June 16, 2020

Marlene Dortch
Federal Communications Commission
Office of the Secretary
445 12th Street, SW
Washington, DC 20554

Re: IBFS File No. SAT-MOD-20200417-00037; Call Signs: S2983 and S3018

Dear Ms. Dortch:

Space Exploration Holdings, LLC (SpaceX) has asked the Commission to authorize a wholesale reconfiguration of the company's non-geostationary satellite orbit (NGSO) fixed-satellite service (FSS) system.[1] It now requests permission to lower the altitude of 2,824 of the company's operational and replenishment satellites by as much as 785 kilometers and double the number of orbital planes.[2] SpaceX's proposal would result in a much denser web of satellites orbiting than ever before contemplated and, with it, a concomitant increase in the unwanted power SpaceX's NGSO system transmitting into co-channel Ku-Band direct broadcast satellite service (DBS) receivers that tens of millions of American consumers depend upon for news, entertainment, and information. Domestic and international rules require SpaceX to demonstrate that its power will not exceed what a standard DBS reference antenna can tolerate.[3] SpaceX has failed to make a facially sufficient showing of compliance, and SpaceX's failure requires dismissal of its application.

NGSO FSS downlink transmissions can cause harmful interference to co-channel DBS receivers. After SkyBridge LLC (Skybridge) proposed an eighty-satellite Ku-Band constellation in the 1990s, participants in the International Telecommunications Union (ITU) process studied the potential for interference to co-channel receivers.[4] At World Radiocommunication Conference 2000 (WRC-2000), the ITU Radiocommunication Sector (ITU-R) recommended protecting DBS against harmful interference from NGSO FSS operators by requiring NGSO operators not to

[1] *See generally* Third Modification Application of SpaceX, File No. SAT-MOD-20200417-00037 (filed Apr. 17, 2020) ("SpaceX Third Modification Application").

[2] *See id*. Narrative at 3-4.

[3] *See* 47 C.F.R. § 25.146(a)(2) ("An NGSO FSS applicant proposing to operate in the 10.7-30 GHz frequency range must certify that it will comply with…[a]ny applicable equivalent power flux-density levels in Article 22, Section II, and Resolution 76 of the ITU Radio Regulations (both incorporated by reference, § 25.108)).

[4] *See Application of SkyBridge L.L.C. for Authority to Launch and Operate a Global Network of Low-Earth Orbit Communications Satellites Providing Broadband Services in the Fixed-Satellite Service*, Order and Authorization, 20 FCC Rcd 12389 ¶¶ 6, 18, 29, 46 (2015).

exceed certain equivalent power flux density (EPFD) limits.[5] The FCC embraced the idea and, shortly after WRC-2000, applied the EPFD downlink limits to existing and future domestic NGSO FSS authorization holders.[6] As a result, DBS operators must today accept interference from NGSO FSS networks operating *below* the permitted EPFD downlink limits, but can claim interference protection from NGSO FSS systems operating *above* the permitted EPFD downlink limits.[7]

The EPFD limits work to safeguard DBS operations, but can prove complex to apply in practice. The EPFD formulas assume a "single-entry" EPFD value defined as the sum of the power flux-densities (PFDs) produced at a geostationary satellite orbit (GSO) receive station by the emissions from all the NGSO transmit stations in a constellation.[8] While software has advanced considerably since the original 1990s-era SkyBridge concept, assessing the single-entry EPFD implications of large constellations of satellites must account for variations in combinations among thousands of objects travelling dozens of orbital paths over time in three-dimensional space.[9] And with 4,408 satellites arrayed in 190 orbital planes, SpaceX's proposed system is an especially large constellation requiring complex modelling to support a certification that the system can satisfy applicable EPFD safeguards.

While SpaceX characterizes its current modification as a "modest adjustment" from its prior concept, the modification in fact reflects a massive reconfiguration of SpaceX's system.[10] Among other things, SpaceX's proposed modification would:

- Relocate all 4,408 satellites to an altitude less than half that of SpaceX's original proposal;
- More than triple the number of orbital planes from its originally authorized system and nearly double them from the currently authorized system;
- Stack the orbital shells with as little as ten kilometers of separation between them; and
- Drop the consistent minimum elevation angle from 40 to 25 degrees.[11]

These and other changes SpaceX has sought since first receiving an FCC authorization for its Norwegian- and U.S.-flagged satellite system result in SpaceX's current proposal bearing little resemblance to the system the FCC first authorized in 2018.

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[5] *See* Final Acts of WRC-2000, Article 22, 22.5C.

[6] *See generally Amendment of Parts 2 and 25 of the Commission's Rules to Permit Operation of NGSO FSS Systems Co-Frequency with GSO and Terrestrial Systems in the Ku-Band Frequency Range et al.*, First Report and Order and Further Notice of Proposed Rule Making, 16 FCC Rcd 4096 ¶¶ 170-204 (2000).

[7] *See id.*; *see also Policies and Rules for the Direct Broadcast Satellite Service*, Report and Order, 17 FCC Rcd 11331 ¶ 128 (2002).

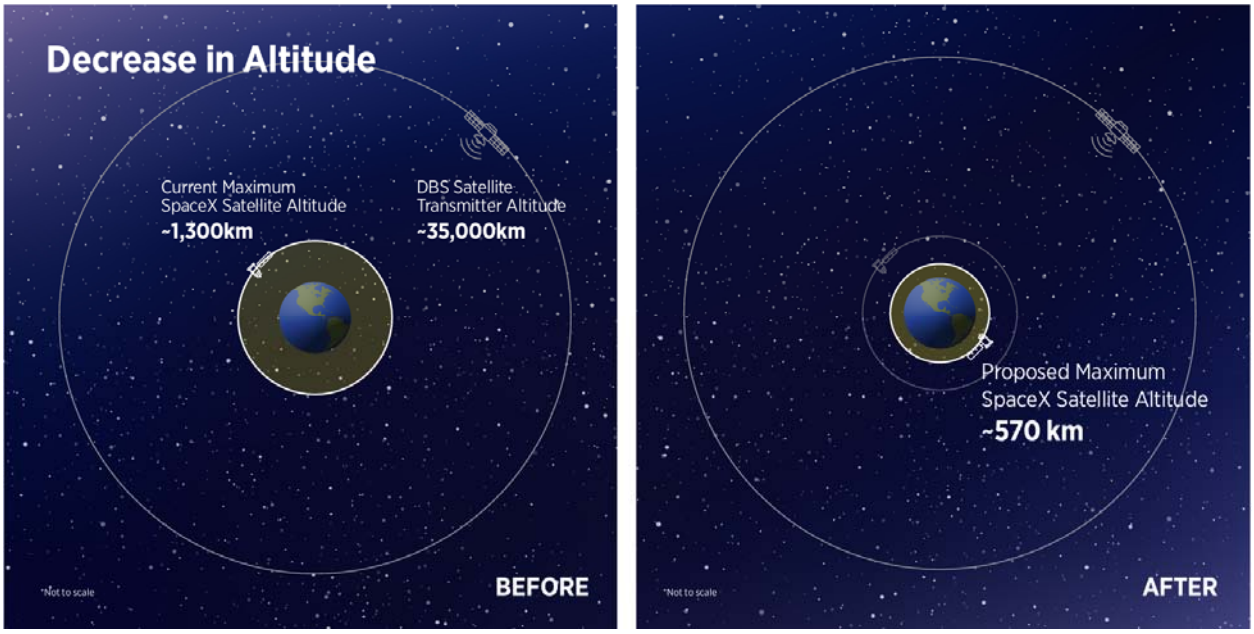
[8] *See* Final Acts of WRC-2000, Article 22, 22.5C.

[9] *EPFD and Recommendation ITU-R S.1503*, Transfinite Systems, https://bit.ly/3g3VEE9 (last visited May 19, 2020).

[10] SpaceX Third Modification Application, Narrative at i.

[11] *See id.* at 3-4.

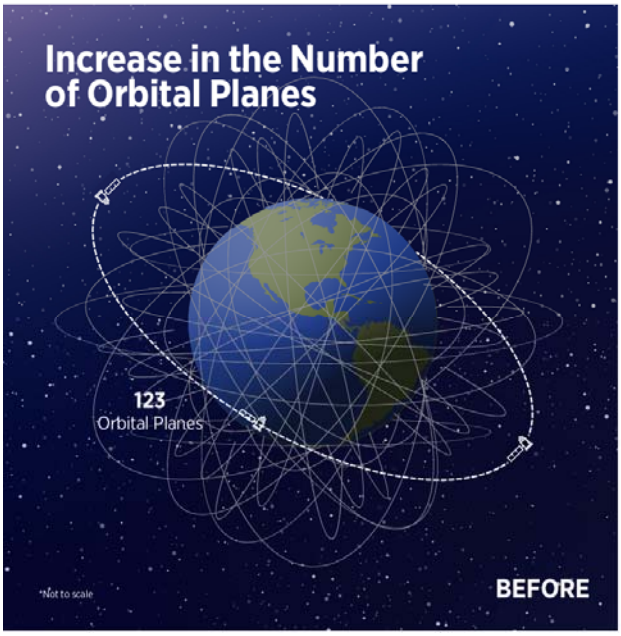
The simplified diagrams below depict how some of the latest proposed changes to the SpaceX system will affect DBS receivers on the ground. First, SpaceX proposes to drop its entire system (4,408 satellites) to substantially lower altitudes.[12]

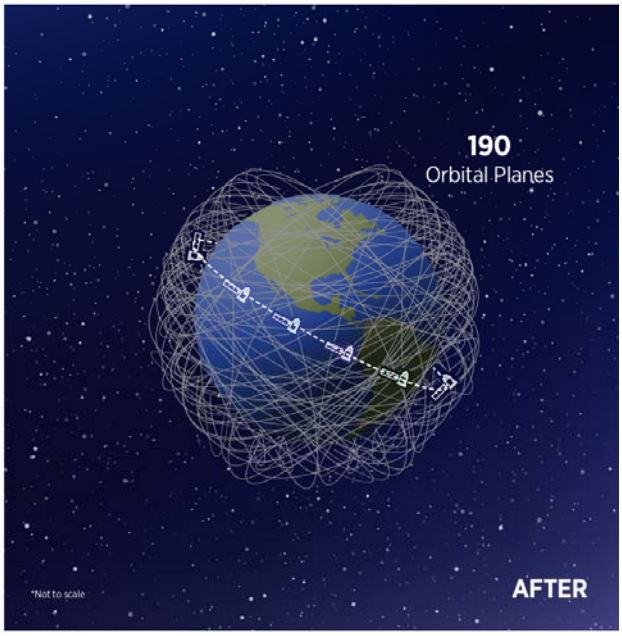


Second, SpaceX proposes to increase the number of orbital planes its system will use from the 83 the FCC originally authorized, beyond the 123 currently authorized, to a new record of 190 orbital planes. [13]

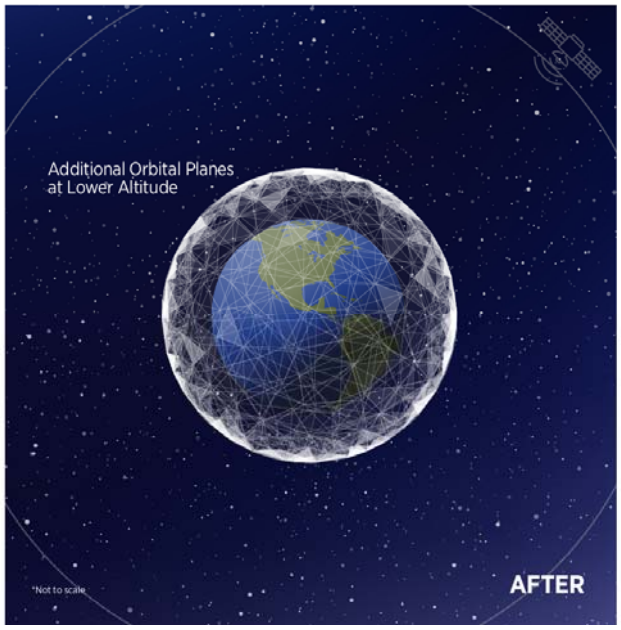
[12] *Compare* SpaceX Initial Application, Technical Attachment at 1, *with* SpaceX Third Modification Application, Narrative at 4.

[13] *Compare* SpaceX Initial Application, Technical Attachment at 1, *with* SpaceX Third Modification Application, Narrative at 3-4.





Taken together, these two variations have the effect of "tightening the net" of satellites encircling the Earth. As shown below, these changes create a sort of "Hoberman" sphere in which satellite density increases as altitude is reduced and the number of orbital planes are increased.



The effect of these changes is to position more SpaceX satellites in between the distant GSO satellites DBS operators, such as those DISH Network relies on to deliver services, and the equipment that their customers use to receive these signals in the band.

The magnitude and complexity of these changes require SpaceX to reliably demonstrate how its new design continues to satisfy the single-entry EPFD limits the FCC has adopted to protect DBS subscribers and other fixed earth station users on the ground.

SpaceX has not come close to meeting this burden. While the company says it has reduced EIRP density to maintain PFD on the ground, dubious assumptions and language in its analysis raise substantial questions about whether the information provided is sufficiently complete, accurate, and reliable.

As a threshold matter, even "modest" changes to system design and operational parameters can matter a great deal. SpaceX recognized as much in its original application:

> [F]or an NGSO satellite system to comply with the EPFD limits for the protection of GSO satellite networks, it must ensure that there is sufficient angular separation between the transmissions from the NGSO satellites … relative to the potential victim GSO earth stations... *A key factor to achieving this goal is the number of SpaceX satellites in the NGSO constellation relative to the service areas being covered.* The SpaceX constellation has sufficient satellites to ensure that there are *always multiple SpaceX satellites visible from any point in the service area at a high elevation angle – always greater than 40 degrees*.[14]

SpaceX's latest system reconfiguration is no "modest" change. Even if it were, the changes proposed to the number of satellites relative to the area being covered, combined with the elevation angle used, undercut the foundation of SpaceX's prior single-entry EPFD analysis.

In addition, troubling discrepancies exist between the single-entry EPFD analysis SpaceX has used and the one employed by others in the industry to account for the maximum number of non-geostationary satellites transmitting with overlapping frequencies to a given location in various latitude ranges. In its single-entry EPFD analysis, for example, OneWeb said that even though no more than two of its satellites would ever transmit service links to any given location, "a much higher value needs to be used when running the EPFD validation software in order to capture the contributions to the $EPFD_{down}$ from all the visible satellites, whether they are intentionally transmitting to this location or not."[15] To account for contributing emissions that would otherwise go uncaptured by the software, OneWeb said it used a value of 40 for all latitude ranges instead of a value of two.[16] Likewise, both Theia and Kepler, constellations with 112 and 140 satellites respectively, used a value of four satellites transmitting with overlapping frequencies to a given location in their EPFD analyses. SpaceX, by comparison, said that because its system is "designed such that only one satellite transmits to a given [end user] location in all latitude ranges," it set this

[14] *See* SpaceX Initial Application, Technical Attachment at 39.

[15] *See* Application of WorldVu Satellites Limited dba OneWeb, File No. SAT-LOI-20160428-00041, Technical Attachment at 5 (filed Apr. 28, 2016) ("OneWeb Application").

[16] *Id.*

parameter "to 1 for purposes of the EPFD validation analysis."[17] SpaceX's decision to use the lowest possible value of this parameter—the absolute least conservative assumption possible—as part of a critical analytical equation that is intended to demonstrate protection to primary GSO operations when other operators with smaller constellations use values that are four to 40 times larger demands further explanation.

Compounding the issues with SpaceX's assumed variable is the nature of the rest of its analysis. The table below compares an excerpt from OneWeb's technical narrative with an excerpt from SpaceX's technical narrative:

OneWeb Application	**SpaceX Application**
Specifically, No. 22.5C and 22.5I of the Radio Regulations defines Equivalent Power Flux Density ("EPFD") limits for the downlink transmissions from an NGSO satellite system in certain Ku and Ka-band downlink frequency ranges that must be met in order to not cause unacceptable interference to GSO satellite networks. The Ku-band EPFD↓ limits of the ITU are also reflected in §25.146, §25.208(g), §25.208(i), §25.208(j) and §25.208(l) of the Commission's rules for Ku-band. In addition, the Commission defines in §25.208(h) and §25.208(m) aggregate EPFD↓ limits arising from multiple co-frequency NGSO systems in Ku-band.	Specifically, No. 22.5C and 22.5I of the Radio Regulations define EPFD limits for the downlink transmissions from an NGSO satellite system in certain Ku- and Ka-band downlink frequency ranges that must be met in order to avoid causing unacceptable interference to GSO satellite networks. The ITU's Ku-band $EPFD_{down}$ limits are also reflected in Sections 25.146, 25.208(g), 25.208(i), 25.208(j), and 25.208(l) of the Commission's rules. In addition, the Commission defines in Sections 25.208(h) and 25.208(m) aggregate $EPFD_{down}$ limits arising from multiple co-frequency NGSO systems operating in the Ku-band.

Duplicating another applicant's work while deviating so egregiously from one of that work's core assumptions reflects a choice by SpaceX that raises questions about how reliable the company's analysis is in the first instance. Especially for an issue as critically important to continued operations as the single-entry EPFD downlink analysis, these limitations suggest something less than the type of robust showing that the Commission and the public have a right to expect.

In its defense, SpaceX asserts that deploying one less satellite in its enormous constellation of space stations—4,408 satellites instead of 4,409—will "facilitate compliance with applicable EPFD limits designed to promote harmonious operations with GSO satellite systems."[18] But whatever incidental benefit a single-satellite reduction may offer, the numerous other changes that SpaceX has proposed—namely, the reductions in satellite orbital altitude, a tripling of the number

[17] *See* SpaceX Initial Application, Technical Attachment at 29-32.

[18] *Id.* at ii.

of orbital planes, closely stacked orbital shells, and a considerably lower minimum elevation angle—all result in material increases in the single-entry EPFD that ground-based receivers likely will experience.

SpaceX has failed to provide a sufficiently reliable showing concerning how its reconfigured system would comply with the single-entry EPFD limits. Section 25.112(a) of the Commission's rules provides that "[a]n application will be unacceptable for filing and will be returned to the applicant if … [t]he application is defective with respect to completeness of answers to questions, informational showings, internal inconsistencies, execution, or other matters of a formal character; or [t]he application does not substantially comply with the Commission's rules, regulations, specific requests for additional information, or other requirements."[19] SpaceX's original 2016 application included details regarding the assumptions and methodology of their EPFD analysis. Since then, SpaceX seems to have continued to refine its EPFD analysis; however, *none* of the three modification applications SpaceX has filed, including the present application, offer any further detail or explanation of changes to the assumptions or to the methodology used to develop these "updates." As a result and in light of its questionable assumptions and other issues, SpaceX does not fully or reliably address the actual effects of EPFD, and, indeed, its present submission raises new concerns about the reliability of the application itself.

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Insisting that SpaceX offer a robust and reliable single-entry EPFD analysis is not regulatory hairsplitting. The EPFD limits on NGSO FSS operations are clear, important to consumers, and well known to SpaceX. Without either a meaningful showing of compliance to support the deficiency, SpaceX's present application is defective and must be dismissed.

Please feel free to contact me with any questions regarding this submission.

Sincerely,

_____/s/_____

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[19] 47 C.F.R. § 25.212(a).