Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
	)	
Space Exploration Holdings, LLC	)	Call Sign: S2992
	)	
Application for Approval for Orbital Deployment and Operating Authority for the Space Exploration Holdings NGSO Satellite System	)	File No. SAT-LOA-20170301-00027

COMMENTS OF WORLDVU SATELLITES LIMITED

WorldVu Satellites Limited, d/b/a OneWeb ("OneWeb"), pursuant to Section 25.154(a) of the rules of the Federal Communications Commission (the "FCC" or "Commission") and the Commission's recent public notice,[1] hereby comments on the application of Space Exploration Holdings, LLC ("Space Exploration Holdings") for operating authority for a non-geostationary orbit ("NGSO"), low-Earth orbit ("LEO") and very-low-Earth orbit ("VLEO") satellite system in the Fixed Satellite Service ("FSS") using V-band frequencies.[2]

[1] *See* 47 C.F.R. § 25.154(a); *Satellite Policy Branch Information: Space Station Applications Accepted for Filing*, Report No. SAT-01262 (rel. Aug. 25, 2017). *See also Satellite Branch Information: Boeing Application Accepted for Filing; Cut-Off Established for Additional NGSO-Like Satellite Applications or Petitions for Operations in the 37.5-40.0 GHz, 40.0-42.0 GHz, 47.2-50.2 GHz and 50.4-51.4 GHz Bands*, Public Notice, 31 FCC Rcd 11957 (Int'l Bur. 2016).

[2] Space Exploration Holdings, LLC, *Application For Approval for Orbital Deployment and Operating Authority for the SpaceX NGSO Satellite System*, IBFS File No. SAT-LOA-20170301-00027 (Call Sign S2992) (filed March 1, 2017) ("Space Exploration Holdings Application").

I. SPACE EXPLORATION HOLDINGS' REQUEST FOR A WAIVER OF THE COMMISSION'S MILESTONE REQUIREMENT IS NOT IN THE PUBLIC INTEREST AND SHOULD BE DENIED

Space Exploration Holdings seeks a waiver from the Commission to reduce its milestone obligation.[3] This request to meet only 14% of its proposed constellation within six years is the second application in which Space Exploration Holdings has sought a waiver of the Commission's milestone regime.[4] Failure to rigorously enforce the Commission's milestone regime increases the risk of spectrum and "space real estate" warehousing. Speculative spectrum and orbital filings create tremendous uncertainty for other applicants who must design their constellations to accommodate these unknown and uncertain orbital deployments and spectrum allocations.[5] Accordingly, Space Exploration Holdings' request is not in the public interest and should be denied.

Space Exploration Holdings' proposal is inconsistent with the current milestone rule[6] and even with the Commission's proposal to relax the milestone rule applicable to NGSO FSS constellations.[7] The proposed new rule would require deployment of only 50% of the

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[3] Space Exploration Holdings Application, Waiver Requests, at 15-16 ("Waiver Requests").

[4] Space Exploration Holdings has asked to launch 11,943 LEO and VLEO satellites total, and only launch 1,600 satellites in the first six years.

[5] *See In re Space Exploration Holdings, LLC, Application for Approval for Orbital Deployment and Operating Authority for the Space Exploration Holdings NGSO Satellite System*, Comments of WorldVu Satellites Limited, at 2-7 (filed June 26, 2017) ("OneWeb Comments"). As OneWeb noted in its Comments on Space Exploration Holdings' Ku- and Ka-band Application, the truncated milestone requirement Space Exploration Holdings seeks would allow it to warehouse spectrum indefinitely and would create uncertain operating conditions for other applicants.

[6] 47 C.F.R. § 25.164(b).

[7] *In re Update to Parts 2 and 25 Concerning Non-Geostationary, Fixed-Satellite Service Systems and Related Matters*, Report & Order and Further Notice of Proposed Rulemaking, IB Docket

constellation within six years of the application grant and full deployment within nine years.[8] The Commission proposed to adopt this milestone regime in order to provide operators with flexibility while "discourag[ing] applicants from seeking authorizations for oversized, unrealistic constellations."[9] The Commission explicitly noted that "allow[ing] applicants to set their own milestone objectives" – as Space Exploration Holdings proposes to do – "would not achieve [the Commission's] dual milestone goals."[10]

OneWeb agrees the Commission should reject these kind of proposed milestones to ensure that applicants are serious about deploying their proposed constellations in their entirety and are incentivized to release spectrum and orbital resources as early as possible if they determine they cannot use them. Under its proposal, Space Exploration Holdings would not be adequately incentivized to deploy more than a small portion of its constellation in a timely manner. Space Exploration Holdings should be required to comply with any milestone requirement that is implemented as a result of the ongoing NGSO rulemaking proceeding.[11] While the Commission has already proposed to offer significant regulatory relief to Space Exploration Holdings and other applicants with respect to milestone requirements, Space Exploration Holdings' further proposed milestone plan and waiver request would "create

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No. 16-408, FCC-CIRC1709-04, ¶¶ 62-67 (rel. Sept. 7, 2017) ("Draft R&O and Further NPRM").

[8] *Id*. at ¶¶ 66-67.

[9] *Id*. at ¶ 66.

[10] *Id*.

[11] The Draft R&O makes clear that any rules adopted pursuant to the NGSO rulemaking will be applied to pending applications. *See* Draft R&O and Further NPRM at ¶ 71.

unnecessary coordination burdens and uncertainty for other operators."[12] The waiver request is not in the public interest and should be denied.

II. SPACE EXPLORATION HOLDINGS' ORBITAL DEBRIS SHOWING IS MISSING CRITICAL INFORMATION

Space Exploration Holdings' application fails to adequately demonstrate that its LEO and VLEO constellations will be operated safely in close proximity to other NGSO constellations. Space Exploration Holdings has proposed to deploy nearly *12,000 satellites*, including 4,425 that will be in close proximity in-orbit to other NGSO constellations, such as Boeing's proposed V-band constellation, Telesat's Ka-band constellation, and OneWeb's Ku- and Ka-band constellations.[13] As discussed in OneWeb's Comments on Space Exploration Holdings' Ku- and Ka-band Application, the proposed LEO constellation poses a substantial risk of collision with other NGSO satellites having similar orbital altitudes, especially given Space Exploration Holdings' refusal to agree to a reasonable buffer zone between operators.[14] Space Exploration Holdings states that it "has determined that no other system is currently licensed by the

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[12] *Id*. at n.139.

[13] *See* Space Exploration Holdings Application at 7 (Space Exploration Holdings plans to launch 4,425 satellites that will operate at altitudes between 1,110 km to 1,325 km – overlapping with OneWeb's earlier-chosen orbital altitude centered on 1,200 km). *See also* Telesat Canada, Petition for Declaratory Ruling to Grant Access to the U.S. Market for Telesat's NGSO Constellation, IBFS File No. SAT-PDR-20161115-00108, Appendix A (Technical Annex) at 1 (filed Nov. 15, 2016) (proposing to operate at altitudes between 1,000 km and 1,248 km); The Boeing Company, Application for Authority to Launch and Operate a Non-Geostationary Low Earth Orbit Satellite System in the Fixed Satellite Service, IBFS File No. SAT-AMD-20170301-00030, at 6-7 (filed Mar. 1, 2017) (proposing to operate at altitudes between 970 km and 1,082 km).

[14] *See* OneWeb Comments at 8-12; *In re Application of Space Exploration Holdings, LLC for Approval for Orbital Deployment and Operating Authority for the SpaceX NGSO Satellite System*, Consolidated Opposition to Petitions and Response to Comments of Space Exploration Holdings, LLC, at 9-10 (filed July 7, 2017).

Commission for, is currently operating in, or has submitted a request for coordination to the ITU with respect to" its exact nominal orbital planes.[15] While OneWeb appreciates that Space Exploration Holdings (like every other NGSO operator) relies on the global public filing mechanism of the ITU to understand the locations of prior-filed constellations, its choice of surrounding orbits presents unnecessary risks to orbital safety. The selected orbit locations of Space Exploration Holdings ignore the large number of satellites from multiple operators that are in such close proximity that they will overlap due to orbital perturbations and/or failed satellites. Furthermore, any fragments from the potential intra-constellation collisions of such a closely knit constellation will affect the other constellations near which Space Exploration Holdings has chosen to orbit. The Commission should require that Space Exploration Holdings adequately demonstrate its ability to avoid becoming a source of orbital debris or collisions to other NGSO systems, and that it maintain an adequate safety buffer zone of at least 125 km – and, preferably, 200 km – from other large constellations.

Space Exploration Holdings claims to have chosen orbital locations for its satellites in a manner meant to "maximize the spacing between satellites and thereby preclude the risk of conjunction."[16] However, the application does not quantify the intra-constellation conjunction distances, in nominal and potential failure modes, for either the LEO or VLEO constellations, or discuss how accurately Space Exploration Holdings will be able to maintain its satellites' orbits, especially in the high-drag VLEO environment. Space Exploration Holdings asserts that its VLEO satellites operate in a "self-cleaning" environment where atmospheric drag quickly

[15] Space Exploration Holdings Application, Attachment A: Technical Information to Supplement Schedule S, at 36 ("Technical Attachment").

[16] *See* Technical Attachment at 36.

destroys any debris.[17] However, this ignores that its VLEO constellation will consist of over 7,500 satellites and that VLEO satellite trajectories may be difficult to predict accurately, with the VLEO constellation likely requiring frequent station-keeping maneuvers. Given the sheer number of objects Space Exploration Holdings proposes to deploy, the risk of intra-constellation collision could be substantial, and the over 7,500 satellites at very low earth orbit could create a debris field which could be virtually impenetrable for passing space missions until the debris de-orbits.

The risk of collision between deorbiting LEO satellites and satellites in the VLEO constellation also appears to be larger than necessary. Space Exploration Holdings intends to target an eccentric disposal orbit for its LEO satellites with a perigee just below its operational VLEO altitude, leaving its LEO satellites in orbits that cross with the VLEO constellation while they decay toward re-entry.[18] During this phase, Space Exploration Holdings intends to passivate the LEO satellites and leave them in an orientation that maximizes their cross-sectional areas.[19] While this orientation reduces orbital lifetime, it also increases the collisional cross-sectional area at a time when the satellites can no longer actively execute collision avoidance maneuvers. This is particularly disturbing since, in this high-drag environment, positional accuracy predictions of both the passivated LEO satellites and the frequently maneuvering VLEO satellites will be compromised. In light of these circumstances, the Commission should request Space Exploration Holdings to consider budgeting the minimum fuel to accelerate this

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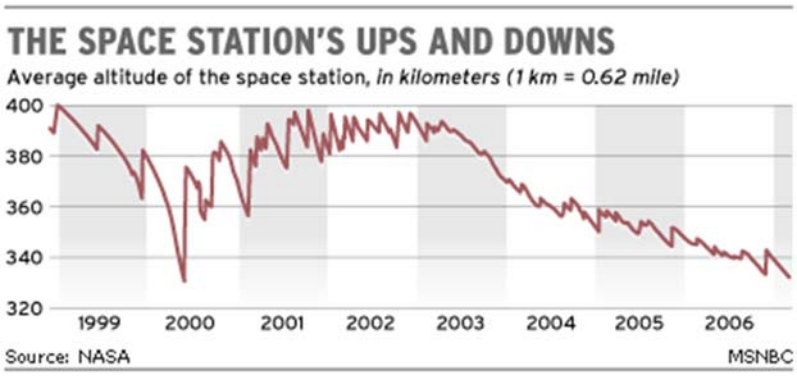
[17] *See id.*

[18] *Compare* Technical Attachment at 39 (LEO satellites to achieve a perigee of 300 km) *with* Space Exploration Holdings Application at 8 (VLEO satellites to occupy orbital planes between 335.9 km and 345.6 km).

[19] Technical Attachment at 39.

phase of its LEO satellites' re-entry to ensure that collisions between VLEO and LEO satellites will be avoided.

Of further concern is that the International Space Station ("ISS") has very limited maneuvering capability and its altitude occasionally drops into and through the proposed VLEO orbit, as demonstrated below:[20]



Risks to the ISS resulting from collisions or fragmentation in the VLEO constellation may be short-lived, but will also be sudden and unpredictable. This is not to say a constellation of the size of Space Exploration Holdings' VLEO constellation should not be authorized purely on the grounds of its potential for space debris or intra-constellation collisions. However, there should be a heightened reliability showing required both for the spacecraft and for its potential for conjunction with other spacecraft (including intra-constellation conjunctions) and with humans in or near its orbit and de-orbit paths.

Space Exploration Holdings provides limited details on the reliability of its 7,500 VLEO satellites, stating only that its propellant "tanks are designed to suffer impact penetration without

[20] James Oberg, "Space station sinks to new low – but it's OK," NBCNEWS.COM, March 15, 2007, *available at* http://www.nbcnews.com/id/17630218/ns/technology_and_science-space/t/space-station-sinks-new-low-its-ok/#.WclYgYWcF-g.

explosive consequences," and a "burst disk ensures that sudden failure of propulsion containment cannot overpressure and fragment the spacecraft."[21] While these statements seem to support a claim that Space Exploration Holdings' propellant tanks will not explode under any hypervelocity impact conditions, they lack the required amount of detail. The Commission should request clarification on this point and should require Space Exploration Holdings to submit additional information on its satellite conjunction calculations to ensure a safe operating environment.

Finally, there is also a substantial risk of human casualty associated with re-entry of Space Exploration Holdings' satellites. Space Exploration Holdings identified a subset of components that pose a risk of human casualty, including five silicon carbide optical components of 1.5 kg each that will survive atmospheric re-entry with an impact energy of 961 Joules (far above the casualty threshold of 15 Joules).[22] This equates to as much as 11,943 pieces of debris that may fall to Earth with enough kinetic energy to cause a human casualty.[23] While the resulting casualty risk *per satellite* falls below NASA's per-satellite threshold of 1:10,000,[24] Space Exploration Holdings' numbers suggest that the aggregate risk system poses a 1 in 3 chance of a casualty risk as the silicon carbide optical components fall to earth. The Commission should require Space Exploration Holdings to address the aggregate casualty risk

[21] *See* Technical Attachment at 37.

[22] *Id*. at 58.

[23] 7,518 VLEO + 4,425 LEO satellites = 11,943 satellites * 5 pieces of re-entry debris per satellite, divided by a 5 year life.

[24] *See* Technical Attachment at 59.

posed by its very large LEO and VLEO constellations and adopt adequate measures to mitigate that risk.

III. SPACE EXPLORATION HOLDINGS' REQUEST FOR A WAIVER OF THE DOMESTIC COVERAGE REQUIREMENT IS NOT IN THE PUBLIC INTEREST AND SHOULD BE DENIED

Space Exploration Holdings' request for a waiver of the domestic coverage requirements contained in Section 25.143(b)(2)(ii) of the Commission's rules, 47 C.F.R. § 25.143(b)(2)(ii), for its initial deployment is not in the public interest. As OneWeb noted in its Comments on Space Exploration Holdings' Ku- and Ka-band Application, the domestic coverage requirement is a critical mechanism for ensuring NGSO FSS systems effectively utilize limited spectrum resources by providing service to all Americans, especially those in remote or underserved areas.[25] Failing to provide coverage to rural and remote areas at the expense of densely populated, wealthier areas significantly undercuts the Commission's efforts to close the digital divide.[26] OneWeb acknowledges the domestic coverage requirement is the subject of a Further Notice of Proposed Rulemaking in the ongoing NGSO rulemaking proceeding,[27] and requests that any action on the Space Exploration Holdings application be conditioned on compliance with any requirements imposed as a result of that proceeding.

[25] *See* OneWeb Comments at 16-24.

[26] *See id*.

[27] *See* Draft R&O and Further NPRM at ¶¶ 73-76.

IV. CONCLUSION

For the foregoing reasons, the Commission should deny Space Exploration Holdings' requests for waivers of the domestic coverage requirement and the current milestone rule. The Commission should also require Space Exploration Holdings to supplement its plans to manage satellite altitudes and trajectories, prevent in-orbit collisions, and minimize orbital debris prior to any disposition of its application by the Commission.

Respectfully submitted,

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September 25, 2017

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 these Comments, that I am familiar with Part 25 of the Commission's rules, that I have either prepared or reviewed the engineering information submitted in these Comments, and that it is complete and accurate to the best of my knowledge and belief.

Dated: September 25, 2017

/s/ Marc Dupuis

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CERTIFICATE OF SERVICE

I, Ashley Yeager, hereby certify that on this 25th day of September 2017, a copy of the foregoing Comments is being sent via first class, U.S. Mail, postage paid, to the following:

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