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	)	

PETITION TO DENY OR DEFER OF WORLDVU SATELLITES LIMITED

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INTRODUCTION AND SUMMARY

In the Modification Application, SEH seeks authority to fundamentally change the orbital configuration and spectrum architecture of its planned NGSO constellation to the significant detriment of other NGSO FSS systems in the Commission's ongoing processing rounds. OneWeb fully supports efforts by NGSO operators to improve and even add to their constellations, including efforts to reduce the potential safety risk to the OneWeb constellation which begins launching this month. However, OneWeb does not support proposed changes that cause drastic increases of interference to other NGSO systems, create new unconsidered risks to the orbital environment, and seek to evade the sole remaining EPFD compliance validation.

OneWeb has built an entire satellite supply chain as well as a state-of-the-art factory in Exploration Park, Florida. This month, Arianespace will begin the launch of OneWeb's first production satellites. It would be patently unjust to allow SEH to increase interference into the OneWeb system—the applicant who initiated the current NGSO processing round—at the precise moment it is about to commence in-orbit operations.

The Commission must not allow SEH to utilize the Ku-band for hundreds of new gateways across the United States, and the Commission should carefully review the potential space debris implications of putting such a massive NGSO system approximately 150 km above the International Space Station. OneWeb reminds the Commission that, while SEH has repeatedly emphasized the reliability of its proposed system, neither of SEH's first two experimental satellites appear to have operated as SEH anticipated.

In particular, OneWeb has significant concerns about the impact of the following changes proposed in the Modification Application:

- **Interference Caused By the Use of the Ku-band for Gateway Links.** SEH's entirely new proposal to add hundreds of new Ku-band gateway links dramatically alters the NGSO sharing environment and is likely to significantly increase interference to other NGSO

operators. SEH's flawed technical analysis—purporting to show a lack of impact to other NGSO constellations—provides no assurance that the change in spectrum architecture will not increase interference to other constellations. To the contrary, OneWeb's own assessment (provided in Section I below) demonstrates that use of the Ku-band for gateway links in addition to user links will negatively impact the NGSO sharing environment. On this basis alone, the Commission should deny the Modification Application or defer its consideration to a subsequent NGSO processing round. Any grant of the Modification Application should be on the condition that SEH accept all additional interference received as a result of the Modification Application.

- **Spacecraft and De-Orbit Reliability at 550 km Orbital Altitude**. OneWeb commends SEH's recognition of the inherent benefits in relocating a substantial portion of its constellation to an orbital altitude that reduces the potential for overlap with other large NGSO constellations. However, the Commission must ensure that SEH's push for a "faster pace of deployment with a simplified design" does not result in the 550 km altitude, just above the International Space Station, becoming a test-bed for large numbers of spacecraft that (i) lack many of the design features previously advertised by SEH for inclusion in its first-generation constellation and (ii) raise critical questions regarding their potential maneuverability.

- **Non-Compliance with Applicable EPFD Requirements**. SEH seeks a waiver of the Commission's recently relaxed EPFD requirements in order to initiate service prior to receiving a "favorable" or "qualified favorable" finding from the ITU. As the ITU is the only remaining bulwark to ensuring compliance with relevant EPFD standards, the Commission should deny SEH's waiver request and ensure that both GSO and NGSO operators are not disadvantaged by SEH's potentially non-compliant operations.

Until SEH successfully resolves these significant concerns, the Commission should deny the Modification Application or defer its consideration until a subsequent NGSO processing round is underway.

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WorldVu Satellites Limited ("OneWeb"), pursuant to Section 25.154(a) of the rules of the Federal Communications Commission (the "Commission") and the Commission's recent public notice,[1] submits this Petition to Deny or Defer the Application ("Modification Application") of Space Exploration Holdings, LLC ("SEH") for authority to modify the license for its low-Earth orbit ("LEO") non-geostationary orbit ("NGSO") satellite system in the fixed satellite service ("FSS").[2]

I. SEH'S PROPOSED USE OF THE KU-BAND FOR GATEWAY LINKS CONSTITUTES A FUNDAMENTAL CHANGE IN SPECTRUM ARCHITECTURE THAT WILL INCREASE INTERFERENCE AND MUST BE CONSIDERED IN A SUBSEQUENT NGSO PROCESSING ROUND

SEH's request to utilize the Ku-band for both user *and* gateway links will introduce significant interference and uncertainty into the NGSO operating environment at the precise moment some NGSO systems are on the cusp of launching their constellations and commencing commercial operations. SEH's conclusion that its modified NGSO FSS system would not cause increased interference is based on a glaringly incomplete and flawed analysis of the NGSO spectrum sharing environment. Consistent with the applicable standard for evaluating license

[1] *See* 47 C.F.R. § 25.154(a); *Satellite Policy Branch Info.; Space Station Applications Accepted for Filing*, Public Notice, Report No. SAT-01364, 2018 FCC LEXIS 3436 at *2 (Dec. 14, 2018). Due to the Commission's lapse in funding occurring on January 2, 2019, these comments are submitted in accordance with guidance in the most recent public notice containing instructions for parties filing comments or petitions that were otherwise due during the government shutdown. *See Revisions to Filing and Other Deadlines Following Resumption of Normal Commission Operations*, Public Notice, DA 19-26, at 2 (Jan. 29, 2019) (extending the filing deadlines for submissions due between January 8 and February 7 during the suspension of operations to February 8, 2019).

[2] *See Space Exploration Holdings, LLC; Application For Approval for Orbital Deployment and Operating Authority for the SpaceX NGSO Satellite System; Application For Approval For Orbital Deployment And Operating Authority for the SpaceX NGSO Satellite System Supplement*, Memorandum Opinion, Order and Authorization, 33 FCC Rcd 3391 (2018) ("SEH Grant").

modification applications, the Commission should deny the Modification Application until these issues are resolved, or at least defer consideration to a subsequent NGSO processing round. The Commission should ensure that any grant of the Modification Application mandates that SEH—not other NGSO FSS operators—must accept all additional interference received as a result of the Modification Application.

A. The Technical Analysis Provided by SEH to Justify Its Use of the Ku-Band for Gateway Connectivity Is Critically Flawed

In the Modification Application and accompanying Technical Attachment ("Technical Attachment"), SEH asserts that its planned constellation changes "will not degrade the interference environment for other NGSOs" or "increase interference to any other NGSO system operating in the bands used by SEH satellites."[3] These erroneous conclusions reflect a critically flawed analysis for at least three reasons.

First, SEH attempts to defend its non-interference claim by quantifying the I/N statistics from its system into another NGSO FSS system, both for downlink and uplink cases.[4] These assessments are flawed from the outset because SEH places only one co-frequency beam per spot in the downlink analysis and only one co-frequency earth station per spot in the uplink analysis.[5] However, SEH states that "up to four satellites can beam co-frequency transmissions to a gateway location."[6] OneWeb acknowledges that SEH has assured the Commission it will

[3] Modification Application at iii; Attachment A, Technical Information to Supplement Schedule S, IBFS File No. SAT-MOD-20181108-00083, at 24 ("Technical Attachment").

[4] *See* Technical Attachment at 25-37.

[5] *Id*. at 26.

[6] *Id*. at n. 8.

operate its initial deployment of 1,584 satellites at lower EIRP levels such that the aggregate PFD at a gateway location is held constant.[7] Yet SEH fails to even consider that PFD at the gateway location would be in *addition* to that of a Ku-band user beam.[8]

To correct these analytical deficiencies, SEH must consider five beams transmitting to a single location and, correspondingly, five simultaneous uplinks from one point to five different satellites. The net result of such analyses would show a long-term interference power increase of 3 dB for the downlink (*i.e.*, an aggregation of four gateway beams + one user beam). With this new architecture, the probability of occurrence of in-line events would increase because the number of interference-causing in-line geometries increases with the number of simultaneous links to or from a single point. The proposed initial deployment, in which SEH would deploy 1,584 satellites and change its use of Ku-band from only user links to both user and gateway links, would result in a near *five-fold increase* in the probability of in-line interference events—this increase is omitted in SEH's Technical Attachment. For the uplink, SEH offers no similar reduction in EIRP density from its transmitting earth stations, resulting in an increase of long-term interference into other NGSO satellites of at least 7 dB. A more accurately representative assessment illustrating the significant interference that will be caused by SEH's proposed modifications is included in Section I.B below.

Second, SEH provides comparative interference statistics for only a single medium-Earth orbit ("MEO") victim NGSO constellation.[9] Notably, SEH provides no analysis assessing the

[7] *See id.*; Modification Application at 11.

[8] OneWeb assumes SEH's gateways run 100% of the time as feeder capacity, in contrast to user links which can utilize TDM and satellite diversity without impacting user experience.

[9] *See* Technical Attachment at 27-37 (comparing the modified SEH system to the IK-NGSO-A10K-1 network operating at 10,355 km).

interference potential of its modified spectrum architecture into any of the other numerous real-world victim NGSO FSS systems that have been proposed in the processing rounds or authorized by the Commission. This omission is particularly surprising in light of SEH's prior insistence that assertions of no-interference must be accompanied by "an analysis to support that assertion" or "detailed technical information needed for an analysis to validate" such an assertion.[10] OneWeb's assessment shows that many of the other NGSO FSS systems are likely to experience increased interference resulting from SEH's proposed modification. The SEH analysis purporting to demonstrate non-interference to other NGSO FSS systems, while relying on results from only one other NGSO system that is neither LEO nor even in the current Ku-band processing round, is not remotely conclusive evidence that interference will not increase to other NGSO systems such as OneWeb's.

Third, SEH's claim that I/N results over 0 dB are irrelevant for comparison because "any interference above that level would effectively preclude operations in the absence of some mitigation strategies" is factually inaccurate.[11] Depending on carrier signal strength and the periodicity and duration of interference, I/N values of several dB above 0 can be managed. The Commission should not neglect interference values below at least +10 dB in such comparisons. SEH's analysis should have included such values, which are necessary for OneWeb and other NGSO operators to fully analyze the interference impact of the modified SEH system.

Simply put, SEH's conclusion that its proposed modifications to its spectrum architecture will not increase interference to other relevant NGSO systems is unsupported by its own

[10] *See* Comments of Space Exploration Holdings, LLC, IBFS File No. SAT-MOD-20180319-00022, at ii (filed July 30, 2018) ("SEH Comments on OneWeb Modification Application").

[11] Technical Attachment at n. 24.

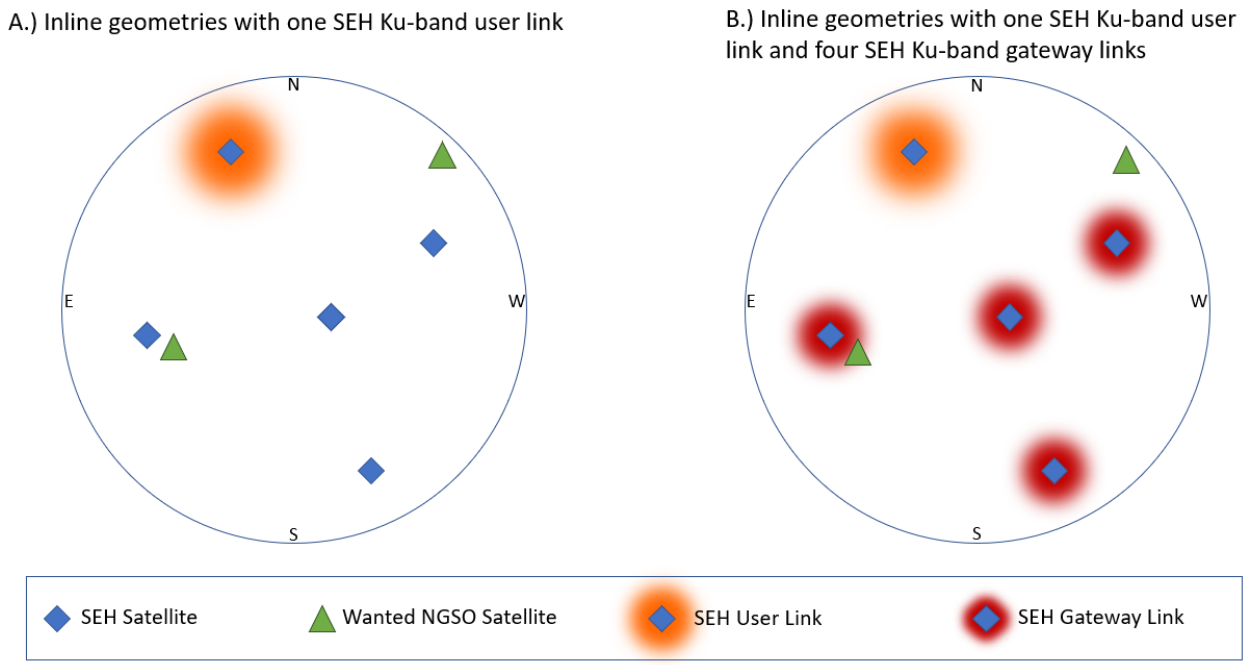
technical analysis. To the contrary, SEH's analysis selectively portrays an NGSO system that, upon closer review, will significantly increase the interference to other co-frequency NGSO systems.

B. OneWeb's Assessment Demonstrates That Numerous Other NGSO FSS Systems Will Experience Interference As a Result of SEH's Proposed Modification

In the absence of a more rigorous analysis from SEH that addresses interference to other co-frequency, NGSO systems proposed in the current processing round, OneWeb developed its own assessment to demonstrate the impacts of the modified SEH system on the NGSO interference environment.

The figures below depict a view of the sky, looking upward from an SEH earth station on the ground, collocated with another NGSO system's earth station. In the sky at this moment in time are five SEH satellites (shown by blue diamonds) and two NGSO satellites of another system (shown by green triangles and labeled "Wanted NGSO Satellite"). The positions of the various satellites are randomly chosen for purpose of this illustration of the problem.

The first graphic (Case A on the left) depicts the interfering signal from the SEH system before SEH's proposed modification. There is only one SEH satellite that is transmitting in Ku-band toward the earth station in this instant, shown with an orange glow. This is because, prior to its proposed system modification, SEH intended to use the Ku-band only for service links. If the other ("wanted") NGSO system pointed its earth station in the direction of this orange glow, it would receive unacceptable interference from SEH. At this moment, however, the angular separation between the single SEH satellite (with the orange glow) and both of the two wanted NGSO satellites means that the wanted NGSO earth station should have no difficulty receiving transmissions from either of the two wanted NGSO satellites.

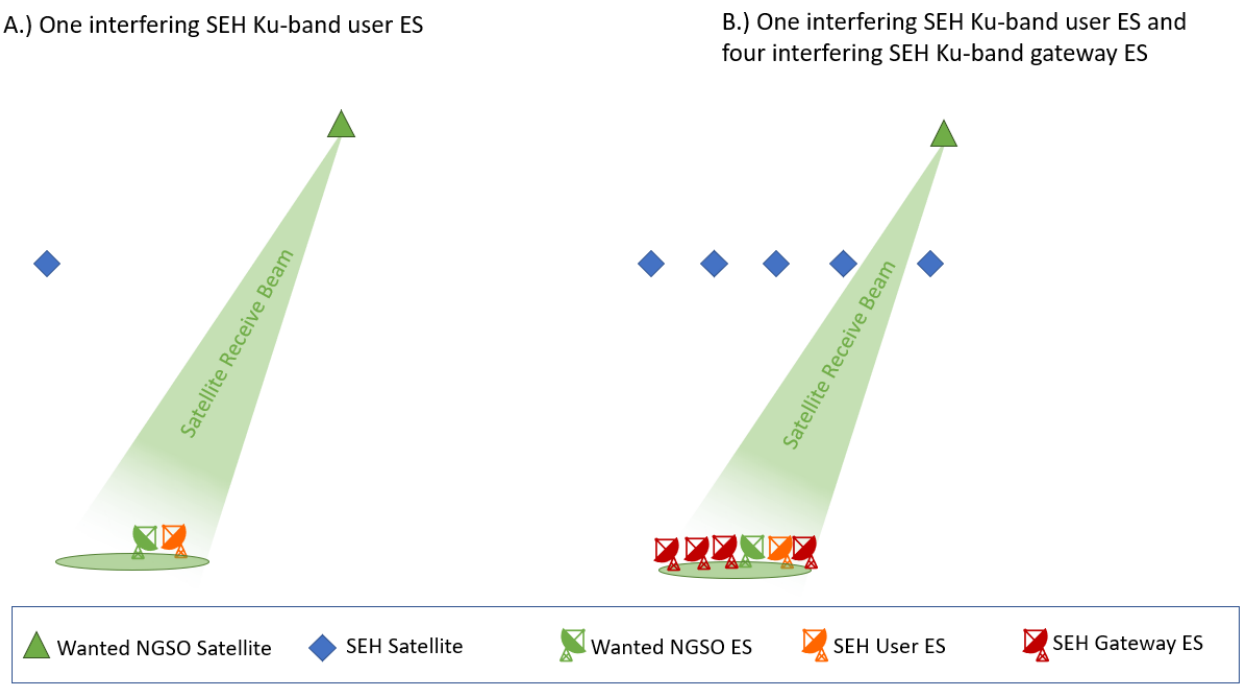


The second graphic (Case B on the right) depicts the interfering signals from the SEH NGSO system after the proposed modification to multiply the number of interfering space stations by five. Instead of only a single SEH satellite using the Ku-band for a user link, there are now four additional satellites that are also using the Ku-band for gateway links to this same Earth location. As demonstrated in Case B, SEH's proposed modification will greatly increase the area of the sky that is inaccessible to other NGSO systems due to interfering signals from SEH. Although SEH does commit to decreasing the EIRP of each gateway downlink by up to 6 dB, this does not mitigate the near 500% increase in the probability of in-line events causing *actual*—not potential—harmful interference.[12] Additionally, in the depicted moment for Case B, instead of having two satellite options for communications, the other NGSO system would only have a single satellite option available to its wanted earth station. Moreover, this single option has increased interference relative to Case A because of two factors: reduced angular separation

[12] Technical Attachment at n. 8.

from the nearest interfering SEH satellite (which may or may not be offset by SEH's promised EIRP reduction) and the aggregation of both user and gateway interfering signals from the multiple SEH satellites in view. In this specific example, the only available communications option for the other NGSO system is also at a lower elevation angle and thus may result in a lower carrier signal in addition to the increased interference.

SEH's proposed modification is fundamentally different than simply adding more satellites or changing orbits, which might alter the *potential* for interference one way or the other via intelligent utilization of geometric link diversity. Instead, this modification results in *actual* higher interference levels and a more difficult sharing environment because additional SEH satellites are communicating with the same point on the Earth. An additional illustration of the problem is depicted in the figures below, showing a wanted NGSO satellite (shown by the green triangle) pointing its receiving beam towards collocated earth stations from both the wanted NGSO system and the SEH system. In Case A, there is only one interfering earth station from the SEH system within the wanted receive beam. Assuming there is ample angular separation between the pointing directions of each earth station, spectrum sharing should be possible between the two NGSO systems.



Case B depicts a similar scenario but considers and illustrates the proposed SEH modification. In this case, there are now five times as many interfering SEH earth stations in the wanted receive beam. Even if all of the SEH earth stations were able to maintain large exclusion angles from the wanted NGSO satellite, the additional SEH earth stations would create a minimum of a 7 dB increase in long-term interference to the wanted uplink. A more likely outcome is that the maintenance of five simultaneous uplinks will result in geometries with reduced angular exclusion, thus creating higher power levels associated with shorter-term interference events.

Critically, SEH provides no analysis whatsoever to quantify the interference effects of its proposed use of Ku-band for gateway links. Instead, the SEH analysis models the interference of only a single SEH link. Unlike SEH's analysis, the foregoing assessment presents a more complete and representative illustration of the significant harmful interference impact of the proposed SEH modification on co-frequency NGSO FSS systems.

C. The Increased Interference That Will Result from SEH's Proposed Modification Mandates Consideration Only in a Subsequent NGSO Processing Round

The standard for granting license modification applications reflects a "flexible approach" by the Commission.[13] As SEH has previously stated, "[t]he legal standard for the Commission to favorably consider a modification request is admittedly quite lenient."[14] However, the Commission has repeatedly stated that this flexible approach does not extend to applications that present significant interference concerns.[15] In cases where an application presents "significant interference problems," the Commission has stated it will "treat the modification as a newly filed application and would consider the modification application in a subsequent processing round."[16] This is precisely the dynamic presented by the Modification Application. As demonstrated above, the Modification Application presents significant interference problems and the Commission should, consistent with its well-established framework for addressing such applications, deny the Modification Application or at least defer its consideration to a subsequent processing round.

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[13] *See* 47 C.F.R. § 25.117(d)(2) (stating modifications will be granted except where such a grant would make the applicant unqualified to hold a space station license or the grant would not serve the public interest); *Teledesic, LLC*, Order and Authorization, 14 FCC Rcd 2261, 2263 ¶¶ 5, 12 (IB 1999) ("*Teledesic*").

[14] SEH Comments on OneWeb Modification Application at 13-14.

[15] *See, e.g., Boeing Co.*, Order and Authorization, 18 FCC Rcd 12317, 12319 ¶ 7 (IB & OET 2003) ("the Bureau has granted [modification applications] in cases where the proposed modification presents no significant interference problem and is otherwise consistent with Commission policies."); *DigitalGlobe, Inc.*, Order and Authorization, 20 FCC Rcd 15696, 15700 ¶ 9 (2005) (reaffirming that "[i]f a proposal will not cause interference to other licensed operations, the Commission generally authorizes it if it is otherwise in the public interest").

[16] *Teledesic*, 14 FCC Rcd at 2264, ¶ 5.

OneWeb notes SEH has previously extolled the virtues of deferring modifications alleged to present significant interference problems to a subsequent processing round, describing such an approach as a "basic tenant of the Commission's rules" that "safeguard[s] the processing-round regime."[17] OneWeb agrees with SEH that consideration of these kinds of modification applications in a subsequent round is the most appropriate result, especially when SEH is proposing to significantly increase the NGSO interference environment—long after other operators have made substantial investments of time and capital to develop their systems. SEH offers a variety of unsupported arguments in an attempt to avoid this result. None of these arguments are compelling, and each should be rejected by the Commission.

SEH initially argues the Modification Application "would not present a significant interference problem" because it is only slightly reducing the number of satellites and decreasing the orbital altitude of its initial deployment of 1,584 satellites.[18] SEH claims this lower operational altitude will result in "fewer [satellites] visible above the minimum elevation angle at any particular time period throughout the United States" and notes "[t]his is a factor that the Commission has previously recognized as demonstrating that a modification will not increase interference to other NGSO systems."[19] SEH's conclusions are baseless because its proposed system is multiplying the number of active links as well as increasing the utilization ratio of

[17] SEH Comments on OneWeb Modification Application at 5.

[18] Waiver Requests, IBFS File No. SAT-MOD-20181108-00083, at 2 (**"**Modification Application, Waiver Requests").

[19] *Id*.

those links to and from certain Earth locations, which will result in significantly increased levels of interference to other NGSO systems.

SEH also touts the ability of its satellites "to transmit and receive at lower EIRP levels."[20] This apparent commitment to reduce EIRP for its new gateway links is similarly misleading. As demonstrated in Section I.A above, SEH fails to consider that even if the aggregate PFD from the SEH gateway links at a gateway location is held constant, this would be in *addition* to the PFD generated by a Ku-band user beam. SEH additionally states that its Technical Attachment confirms that "these and other attributes of the proposed modification" will ensure the Modification Application does not increase interference compared to the previously authorized SEH system.[21] There may be other secret "attributes" of which OneWeb is unaware, but the system design SEH presents in the Modification Application will substantially increase interference to other NGSO operators. Regardless of what these other attributes might be, it is extremely unlikely they will be capable of mitigating the significant additional interference caused by SEH's proposed use of the Ku-band for both gateway and user links. As described in Sections I.A and I.B above, these proposed modifications will result in the satellites of other NGSO constellations experiencing increased in-line events causing *actual* interference to their networks.

SEH repeatedly characterizes these proposed fundamental changes to its spectrum architecture as "modest modification[s]."[22] These changes are anything but "modest." To the contrary, they constitute a whole cloth new system with new link dynamics and interference

[20] *Id*. at 3.

[21] *Id*.

[22] *See* Modification Application at i, ii, and 9.

characteristics. OneWeb's assessment demonstrates the Modification Application will result in other NGSO systems experiencing increased interference. As such, SEH's request for a waiver of the processing round requirements should be denied and consideration of the Modification Application should be denied or deferred until the Commission initiates a subsequent NGSO processing round. At a minimum, the Commission should condition any grant of the Modification Application on SEH's acceptance of all interference created by its proposed spectrum architecture changes.

II. SEH'S PROPOSED OPERATIONS AT AN ORBITAL ALTITUDE OF 550 KM PRESENT SIGNIFICANT ORBITAL DEBRIS CONCERNS

OneWeb commends SEH for its proposal to relocate its initial deployment of 1,584 satellites to create greater orbital separation from other NGSO FSS constellations. As SEH correctly points out, a 550 km orbital altitude "will bring the additional benefit of increasing the space" between large NGSO constellations.[23] The Commission should encourage SEH to continue to assess the potential for relocating the rest of its planned constellation to orbital altitudes more suitable to accommodate several thousand spacecraft.

However, SEH's proposed operations at 550 km are not a panacea for the significant orbital debris issues that SEH's proposed constellation continues to present. This planned initial deployment of 1,584 satellites at 550 km raises several other concerns that must be addressed prior to any grant of the Modification Application. Specifically, the Commission must not allow the 550 km altitude to become a test-bed for SEH's apparently fluid system design. Moreover, in

[23] Technical Attachment at 43.

light of the principles espoused in the current Orbital Debris Notice of Proposed Rulemaking,[24] the Commission must ensure SEH's first-generation spacecraft satisfy appropriate and verifiable reliability standards. Finally, at this time, the Commission should not determine that SEH's "revised" orbital debris mitigation plan satisfies its original license conditions, or the Commission should at least refrain from doing so until the Orbital Debris NPRM proceeding is concluded.

A. The Commission Must Seek More Information from SEH Regarding Its Proposed Operations at 550 km

SEH touts the virtues of relocating its initial spacecraft operations to 550 km, arguing that this relocation will "ensur[e] that any orbital debris will quickly re-enter and demise in the atmosphere" because of the "[s]elf-cleaning" nature of this orbit. [25] SEH claims this proposed change is the result of a "rigorous, integrated, and iterative" process, including insights gained from its operation of two experimental satellites, Microsats 2A and 2B.[26] OneWeb agrees that proposing constellation changes to facilitate the expedited disposal of non-functional or end-of-life spacecraft is consistent with principles of responsible orbital stewardship. However, SEH's proposed operations at 550 km present unique and troubling issues that must be addressed prior to any grant of the Modification Application.

As an initial matter, the Commission and other NGSO operators must be provided more information regarding the propulsive capabilities and maneuverability of Microsats 2A and 2B,

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[24] *See generally Mitigation of Orbital Debris in the New Space Age, et al., Notice of Proposed Rulemaking and Order on Reconsideration*, IB Dkt. No. 18-313, FCC 18-159 (2018) ("Orbital Debris NPRM").

[25] Modification Application at iii; Technical Attachment at 38.

[26] Technical Attachment at 1, 38.

the operation of which SEH confidently describes as both a "successful demonstration" and a "major step forward."[27] In the experimental license application seeking authority to launch and operate Microsats 2A and 2B, SEH stated that "[a]fter insertion [at 514 km], the satellite orbits will be raised to the desired mission altitude of 1125 km circular."[28] In further correspondence with the Commission, SEH expressed its intention to "engage in orbit-raising maneuvers until the spacecraft reach a circular orbit at an altitude of 1,125 km" after initial operations were performed.[29] Based on publicly available information, it appears these experimental satellites were never raised to an operational altitude of 1,125 km.[30]

OneWeb appreciates that in-orbit failures and anomalies are not uncommon in the satellite industry. However, OneWeb highlights these potential operational setbacks because of the potential operational challenges they portend in light of SEH's plan to kick-start the

[27] Modification Application at 3-4.

[28] *See* ELS File No. 0298-EX-CN-2016, Call Sign WI2XTA, *Appendix A, Question 7 Narrative, rev. 2* at 1. SEH later clarified that initial operations of Microsats 2A and 2B would be conducted at 511 km. *See* Letter from Patricia Cooper, Vice President of Government Affairs, SpaceX, to Walter Johnston, Chief, Electromagnetic Compatibility Division, OET at 1 (Feb. 1, 2018) ("Cooper Letter").

[29] Cooper Letter at 1.

[30] *See* CALSKY, https://www.calsky.com/observer/satorbit.cgi?file=43216.png&lang=en (history of Microsat 2A's orbital profile) (last visited Feb. 8, 2019) and CALSKY, https://www.calsky.com/observer/satorbit.cgi?file=43217.png&lang=en (history of Microsat 2B's orbital profile) (last visited Feb. 8, 2019). *See also* Michael Koziol, *SpaceX Confident About Its Starlink Constellation for Satellite Internet; Others, Not So Much,* IEEE SPECTRUM (Jan. 6, 2019, 3:00 PM), https://spectrum.ieee.org/aerospace/satellites/spacex-confident-about-its-starlink-constellation-for-satellite-internet-others-not-so-much ("After launch, Tintin A and B were supposed to propel themselves from their initial orbital altitude of 511 kilometers to their final operational orbit of 1,125 km. But the satellites remained in their initial orbits; SpaceX has never been clear about why.").

deployment of its NGSO system. The Modification Application is sprinkled with references to SEH's "iterative culture," "rapid innovation," and "approach of rapid design, manufacturing, and test iteration."[31] Potentially as a result of this increased focus on speed to orbit, it is notable that SEH's initial deployment of 1,584 satellites proposes early iterations of satellites with no inter-satellite links, no Ka-band capabilities, and different reaction wheels from future designs.[32] While SEH's rapid iteration philosophy may have served it well in the development of its launch vehicles (which return to Earth very quickly), this "test and discard" approach may not be as well suited to the crowded LEO operating environment where spacecraft can linger for years. The Commission should not allow the LEO environment above the International Space Station to be a "move fast and fail often" test-bed for spacecraft design. Careful observance of in-orbit spacecraft control, collision avoidance, and disposal reliability is required. To do otherwise would be to force other operators to accept serious risk in order to accommodate SEH's self-described "aggressive constellation deployment schedule."[33]

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[31] *See, e.g.,* Modification Application at 4, 5. *See also* Eric M. Johnson, Joey Roulette, *Musk shakes up SpaceX in race to make satellite launch window: sources*, REUTERS (Oct. 31, 2018, 1:05 AM), https://www.reuters.com/article/us-spacex-starlink-insight/musk-shakes-up-spacex-in-race-to-make-satellite-launch-window-sources-idUSKCN1N50FC ("Rajeev wanted three more iterations of test satellites," one of the sources said. "Elon thinks we can do the job with cheaper and simpler satellites, sooner.").

[32] *See* Technical Attachment at 46. This is particularly interesting in light of SEH's prior unfounded criticism of modification applications that allegedly offered no "technological improvements." *See, e.g.,* SEH Comments on OneWeb Modification Application at iii ("OneWeb proposes to 'modify' its current license to add well more than a thousand satellites without proposing any technological improvements to those satellites, simply many more of them.").

[33] Modification Application, Waiver Requests at 3.

OneWeb is not alone in expressing concerns about the LEO environment potentially being populated with large numbers of satellites with no design heritage and limited or no propulsion or maneuverability in order to meet an aggressive deployment schedule. In the recently adopted Orbital Debris NPRM, the Commission noted that "[a] design or reliability flaw resulting in malfunction of spacecraft during deployment or mission operations could result in a significant number of non-functional spacecraft in an operational orbit, contributing to the orbital debris population."[34] This echoes SEH's own concerns, expressing anxiety to the Commission that:

> a large number of such nonmaneuverable smallsats complicate the deployment of any spacecraft that transits through the sub-ISS altitudes…A steady rain of uncontrolled de-orbiting smallsats would also present a significant collision concern…Accordingly, the Commission cannot overlook the potential danger presented by smallsats operating at such altitudes with limited maneuvering capabilities.[35]

Consequently, SEH explicitly supported the Commission's adoption of a requirement that "a smallsat applicant must certify that its satellite(s) have sufficient propulsion capabilities to perform collision avoidance maneuvers – regardless of their deployment altitude" in order to qualify for streamlined treatment.[36] OneWeb agrees with SEH and believes that large-scale deployments of satellites lacking adequate propulsive or maneuverability capabilities raise significant concerns.

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[34] Orbital Debris NPRM at ¶ 42.

[35] Comments of Space Exploration Technologies Corp., IB Dkt. No. 18-86, at 10 (filed July 9, 2018).

[36] *Id*.

For these reasons, the Commission must seek additional information from SEH regarding the propulsive capabilities and maneuverability of its proposed initial deployment satellites. In the Orbital Debris NPRM, the Commission proposed to require applicants to include a description of this information in their applications.[37] SEH stated that the ongoing operation of Microsats 2A and 2B "provided key operational lessons that [it] has quickly integrated into the system's design."[38] As the Commission considers the Modification Application, it must inquire as to how the propulsion systems and maneuverability of the SEH experimental satellites fared in the very operating environment in which SEH intends to launch 1,584 satellites beginning later this year.[39] To not seek this critical information would jeopardize the ability of other NGSO operators to effectively assess and plan for operations in the LEO operating environment at the very moment many NGSO operators are poised to launch their own NGSO constellations.

B. SEH's Updated Orbital Debris Mitigation Plan Leaves Critical Questions Unanswered and Cannot Support Grant of the Modification Application

In SEH's initial authorization, the Commission stated that SEH's proposed constellation "necessitate[d] a further assessment of the appropriate reliability standards of these spacecraft, as well as the reliability of these systems' methods for deorbiting the spacecraft" and conditioned the license on future approval of an updated orbital debris mitigation plan.[40] In the Modification

[37] *See* Orbital Debris NPRM at ¶ 39.

[38] Modification Application at i.

[39] The Commission previously inquired about the maneuverability of SEH's satellites within the context of its initial license application. *See* Letter from Jose P. Albuquerque, Chief, Satellite Division, to William M. Wiltshire and Paul Caritj, Counsel to SpaceX, IBFS File No. SAT-LOA-20170301-00027 at 1 (June 22, 2017).

[40] SEH Grant at ¶¶ 15, 40(p).

Application, SEH submitted an updated orbital debris showing and asked the Commission to find that it satisfies this condition.[41] Based on the orbital debris mitigation plan provided in the Modification Application, any such finding by the Commission would remain premature at this time for several reasons.

Specifically, the following parts of the updated orbital debris plan SEH provided in the Modification Application merit closer scrutiny by the Commission:

Confirmation of Maneuverability. First, as described in Section II.A above, it appears that the operations of SEH's experimental satellites have not unfolded as planned, which raises many important reliability and predictability concerns. For example, SEH has repeatedly emphasized the maneuverability of its satellites as a critical component of its ability to mitigate the collision risk inherent in operating and replenishing a constellation of approximately 12,000 spacecraft.[42] SEH's new orbital debris mitigation plan offers no insights as to the continued viability of such capabilities in light of the data received from the operation of Microsats 2A and 2B. Prior to any action on this updated orbital debris mitigation plan, the Commission must seek more information from SEH before it can validly determine that SEH's proposed constellation

[41] Modification Application at n. 8.

[42] *See, e.g.* Letter from William M. Wiltshire, Counsel to SpaceX to Jose P. Albuquerque, Chief, Satellite Division, IBFS File No. SAT-LOA 20170301-0027 at 4, (July 24, 2017) ("Response to Commission Letter") ("SpaceX has designed a rigorous maneuver response procedure to react to Joint Space Operations Center ("JSpOC") conjunction warning messages…"); *id.* ("All satellites will have sufficient propellant and capability to perform any avoidance maneuvers required for all phases of the satellites' mission."); Space Exploration Holdings, LLC, *Consolidated Response to Comments*, IBFS File No. SAT-LOA 20170301-0027, at 11 (filed Oct. 10, 2017) ("SpaceX satellites are designed with propulsion systems capable of performing frequent maneuvers to avoid any satellite or trackable orbital debris.") ("Consolidated Response").

will not pose a risk of creating significant orbital debris at the 550 km altitude as well as the 1,110-1,325 km altitude range.

Spacecraft Reliability Risks at 550 km Operational Altitude. The orbital debris mitigation plan contained in the Modification Application indicates that SEH intends to rely on the effects of atmospheric drag at 550 km to "ensure[] rapid decay even in the absence of the nominally planned disposal sequence."[43] Although OneWeb acknowledges the potential for more rapid de-orbits of disabled or end-of-life spacecraft at the 550 km orbit as compared to the 1,125 km orbit, the Commission should be deeply concerned with the idea of this altitude—an altitude through which OneWeb's own satellites must soon traverse during the orbit raising process and which is already populated by a multitude of small satellites—being populated with more than 1,500 SEH satellites whose operational capabilities raise important questions. To ameliorate this significant risk, the Commission should inquire as to the design heritage and expected reliability of SEH's first-generation spacecraft to determine the continued validity of its prior concerns about the reliability issues presented by SEH's constellation.

SEH's updated orbital debris mitigation plan should not be accepted if SEH cannot demonstrate it has sufficiently assuaged the well-founded concerns articulated by the Commission in the SEH grant.[44] At a minimum, SEH should update the Modification Application to demonstrate its adherence to a high degree of reliability in its spacecraft and de-orbit designs. As the proposed operator of the largest NGSO constellation by an order of

[43] Technical Attachment at 40. *See also id.* at 42 ("operating at the 550 km altitude provides a passive back-up mechanism that will quickly and efficiently eliminate orbital debris due to natural drag, thereby reducing the risk for the SpaceX constellation as well as the LEO environment as a whole.").

[44] *See* SEH Grant at ¶ 15.

magnitude, SEH cannot be allowed to avoid potentially serious reliability issues by simply relocating to an altitude that offers greater de-orbit redundancies. Fundamentally, the Commission must determine whether these potential reliability issues are consistent with well-established principles of orbital stewardship prior to any action on the Modification Application. OneWeb respectfully suggests such a determination is not appropriate until the Commission concludes its recently initiated Orbital Debris NPRM.

Continued Concerns Regarding SEH's Troubling Casualty Risk Analysis. OneWeb notes that SEH's de-orbit casualty risk analysis continues to present a troubling risk profile.[45] OneWeb is not alone in expressing concerns that SEH's constellation presents a real risk of injury or death on Earth: for example, IEEE Spectrum recently estimated that the "overall risk of debris from the constellation causing an injury or death will be 45 percent. This means that NASA's software says that it is nearly as likely than not, that one of the Starlink satellites will injure or kill someone, about every six years."[46] The Modification Application makes clear that nine fragments from every SEH satellite could potentially strike Earth and result in a human casualty.[47] OneWeb notes that SEH's updated casualty risk analysis presents a Risk of Human Casualty Rate of 1:19,800, which is consistent with previous calculations SEH has provided.[48] However, SEH continues to calculate this figure on a per-satellite basis and fails to address the

[45] Technical Attachment at 45-47.

[46] *See* Mark Harris, *Here Are the Odds That One of SpaceX's Internet Satellites Will Hit Someone*, IEEE SPECTRUM (Dec. 17, 2018, 12:08 PM), https://spectrum.ieee.org/tech-talk/aerospace/satellites/the-odds-that-one-of-spacexs-internet-satellites-will-hit-someone.

[47] Technical Attachment at 46.

[48] *See* Consolidated Response at 17 ("Depending upon operational inclination, the total risk from the SpaceX system is preliminarily calculated at between 1:17,400 and 1:31,200.").

aggregate risks created by its proposed system of 11,927 satellites. If SEH considered such an analysis, it would become clear that the updated orbital mitigation plan would still result in more than 100,000 objects striking Earth over the course of one generation of SEH's constellation.

SEH attempts to soften the impact of this data by portraying the DAS analysis as a conservative tool that does not "take into consideration the degree to which people would be located within structures that would provide shelter from potential impact."[49] SEH cites a section of the NASA Standard to buttress this argument, arguing that "even lightly-sheltered structures provide protection against falling debris with up to a few kilojoules of kinetic energy."[50] However, SEH fails to acknowledge that the very next section of NASA Standard 8719.14A clarifies that the positive effects of any such shelter are offset to some degree by the under-accounting of risk from bouncing debris.[51] The Commission should ignore SEH's attempts to draw attention away from the troubling results depicted in the DAS analysis by highlighting this potential "sheltering effect." The benefits of any such sheltering effect do not alter the fact that SEH's DAS analysis continues to demonstrate the very troubling casualty risk posed by SEH's proposed system.

OneWeb acknowledges that the Commission's rules currently do not require a casualty risk analysis on an aggregate basis. However, the Commission appears to have recognized the value of this kind of analysis and specifically invited comment on whether it should require applicants to provide an aggregate, system-wide analysis to evaluate casualty risk.[52] Given the

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[49] Technical Attachment at 47.

[50] *Id*.

[51] *See* NASA Standard 8719.14A at § 4.7.3(e).

[52] Orbital Debris NPRM at ¶ 62.

size and scope of SEH's proposed constellation, the Commission should carefully consider the implications of approving an updated orbital debris plan that fails to provide such an aggregate analysis or materially improve upon its already troubling casualty risk profile. As an initial matter, the Commission should consider refraining from accepting SEH's updated orbital debris mitigation plan until SEH updates the Modification Application with the results of the ORSAT analysis. In fact, SEH explicitly concedes NASA's ORSAT tool would "more accurately account for" factors influencing the DAS re-entry analysis, even though the "results of this analysis are not yet available."[53] The potential size of SEH's constellation and its apparent discomfort with the results of its own DAS re-entry analysis weigh in favor of the Commission taking a very cautious approach as it determines the acceptability of SEH's casualty risk profile.

Ongoing Orbital Debris Rulemaking. The Orbital Debris NPRM has proposed fundamental changes to the Commission's existing framework for reviewing orbital debris issues, including issues that directly impact the Commission's consideration of many parts of SEH's updated orbital debris plan. These include issues involving propulsion and maneuverability information, spacecraft and de-orbit reliability, and casualty risk analysis.[54] In light of the transformational nature of the Commission's proposals, the Commission should refrain from accepting SEH's updated orbital debris showing until the appropriate rulemaking is concluded. At a minimum, OneWeb respectfully requests that any grant of the Modification

[53] Technical Attachment at 47.

[54] *See* Orbital Debris NPRM at ¶¶ 39, 42, and 62.

Application should be conditioned on SEH's future compliance with any rules adopted or modified in this ongoing orbital debris rulemaking proceeding.[55]

III. THE COMMISSION SHOULD DENY SEH'S REQUEST FOR A WAIVER OF THE EPFD VALIDATION REQUIREMENT

A. ITU Review Is Now the Only Substantive EPFD Analysis Conducted Before Launch and Operation of an NGSO Constellation

In the Modification Application,[56] SEH requests a waiver of Section 25.146(a)'s requirement that NGSO licensees receive a "favorable" or "qualified favorable" finding by the ITU Radiocommunication Bureau regarding compliance with EPFD limits.[57] SEH attempts to justify this waiver request by alluding to the ITU's "volume of pending filings" as evidence the ITU will be unable to render an EPFD finding quickly enough to meet SEH's "aggressive constellation deployment schedule."[58] This justification does not come close to satisfying the Commission's standard for granting a waiver of its rules.[59] If the Commission followed this approach, it would establish a dangerous precedent which could result in satellite operators having rules waived based on nothing more than a showing of impatience. SEH's waiver request must simply be denied.

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[55] *See, e.g. In the Matter of WorldVu Satellites Limited; Petition for a Declaratory Ruling Granting Access to the U.S. Market for the OneWeb NGSO FSS System*, Order and Declaratory Ruling, 32 FCC Rcd 5366, 5372 ¶ 12 (2017) (conditioning grant of OneWeb's petition "on the outcome of any rulemaking proceedings").

[56] *See* Modification Application at n. 14.

[57] 47 C.F.R. § 25.146(c). In addition, this requirement is a condition of SEH's authorization. *See* SEH Grant at ¶ 40n.

[58] Modification Application, Waiver Requests at 3.

[59] *See WAIT Radio v. FCC*, 418 F.2d 1153, 1157 (D.C. Cir. 1969), *cert. denied*, 409 U.S. 1027 (1972).

Previously, the Commission required a "comprehensive technical showing" demonstrating EPFD compliance by NGSO FSS applicants.[60] However, in the recently concluded NGSO rulemaking proceeding, the Commission found this review unnecessary and duplicative of EPFD compliance reviews that NGSO operators must submit to the ITU.[61] The elimination of Commission EPFD limit review left the ITU's review of EPFD compliance as the only substantive emission assessment that NGSO operators must undergo before launch and operation of an NGSO constellation as far as interference to GSO satellite networks is concerned. In fact, the Commission explicitly stated that it is "relying on ITU EPFD limits" to the degree that these limits are incorporated by reference into the Commission's regulations.[62] The singular nature of ITU EPFD review and the degree to which the Commission now relies on this review underscores the importance of ensuring that all NGSO constellations are required to undergo this process.

Failure to control the EPFD levels of even a single NGSO constellation operator could have significant negative consequences. Article 22 of the ITU Radio Regulations provides for both single-entry and aggregate EPFD limits.[63] While each NGSO operator is responsible for meeting the single-entry limits, the existence of an aggregate limit means that each operator's compliance with EPFD limits directly impacts the allowable emissions of every other operator. In this context, an NGSO operator that generates more emissions than the single-entry limits is in

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[60] *See* 47 C.F.R. § 25.146(a) (2016).

[61] *See Update to Parts 2 and 25 Concerning Non-Geostationary, Fixed-Satellite Service Systems and Related* Matters, Report and Order and Further Notice of Proposed Rulemaking, 32 FCC Rcd 7809, 7822 ¶ 41 (2017).

[62] *Id.* at ¶ 42.

[63] ITU Radio Regulations, Art. 22.

effect taking up more than its "fair share" of the aggregate limit. Without ITU review of its emissions, SEH may generate unbridled and unmonitored EPFD levels, impacting the operational abilities of the other NGSO operators by contributing more than its assigned proportion of the aggregate EPFD limit.

The Commission may waive application of its rules for "good cause shown" or if "such deviation would better serve the public interest."[64] As SEH has noted, the party seeking a waiver "bears the burden of showing good cause for the requested departure from the rule" which constitutes a "clear and heavy burden."[65] In this case, SEH has not shown good cause that its waiver request should be granted, because such a grant would not serve the public interest. While SEH claims that its "original ITU filings were submitted several years ago" and still has not seen results, the ITU did not ask for EPFD validation files until early 2017.[66] At that time, several administrations simultaneously submitted EPFD compliance data for processing by the BR. Understandably, the ITU was likely backlogged by this influx and as a result has only posted EPFD compliance results for SEH's filings on November 27, 2018.[67] It is likely that more recent and future NGSO filings to the ITU, as may be used to support the operation of the proposed modified SEH system, would have their EPFD compliance validated more expeditiously by the ITU.

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[64] 47 C.F.R. § 1.3; *GE American Communications, Inc.*, 16 FCC Rcd 11038, 11041 ¶ 9 (IB 2001).

[65] SEH Comments on OneWeb Modification Application at 8.

[66] *See* ITU Circular Letter CR/414 (Dec. 6, 2016) (referring to the BR plan to imminently send out letters to the individual admins requesting the EPFD compliance data).

[67] ITU, https://www.itu.int/ITU-R/go/space-epfd-data (last visited Feb. 8, 2019).

SEH's self-serving conclusion—that the ITU's review is simply not moving quickly enough—is a clear prioritization of the company's business interest over the public interest. The public interest would plainly be better served by ensuring that SEH satisfies the only substantive verification of its EPFD compliance.[68] Given the importance of compliance with EPFD limits, for the benefit of GSO satellite networks, other NGSO operators, and the public, the mere opinion that ITU review is not moving quickly enough to satisfy SEH's "aggressive deployment schedule" is not nearly enough to show good cause for a rule waiver. A favorable disposition of SEH's waiver request by the Commission would set a troubling precedent for future NGSO operations, in which EPFD limits are ultimately not subject to any substantive independent review.

B. The Prior Favorable Finding Issued by the ITU Is Not Applicable to SEH's Proposed Modification

OneWeb understands that SEH received a "favorable" finding from the ITU on November 27, 2018 based on EPFD validation information submitted prior to the contemplated modification of SEH's constellation.[69] For readily apparent reasons, OneWeb believes this favorable finding cannot be used to meet the Commission's requirement of ITU EPFD compliance for the proposed modified SEH system. SEH's proposed modification, as demonstrated in Section I above, has significantly altered the technical and EPFD profile of the SEH NGSO constellation, and this will most certainly impact the EPFD compliance assessment. The ITU's recent favorable finding was calculated from data given to the organization based on an earlier iteration of SEH's constellation (as SEH claims, the data was submitted "several years

[68] Modification Application, Waiver Requests at 4.

[69] ITU, *supra* note 67.

ago") submitted in its original license application.[70] Given the significant changes outlined in SEH's Modification Application, it would be imprudent for the Commission to allow SEH to rely upon the November 2018 ITU finding to satisfy the conditions on its grant.[71]

IV. CONCLUSION

For the foregoing reasons, OneWeb respectfully requests the Commission deny the Modification Application or defer any consideration until a subsequent processing round is initiated. As demonstrated above, SEH's significant changes to its spectrum architecture will materially increase actual interference to other NGSO operators, including OneWeb. Moreover, SEH's proposed operations at 550 km raise numerous unanswered questions that must be addressed before the Commission approves SEH's updated orbital debris mitigation plan. Furthermore, in order to not disadvantage both GSO and other NGSO operators, the Commission should deny SEH's request for a waiver of the EPFD compliance demonstration prior to initiating service.

Respectfully submitted,

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February 8, 2019

[70] Modification Application, Waiver Requests at 3; *See Space Exploration Holdings, LLC, Application for Approval for Orbital Deployment and Operating Authority for the SpaceX NGSO Satellite System*, IBFS File No. SAT-LOA-20161115-00118 (filed Nov. 15, 2016).

[71] SEH Grant at ¶¶ 29, 40(n).

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 Petition to Deny or Defer 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: February 8, 2019

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CERTIFICATE OF SERVICE

I, Samuel Swoyer, hereby certify that on this 8th day of February 2019, a copy of the foregoing Petition to Deny or Defer is being sent via first class, U.S. Mail, postage paid, to the following:

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