



UNITED STATES DEPARTMENT OF COMMERCE
National Telecommunications and
Information Administration
Washington, D.C. 20230

February 8, 2022

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

Re: Report No. SAT-01598 Space Station Applications Accepted for Filing, Space
Exploration Holdings, LLC (SAT-AMD-20210818-00105)

Dear Ms. Dortch,

The National Telecommunications and Information Administration (NTIA) submits the enclosed letters on behalf of the National Aeronautics and Space Administration (NASA) and the National Science Foundation (NSF) in the above-referenced proceeding. Please direct any questions you may have regarding these submissions to the undersigned at ksmith@ntia.gov.

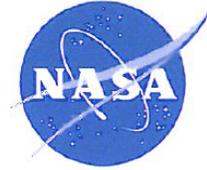
Respectfully submitted,

A handwritten signature in black ink, appearing to read "Kathy Smith".

Kathy Smith
Chief Counsel

enclosures

National Aeronautics and
Space Administration
Headquarters
Washington, DC 20546-0001



February 7, 2022

Human Exploration and Operations Mission Directorate

Reply to Attn of:

Ms. Marlene Dortch, Secretary
Federal Communications Commission
445 Twelfth Street, S.W.
Washington, DC 20554

SUBJECT: Report No. SAT-01598 Space Station Applications Accepted for Filing, Space Exploration Holdings, LLC (SAT-AMD-20210818-00105)

Dear Ms. Dortch,

The National Aeronautics and Space Administration (NASA) submits this letter in response to the amendment ([SAT-AMD-20210818-00105](#)) filed by Space Exploration Holdings, LLC (SpaceX) for a second-generation non-geostationary orbit satellite system, hereby referred to as Gen2.

With the increase in large constellation proposals to the FCC, NASA has concerns with the potential for a significant increase in the frequency of conjunction events and possible impacts to NASA's science and human spaceflight missions. Consequently, NASA submits this letter for the purpose of providing a better understanding of NASA's concerns with respect to its assets on-orbit, and to further mitigate the risk of collisions for the benefit of all involved. NASA wants to ensure that the deployment of the Starlink Gen 2 system is conducted prudently, in a manner that supports spaceflight safety and the long-term sustainability of the space environment. Recognizing the importance of spaceflight safety and ensuring a sustainable space environment, NASA has provided similar comments in response to other proposed large constellations.

The pending FCC application proposing an additional ~30,000 satellites in Low-Earth Orbit ([SAT-LOA-20200526-00055](#)), and its previously referenced amendment, outline operations of constellations of satellites in orbits that have the potential to impact NASA operations and the safety of NASA assets. As such, NASA offers the following observations and recommendations:

Substantial Congestion in the Low Earth Orbit (LEO) Environment

There are currently ~25,000 total objects tracked on-orbit. About 6,100 of those objects have a perigee below 600 km. SpaceX's Gen2 expansion would more than double the number of tracked objects in orbit and increase the number of objects below 600 km over five-fold, without factoring in growth from other proposed constellations. An increase of this magnitude into these confined altitude bands inherently brings additional risk of debris-generating collision events based on the number of objects alone. NASA anticipates current and planned science missions, as well as human space flight operations will see an increase in conjunctions.

Such a significant increase in total object volume raises concern regarding a potential impact to on-orbit tracking and conjunction screening. If NASA were unable to receive reliable and timely conjunction notifications the quality of the on-orbit protection provided to NASA would be degraded and the safety of the International Space Station (ISS) and all other NASA assets may be impacted.

NASA recommends SpaceX generate analysis demonstrating the auto-maneuver capability is sufficiently scalable to the entire proposed constellation size, including inter-constellation conjunctions, while accounting for challenges in flying lower altitudes during greater solar activity.

Collision Assessment Conjunction Avoidance Coordination

The application states that the collision risk with large objects is zero because each spacecraft can maneuver. Zero risk is possible for any single maneuverable spacecraft if the event is mitigated down to zero probability of collision (P_c). However, considering multiple independent constellations of tens of thousands of spacecraft and the expected increase in the number of close encounters over time, the assumption of zero risk from a system-level standpoint lacks statistical substantiation. With the potential for multiple constellations with thousands and tens of thousands of spacecraft, it is not recommended to assume propulsion systems, ground detection systems, and software are 100% reliable, or that manual operations (if any) are 100% error-free.

While SpaceX may be able to show that the auto-maneuver capability scales appropriately within the Starlink constellation, the concern remains that other vendors proposing large constellations would also use auto-maneuvering capability within altitude ranges occupied by Starlink, thereby requiring multiple autonomous constellations to maneuver out of each other's way without clearly defined rules of the road for such interactions. NASA recommends SpaceX commission a risk analysis that addresses the efficacy of autonomous-vs.-autonomous constellation conjunction assessments and mitigation actions to provide confidence that the situation could be sufficiently addressed. If the recommended analysis is conducted, NASA requests the opportunity to review the results to help ensure there will be minimal risk to NASA and other assets.

Potential Additional Impacts to Science Missions

NASA has approximately 14 Earth observing missions in operations or development with lidar and radar instruments spanning both the radio and optical electromagnetic spectrum. These missions make critical measurements of Earth's climate as an interrelated system. Since the updated altitudes of Starlink now propose an additional 30,000 satellites 'below' the majority of Earth observing missions, there is the potential for sun-glint and reflections from the Starlink spacecraft to cause impacts to those missions' measurements.

Around 8% of composite images captured by the Hubble telescope are impacted by satellites captured during exposures. The Hubble telescope is in an orbit at 535 km. This proposed Starlink license amendment includes 10,000 satellites in or above the orbital range of Hubble, a situation that could more than double the fraction of Hubble images degraded. Furthermore, degradation severity will increase as the orbital proximity of the obscuring Space-X Gen2 satellites in relation to Hubble decreases.

Per Congressional direction, NASA uses wide-field ground-based telescopes to survey for asteroids that could potentially impact the Earth and cause harm. These telescopes occasionally find satellite streaks in their images that could interfere with or hide asteroid detections. With the addition of ~30,000 Starlink satellites as described in the Gen2 amendment request, NASA estimates that there would be a Starlink in every single asteroid survey image taken for planetary defense against hazardous asteroid impacts, decreasing asteroid survey effectiveness by rendering portions of images unusable. This could have a direct impact on NASA's ability to fulfill its Congressional mandate and could have a detrimental effect on our planet's ability to detect and possibly redirect a potentially catastrophic impact.

In an effort to ensure a mutually beneficial space environment to meet commercial, exploration and scientific needs, NASA looks forward to working with SpaceX to better understand Gen2's operational parameters. Specifically, NASA requests additional information including: spacecraft and laser specifications including deployed dimensions, communications plan, ground segment expansion, orbital spacing, and deployment schedule. This will inform a thorough analysis of risks and impacts to NASA's missions and enable a mitigation strategy. As NASA evolves its study and mitigation plans, additional data also may be requested.

In parallel, NASA would like to ensure that SpaceX is aware of the impacts to NASA's science objectives and work together to fully minimize these impacts through robust mitigations.

Potential Impacts due to Radio Frequency Interference (RFI)

Starlink operations in the 14.0-14.5 GHz band overlap or are adjacent to frequencies supporting NASA's Tracking and Data Relay Satellite System (TDRSS). Continued frequency coordination of SpaceX operations in this band, through the interagency frequency coordination process, is critical to maintain no impacts to existing NASA operations. NASA has taken preventative measures to reduce potential RFI to TDRSS and provides certain operational conditions to the FCC, which are appended to the SpaceX licenses. NASA requests for the FCC to support these conditions and to continue coordination of SpaceX operations in compliance with existing processes.

The Effect on Launch Collision Avoidance

SpaceX is proposing ~20,000 additional Starlink satellites in the 328-360 km altitude range, which is below the ISS and is a common phasing altitude for ISS visiting vehicles. The proposed volume of autonomously maneuvering satellites directly parked in common phasing altitudes could result in potential loss of launch/entry opportunities impacting science and utilization for ISS.

NASA is also concerned with an increasing unavailability of safe launch windows, especially for missions requiring instantaneous or short launch windows, such as planetary missions like Europa Clipper, which would be significantly affected due to a lost launch opportunity.

NASA recommends SpaceX commission analysis of launch window availability against the current catalog compared to the current catalog plus the proposed full constellation to demonstrate that the increase in launch conflicts does not significantly reduce access to space. NASA is specifically interested in analysis that may predict how this expansion impacts future NASA Science Missions, Commercial Crew and Re-Supply launch/entry opportunities.

In addition to the previous requests stated in this letter, NASA suggests that SpaceX work with NASA to demonstrate the proposed capability with increasing volumes of satellites prior to each successive launch so that it may troubleshoot any issues that arise and make adjustments, as necessary. This incremental approach would allow SpaceX to gradually prove their concept of operations and troubleshoot any issues that arise along the way.

There is a clear need to develop a longer-term plan for conjunction and interference mitigation at a national and international level, and NASA looks forward to contributing our expertise in this endeavor in collaboration with commercial operators. NASA appreciates SpaceX's collaboration and partnership in addressing conjunction concerns to date. The proposed increase in the number of Starlink spacecraft on orbit will require expanded coordination and communication between the two parties to ensure the continued safety of both SpaceX and NASA assets. NASA looks forward to SpaceX's sustained support in our mutual endeavor to safely operate all spacecraft.

Although these observations and recommendations are made with respect to the subject report and filings, they can be generally applied to other large constellations, and NASA is supportive of the creation of "best practices" focused on such programs. NASA would encourage all spacecraft operators, especially those contemplating large constellations, to consult the NASA Spacecraft Conjunction Assessment and Collision Avoidance Best Practices Handbook (https://nodis3.gsfc.nasa.gov/OCE_docs/OCE_51.pdf). The handbook addresses various topics related to effective and mature conjunction assessment practices supporting a safe space environment for all operators. Space operators can use the handbook to benchmark their existing practice or in support of establishing an effective conjunction assessment capability. Many of the topics covered in the handbook are pertinent to the items above and may be a resource for SpaceX in addition to any feedback on the filing.

Should you have any questions, do not hesitate to contact me at (321) 607-2286 or samantha.fonder@nasa.gov.

Sincerely,

A handwritten signature in blue ink, appearing to read 'S. Fonder', with a long horizontal stroke extending to the right.

Samantha Fonder

NASA Representative to the Commercial Space Transportation Interagency Group
Space Operations Mission Directorate, Launch Services Office



National Science Foundation
Electromagnetic Spectrum Management

February 7, 2022

Comments to the Federal Communications Commission on filing SAT-AMD-20210818-00105

The National Science Foundation (NSF) submits this letter in response to the amendment filed by Space Exploration Holdings, LLC (SpaceX) for a second-generation non-geostationary orbit satellite system to emphasize the key role of ground-based optical, infrared and radio astronomy for scientific investigation and discovery.

NSF facilitated a coordination agreement for the first-generation system, per the requirement of US131, between SpaceX and radio astronomy sites listed therein. Productive conversations are ongoing with SpaceX to update this coordination agreement and NSF will notify the FCC when the updated agreement incorporating the new system parameters has been executed. In general, large NGSO systems will impact radio astronomy observatories which have traditionally relied upon their remote location to avoid interference.

NSF continues to work with operators in the development of recommendations to minimize the impact to optical and infrared astronomy. Mitigations encouraged by NSF include reducing optical brightness to 7th magnitude or fainter via darkening, deflecting light away from the Earth, or attitude maneuvering, moving orbital elevations to ~700 km or lower, provision of orbital information for astronomers to work on scheduling observations around satellite locations, and other ideas to be developed. SpaceX has developed, implemented, and tested a number of ideas which have markedly improved the observed brightness of their satellites, and with the increase in proposed numbers, this effort is appreciated and even more critical.

NSF shares the general concerns of NASA, regulators, and satellite operators with respect to orbital debris and congestion and supports thoughtful consideration and planning to prevent and avoid unintended consequences.

Best regards

A handwritten signature in black ink, appearing to read 'Jonathan Williams'.

Jonathan Williams

Ashley VanderLey

National Science Foundation