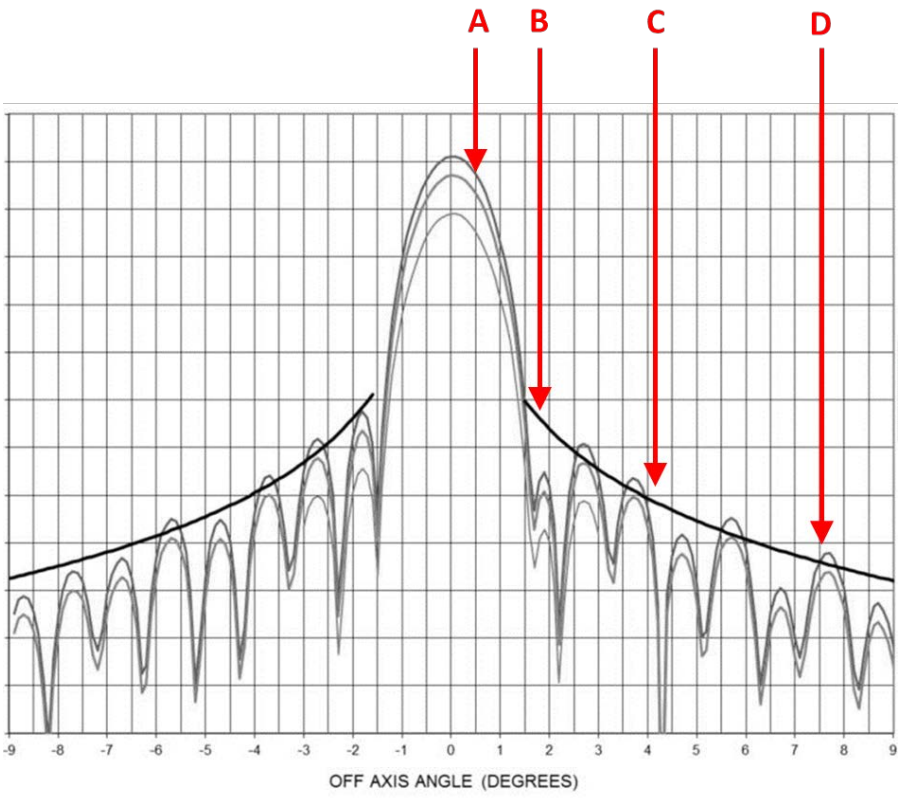

Figure 1: Four simultaneous interfering signals arriving at victim earth station from various angles

The "worst-case" analysis of SEH's licensed operations always chooses the single worst-case link, coming from satellite A, which then results in the highest I/N value at each timestep. Next, consider that in SEH's analysis of its proposed modified operations, the simulation will choose the same worst-case link (A) at this same timestep. However, the simulation will also include three additional links (B, C, D) that, by definition, will have lower I/N values than that of the single worst-case link. The averaging effect (i.e. aggregating each link, but with 6 dB of reduction) of incorporating all four links into each timestep's I/N calculation will always yield a final value that is lower than that of the single worst-case link in the licensed operation. The simulation results thus give the false appearance of less interference in the proposed modified operations than in the licensed operations.

Method	Original License	Proposed Modified Operations	Apparent Result
SEH "worst-case"	I/N from A	Average I/N from A, B, C, D	I/N(Average) < I/N(A) Interference is **decreased**

Figure 2: Simulation I/N calculation at each timestep

SEH's analysis does not accurately reflect their own operations – as they say: "in a real deployment, it is highly unlikely that the SpaceX earth station will transmit to all worst-case satellites with the smallest off-axis sepration [sic] angle from a victim satellite at each time step."[11] If the as-licensed SEH constellation were to actually choose the worst-case link (A) at each timestep, then perhaps the provided analysis would more accurately reflect actual operations. However, the I/N curves show that this method of operation would be impossible because of nearly constant unacceptable interference.

[11] Further Opposition at A-5.

Instead, the Commission should consider the more likely and spectrally efficient scenario where SEH would prefer to choose the link with the lowest I/N in each timestep, depicted as satellite D. In this more realistic scenario, the averaging effect of then including additional I/N values from A, B, and C, as proposed by SEH, will *increase* the actual interference to the OneWeb system.

Method	Original License	Proposed Modified Operations	Apparent Result
SEH "worst-case"	I/N from A	Average I/N from A, B, C, D	I/N(Average) < I/N(A) Interference is **decreased**
More realistic	I/N from D	Average I/N from A, B, C, D	I/N(Average) > I/N(D) Interference is **increased**

Figure 3: Simulation I/N calculation at each timestep

The Commission should recognize that SEH's New Interference Analysis therefore considers only the *best-case* difference in I/N through a painstakingly tailored scenario which will not happen in the real world. A more complete analysis would instead capture the *worst-case* difference in I/N. Thus, SEH's New Interference Analysis fails to substantiate SEH's claim that the "proposed modification will not result in increased interference" to the OneWeb system.[12]

Second, the New Interference Analysis barely scratches the surface of the analyses that SEH should have performed. In alignment with the requests in the Commission Letter, the Commission should request SEH provide a complete interference analysis, consistent with current ITU guidance.[13] For example, such an analysis would include:

[12] Further Opposition at 10.

[13] ITU, *Non-GSO subject to coordination and potential steps for their modifications* (Dec. 8, 2018), https://www.itu.int/en/ITU-R/space/WRS18space/WRS18-Non_GSO_subject_to_CR_and_potential_steps_for_their_mods-06122018.pdf ("[I]t should be explained why [the analysis] leads to worst-case situations so that the analysis based on this assumption guarantees that the I/N levels are not increased by the proposed changes").

- true worst-case differences in I/N, which would represent a better understanding of the true impact of SEH's proposed modifications on the NGSO interference environment. At a minimum, SEH should provide the additional analysis of I/N into OneWeb's smallest user terminals. SEH has only considered I/N into a victim antenna with a gain of 53.6 dB in the Ku-band, which is a five-meter antenna and does not represent the consumer size terminal with which OneWeb will provide service;

- "all or several types of earth stations characterized by their antenna pattern used, maximum gain and noise temperature – one with maximum gain/lowest beam width and another with a minimum gain/highest beam width for a range of different antenna patterns used"[14];

- analyses for additional latitudes, or if providing only one, explain why the chosen latitude represents the worst-case *difference* in I/N value (and not absolute I/N value) which will not be exceeded; and

- I/N curves considering different satellite selection strategies, or if providing only one, explain why the chosen method represents the worst-case *difference* in I/N value (instead of a fabricated case which biases results in SEH's favor, as is currently provided). In the latter case, the selection strategy should then become a condition of any future grant, as any departure from this operation will not have been tested for its interference impact on other NGSO FSS systems.

OneWeb also has concerns stemming from statements by SEH regarding the maximum EIRP of earth stations, number of gateway sites, and number of satellites operating with Ku-band gateways.[15] For example, SEH has not stated that the maximum EIRP level of its gateways will be identical to that of its user terminals. This should be an explicit condition of any future grant of the Modification Application. If SEH's gateway earth stations are permitted to have higher EIRP as a result of the proposed modification, interference into other NGSO FSS systems will increase, rendering the foregoing I/N analyses moot.

OneWeb is not alone in its views on the New Interference Analysis presented by SEH. In the words of Kepler, the New Interference Analysis is "fundamentally misleading" and "do[es]

[14] *Id.*

[15] *See generally* Further Opposition.

not adequately address the interference concerns of the parties."[16] Thus, SEH's new technical analysis does no more to support its modification request than its "patently inadequate" technical showing in the Modification Application.[17] As SEH has utterly failed to demonstrate that its proposed modifications will not increase interference to other NGSO FSS systems, the Modification Application should be denied, or, at a minimum, considered only in a subsequent processing round.

II. THE COMMISSION MUST CAREFULLY EVALUATE THE IMPACT OF SEH'S PROPOSED OPERATIONS AT 550 KM PRIOR TO ANY GRANT OF THE MODIFICATION APPLICATION

In the OneWeb Petition, numerous orbital debris issues were noted related to SEH's proposed relocation of 1,584 satellites from the 1,150 km altitude to the 550 km altitude.[18] SEH cavalierly dismissed OneWeb's concerns, variously characterizing them as "curious," the result of "misconceptions," and "clutch[ing] at…threads."[19] Notably, the Commission appears to share OneWeb's concerns, as evidenced by the recent request for information sent to SEH regarding the Modification Application.[20] The Commission's request touches on many of the issues highlighted in the OneWeb Petition.

In particular, the OneWeb Petition pointed out the apparent orbital stasis of SEH's experimental satellites.[21] SEH responded that leaving these satellites at the 550 km orbit was a

[16] Kepler Reply Comments at 7.

[17] SES Americom, Inc. and O3b Limited, Comments of SES Americom and O3b Limited, IBFS File No. SAT-MOD-20181108-00083, at 2 (filed Feb. 8, 2019).

[18] *See* OneWeb Petition at 12-22.

[19] Further Opposition at 11-12, 14.

[20] *See* Commission Letter.

[21] *See* OneWeb Petition at 14.

"conscious decision" that ultimately "validated" SEH's technology.[22] However, OneWeb agrees with the Commission that SEH must update the Modification Application with a collision risk assessment "assuming a propulsion or other system failure that renders the satellite incapable of collision avoidance immediately following orbital injection."[23] This is precisely the kind of information that OneWeb and other operators (in particular, the small satellite community) need to review and assess in order to provide comments prior to any further Commission action on the Modification Application.[24]

Similarly, SEH brushed aside OneWeb's concern about SEH's troubling casualty risk profile.[25] Yet the Commission has further inquired about SEH's controlled re-entry capabilities and casualty risk, as well as their potential effects on human populations.[26] OneWeb commends the Commission for seeking this information and respectfully reserves the right to provide further comments subsequent to any responsive submission by SEH.

OneWeb agrees with other petitioners in this proceeding that critical questions regarding the impact of the Modification Application on the orbital environment remain unanswered. Any

[22] Further Opposition at 12-13. OneWeb notes that if this was a conscious decision, it is curious that SEH did not notify the Commission of such a drastic change in its mission parameters.

[23] Commission Letter at 1.

[24] The CSSMA Joint Reply details how CSSMA requests an SEH "collision risk analysis" that "demonstrates that SpaceX's commitment to assume the burden of conducting collision avoidance maneuvers is operationally practical and credible." Commercial Smallsat Spectrum Management Association, Joint Reply, IBFS File No. SAT-MOD-20181108-00083, at 2 (filed Feb. 22, 2019).

[25] *See* Further Opposition at 14.

[26] *See* Commission Letter at 1 (asking SEH to describe whether "the proposed satellites are capable of a controlled re-entry, i.e., re-entry specifically and reliably targeted at broad ocean areas, away from human populations").

consideration of the Modification Application by the Commission before these issues are resolved would be premature.

III. SEH'S SCANT SUPPORT FOR ITS REQUEST FOR A WAIVER OF THE EPFD VALIDATION REQUIREMENT REMAINS UNCONVINCING AND FAILS TO SATISFY THE COMMISSION'S STANDARD FOR GRANTING A RULE WAIVER

In the Further Opposition, SEH fails to provide a compelling justification for why its request for a waiver of the ITU EPFD validation requirement should be granted. SEH does not adequately address the importance of the ITU performing its compliance verification and the troubling precedent that granting the SEH waiver request would set. OneWeb successfully obtained a favorable finding for its EPFD compliance prior to commencing launch of its NGSO FSS constellation; there is no reason SEH should be entitled to bypass this process. As such, SEH's waiver request should be denied.

A. SEH Has Failed to Adequately Provide its EPFD Validation Files for Verification

In the Further Opposition, SEH claims that it provided the input data files used for an EPFD analysis of its modified constellation.[27] SEH also suggests OneWeb may have "simply overlooked" the inclusion of these files.[28] It appears the EPFD input files SEH references are currently not available in IBFS.[29] Setting aside the unavailability of the EPFD input files, SEH once again provides no justification for its waiver request aside from the desire for an "expedited

[27] *See* Further Opposition at 17.

[28] *Id.*

[29] The Commission should include a request for these EPFD input files into any subsequent request for information from SEH.

deployment schedule."[30] SEH plainly fails to satisfy the Commission's well-established waiver standard, and its request for waiver of the EPFD compliance requirement should be denied.

B. Launch of SEH's System Without an ITU "Favorable" or "Qualified Favorable" Finding Would Undermine the ITU Review Process

The Further Opposition relies on a series of sleights-of-hand and equivocations to obfuscate the importance of the EPFD validation requirements that SEH is attempting to bypass. The OneWeb Petition details how Section 25.146(c)'s requirement that NGSO FSS licensees receive a "favorable" or "qualified favorable" finding by the ITU Radiocommunication Bureau regarding compliance with EPFD limits is the only substantive emission assessment that NGSO FSS systems must undergo before launch and operation.[31]

Contrary to SEH's assertion, OneWeb does not question the Commission's competency to substantively review EPFD compliance; OneWeb merely points out that such review is no longer a part of the Commission's rules. Because the Commission eliminated this review, granting SEH a waiver of the ITU validation requirement would set a troubling precedent for the FSS environment going forward.

Waiver of this condition would harmfully relegate EPFD compliance to a post hoc obstacle that NGSO FSS operators must address, potentially *after* they have begun launching and operating their constellations. This potential abdication of any role for *either* the Commission or the ITU is simply not in the public interest and, as OneWeb explained in the OneWeb Petition,

[30] Further Opposition at 17.

[31] *See* 47 C.F.R. § 25.146(c); OneWeb Petition at 23.

could jeopardize both NGSO and GSO operations.[32] As SEH itself has stated, "waivers cannot come at the expense of other licensed NGSO systems."[33]

SEH attempts to minimize the troubling precedent a grant of its waiver request would set by highlighting various half-measures and self-determinations. For instance, SEH notes that it "recognizes that it must comply with the ITU's EPFD limits" and "has certified that its constellation (as modified) will do so,"[34] yet fails to address the very real need for the ITU to conduct the analysis necessary to complete certification *by the ITU*, not by SEH. If SEH's waiver request is granted, it would effectively be held to a standard of compliance centered on self-certification—a standard that should then apply to all NGSO FSS systems. Likewise, SEH stresses the similarity of the EPFD compliance proposed in its Modification Application to that of its licensed constellation.[35] However, the ITU's EPFD compliance verification of SEH's *licensed* constellation is irrelevant to OneWeb's concerns regarding SEH's attempt to bypass ITU certification of the EPFD compliance for SEH's *modified* constellation.

The Commission may waive application of its rules for "good cause shown" or if waiver would "better serve the public interest."[36] As the GSO Satellite Operators have noted, SEH's "expedient deployment should not be valued over the assurance of a safe operational

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[32] *See* OneWeb Petition at 24.

[33] Space Exploration Holdings, LLC, Reply of Space Exploration Holdings, LLC, IBFS File Nos. SAT-LOA-20170301-00028, SAT-AMD-20170929-00137, SAT-AMD-20180131-00013, at 4 (filed Mar. 4, 2019).

[34] Further Opposition at 18.

[35] *Id*. at 17.

[36] 47 C.F.R. § 1.3; *GE American Communications, Inc.*, 16 FCC Rcd 11038, 11041 ¶ 9 (IB 2001).

environment for all satellite operators."[37] SEH has failed to provide the justification necessary for the Commission to grant its waiver request because it has not shown that bypassing ITU validation requirements would serve the public interest better than enforcement of the Commission's recently relaxed rule regarding EPFD compliance.[38]

Without seeking a waiver from the Commission, OneWeb sought and received a favorable rating for ITU compliance well in advance of the momentous launch of OneWeb's first production satellites last week. Meanwhile, SEH's paper-thin justification for its waiver request continues to fall far short of the Commission's waiver standard. Thus, SEH's waiver request is not in the public interest and should be denied.

IV. CONCLUSION

As demonstrated above, the Further Opposition fails to resolve OneWeb's fundamental concerns about SEH's proposed modifications causing increased RF interference to other NGSO FSS systems and the potentially serious consequences with respect to the generation of space debris. These concerns are particularly justified given the significant impact SEH's proposed satellite system could have on the satellite systems currently in orbit, including OneWeb, and the systems of other operators opposed to the Modification Application. Presently, these concerns remain unaddressed and unresolved, and a Commission request to SEH for additional information regarding the Modification Application remains outstanding. Therefore, OneWeb restates its request that the Commission deny the Modification Application or defer any consideration until a subsequent processing round is initiated.

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[37] GSO Satellite Operators, Reply of EchoStar Satellite Operating Corporation, Hughes Network Systems, LLC, and Intelsat License LLC, IBFS File No. SAT-MOD-20181108-00083, at 4 (filed Mar. 5, 2019).

[38] *See* 47 C.F.R. § 25.146.

Respectfully submitted,

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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 Reply of WorldVu Satellites Limited, 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.

Date: March 5, 2019

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CERTIFICATE OF SERVICE

I, Samuel Swoyer, hereby certify that on this 5th day of March 2019, a copy of this Reply of WorldVu Satellites Limited is being sent via first class, U.S. Mail, postage paid, to the following:

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