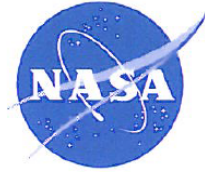


National Aeronautics and  
Space Administration  
**Headquarters**  
Washington, DC 20546-0001



June 26, 2017

Reply to Attn of:

Human Exploration and Operations Mission Directorate

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

Subject: DA 17-524 Report No. SPB-271 Applications Accepted For Filing, Specifically Space Exploration Holdings, LLC (SAT-LOA-20161115-00118) and Theia Holdings A, Inc (SAT-LOA-20161115-00121)

Dear Ms. Dortch,

The National Aeronautics and Space Administration (NASA) submits this letter in response to the Federal Communications Commission's (FCC) Public Notice of May 26, 2017 (DA 17-524) titled "Applications Accepted for Filing: Cut-Off Established for Additional NGSO-Like Satellite Applications or Petitions for Operations in the 12.75-13.25 GHz, 13.85-14.0 GHz, 18.6-18.8 GHz, 19.3-20.2 GHz, and 29.1-29.5 GHz Bands." With the increase in large constellation proposals to the FCC, NASA has concerns over the possibility of a significant increase in frequency of conjunction events. Consequently, NASA submits this letter during the public comment period for the purpose of providing a better understanding of NASA's interests with respect to its personnel and assets on-orbit, to further mitigate the risks of collisions for the mutual benefit of all involved.

NASA has considerable assets in low Earth orbit (LEO) including space-based personnel, the International Space Station (ISS), and more than twenty high-value scientific spacecraft. The applications referenced in the subject report and public notice outline operations of constellations of satellites in low Earth orbit that have the potential to impact NASA operations and safety of space-based personnel and assets. As such, NASA offers the following observations and recommendations:

1. For large constellations such as the one proposed by SpaceX, NASA notes that the reliability of the design and fabrication of the spacecraft and the reliability that the spacecraft can accomplish the post-mission disposal are of particular interest from the perspective of keeping the orbital environment safe. A design or fabrication flaw can potentially lead to malfunction or even explosion of many spacecraft during the deployment or mission operations of the constellation. Likewise, clearing an operational orbit of non-operating spacecraft becomes more important when applied to a large constellation.

Neither the U.S. Government Orbital Debris Mitigation Standard Practices nor the international Inter-Agency Space Debris Coordination Committee (IADC) Space Debris Mitigation Guidelines quantify a minimum reliability, and currently, no consensus exists on what the two reliability numbers should be. For discussion purposes, a design and fabrication reliability on the order of 0.999 or better per spacecraft may be prudent to mitigate the risk of malfunction in a 4,000+ spacecraft constellation. For the reliability of post-mission disposal operations, NASA sets a minimum reliability for NASA spacecraft at 0.9 (NS 8719.14A, Req. 4.6-4), but this threshold may not be sufficient for a large constellation.

Two studies are currently underway that may shed light on best practices for large satellite constellations: NASA's Orbital Debris Program Office (ODPO) is performing an internal parametric study which will be completed later this year and the IADC study on large constellations will take another year or so to complete. In the meantime, NASA recommends that companies proposing large constellations should develop ways to deal with random failures such that they not pose a threat to other U.S. assets including the ISS.

2. The SpaceX proposed LEO constellation will operate at an altitude above the ISS. At the end-of-life for these spacecraft, SpaceX intends to lower the perigee until propellant is exhausted, resulting in a perigee of approximately 300 km, which is below the operational altitude of the ISS. The apogee will be gradually lowered through atmospheric drag and reentry is expected within one year. It appears that at this point there will be no remaining capability to perform collision avoidance maneuvers. Although a right ascension of the ascending node (RAAN) can be chosen that initially avoids the ISS and visiting vehicles, there will be recession of the orbit over a period of time (months) that could lead to potential conjunctions. Therefore, NASA recommends that SpaceX seek out creative ways to guarantee they can avoid the ISS and other high value assets for the *entire* deorbit phase of their spacecraft.
3. In addition, the SpaceX proposed VLEO constellation would operate below ISS and only conceptually poses risks to visiting vehicle traffic to/from the ISS. Based on NASA's discussions with SpaceX in March 2017, NASA notes that the concept of operations for this constellation is not mature enough to offer any recommendations at this time.
4. Regarding Theia Holdings A, Inc., with a proposed 120 satellite constellation in 8 sun-synchronous orbits and a mean altitude of 800 km, NASA notes that this is right above the A-Train succession of Earth observing satellites (705 km) and right below NOAA polar-orbiting weather satellites (820 km). It is also a relatively high-risk orbital area due to the high percentage of Iridium-33/Cosmos-2251 and Fengyun-1C debris in that region. NASA recommends that Theia Holdings enter into technical discussions with NASA and/or the military as soon as possible to ensure that they can optimize their orbit altitude choice for avoidance of both existing missions and high debris altitudes. NASA also recommends that Theia Holdings establish a robust collision avoidance risk analysis process, including developing expert risk assessment to interpret predicted close approach data received from Joint Space Operations Center.

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. Should you have any questions, do not hesitate to contact me at 202-358-3784 or [anne.sweet-1@nasa.gov](mailto:anne.sweet-1@nasa.gov).

Sincerely,

A handwritten signature in black ink, appearing to read "Anne Sweet", with a long horizontal flourish extending to the right.

Anne E. Sweet  
NASA Representative on the Commercial Space Transportation Interagency Group  
Program Executive, Launch Services Office  
Human Exploration and Operations Mission Directorate