

**Before the
Federal Communications Commission
Washington, D.C. 20554**

In the Matter of)	
)	
Space Exploration Holdings, LLC)	IBFS File No. SAT-LOA-20161115-00118
)	
Application For Approval for Orbital Deployment and Operating Authority for the SpaceX NGSO Satellite System)	Call Sign S2983
)	
Application For Approval For Orbital Deployment And Operating Authority for the SpaceX NGSO Satellite System Supplement)	SAT-LOA-20170726-00110 Call Sign S3018

MEMORANDUM OPINION, ORDER AND AUTHORIZATION

Adopted: March 28, 2018

Released: March 29, 2018

By the Commission: Commissioner Rosenworcel issuing a statement.

I. INTRODUCTION

1. In this Memorandum Opinion, Order and Authorization, we authorize Space Exploration Holdings, LLC (SpaceX) to construct, deploy, and operate a proposed non-geostationary orbit (NGSO) satellite system comprising 4,425 satellites for the provision of fixed-satellite service (FSS) around the world.¹ In granting those parts of SpaceX’s Application and Supplemental Application that were accepted for filing, we address concerns expressed by commenters seeking various conditions on the grant and partially deny two Petitions to Deny. Grant of this application will enable SpaceX to bring

¹ *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) (SpaceX Application). On November 22, 2016, SpaceX submitted an erratum to its application that contains a corrected version of the Technical Attachment, in which the scale of the axes in the antenna beam contour diagrams (Figures A.3.1-3 through A.3.1-8 and A.3.2-1 through A.3.2-5) reflects the written description, and a corrected version of the associated GXT files to update those in the original Schedule S. See Letter from William M. Wiltshire, Counsel to SpaceX, to Marlene H. Dortch, Secretary, FCC, (Nov. 22, 2016) (SpaceX Erratum). As described below, SpaceX subsequently filed a second application seeking to add certain frequency bands to its system. *Space Exploration Holdings, LLC, Application for Approval for Orbital Deployment and Operating Authority for the SpaceX NGSO Satellite System Supplement*, IBFS File No. SAT-LOA-20170726-00110 (filed Jul. 26, 2017) (SpaceX Supplemental Application). SpaceX’s request in the Supplemental Application for operations in the 29.3-29.5 GHz frequency bands is not before us, because the International Bureau has not accepted that part of the application for filing. See *Satellite Policy Branch Information: Space Station Applications Accepted for Filing*, Public Notice, Report No. SAT-01277 (IB Oct. 20, 2017). The International Bureau deferred a determination concerning the acceptability for filing for the 29.3-29.5 GHz band because the International Telecommunication Union (ITU) Radio Regulations limit the use of the band 29.1-29.5 GHz by the FSS to geostationary-satellite systems and feeder links to NGSO systems in the mobile-satellite service. See 5.535A of the ITU Radio Regulations.

high-speed, reliable, and affordable broadband service to consumers in the United States and around the world, including areas underserved or currently unserved by existing networks.²

II. BACKGROUND

2. *Application.* On November 15, 2016, SpaceX filed an application requesting authority for its proposed NGSO FSS satellite system, comprising 4,425 satellites in 83 orbital planes, at an approximate altitude of 1,110 to 1,325 kilometers. In this application, SpaceX proposes to operate in the 10.7-12.7 GHz, 13.85-14.5 GHz, 17.8-18.6 GHz, 18.8-19.3 GHz, 27.5-29.1 GHz, and 29.5-30 GHz bands. SpaceX also requests waivers of certain Commission rules.³

3. *Processing Rounds.* On July 15, 2016, the Commission accepted for filing the petition for declaratory ruling of WorldVu Satellites Limited, d/b/a/ OneWeb (OneWeb Petition).⁴ At the same time that the Commission accepted the OneWeb Petition for filing, it initiated a processing round for additional NGSO-like applications and petitions in the frequency bands requested by OneWeb.⁵ The processing round closed on November 15, 2016. Eleven additional applications and petitions were filed for NGSO-like satellite systems, including the application filed by SpaceX.⁶ On May 26, 2017, the SpaceX Application was accepted for filing, and at the same time a second processing round was initiated for the additional frequency bands requested by other applicants and petitioners.⁷ The second processing round closed on July 26, 2017 with two additional applications received, including a supplemental application from SpaceX, which requested the addition of the 12.75-13.25 GHz, 19.7-20.2 GHz and 29.3-29.5 GHz bands.⁸ In that application, SpaceX also requested certain waivers of the Commission rules.⁹

² 47 U.S.C. § 151; SpaceX Application, Narrative at 3.

³ SpaceX requests waiver of sections 25.202(a)(1), 25.202(g)(1), 25.157(e), 25.164(b), 25.208(e), 25.145(c), 25.146(i), 25.146(a), and 25.202(a)(1) n.6 of the Commission's rules, and conditional waiver of any restriction in section 2.106 of the Commission's rules on SpaceX's proposed use of the 17.8-18.6 GHz band, and waiver of various limitations in the Commission's Schedule S, in connection with this application.

⁴ *OneWeb Petition Accepted for Filing, IBFS File No. SAT-LOI-20160428-00041; Cut-Off Established for Additional NGSO-Like Satellite Applications or Petitions for Operations in the 10.7-12.7 GHz, 14.0-14.5 GHz, 17.8-18.6 GHz, 18.8-19.3 GHz, 27.5-28.35 GHz, 28.35-29.1 GHz, and 29.5-30.0 GHz Bands*, Public Notice, 31 FCC Rcd 7666 (IB 2016).

⁵ *Id.*; see also 47 CFR § 25.157(a) (defining “NGSO-like satellite operation” as operation of any NGSO satellite system, and operation of a geostationary-satellite orbit, mobile-satellite service satellite to communicate with earth stations with non-directional antennas).

⁶ See IBFS File Nos. SAT-MOD-20160624-00060 and SAT-AMD-20161115-00116 (O3b Limited); SAT-PDR-20161115-00108 (Telesat Canada); SAT-LOA-20161115-00109 (The Boeing Company); SAT-PDR-20161115-00111 (Space Norway AS); SAT-PDR-20161115-00112 (LeoSat MA, Inc.); SAT-LOA-20161115-00113 (Karousel LLC); SAT-PDR-20161115-00114 (Kepler Communications Inc.); SAT-LOA-20161115-00117 (Audacy Corporation); SAT-LOA-20161115-00118 (SpaceX); SAT-PDR-20161115-00120 (ViaSat, Inc.); and SAT-LOA-20161115-00121 (Theia Holdings A, Inc.).

⁷ *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*, Public Notice, DA 17-524 (IB rel. May 26, 2017). The application of Kepler Communications Inc. was accepted for filing in a subsequent public notice. See *Satellite Policy Branch Information: Space Station Applications Accepted for Filing*, Public Notice, Report No. SAT-01259 (IB Aug. 11, 2017).

⁸ See IBFS File Nos. SAT-LOA-20170726-00110 (SpaceX Supplemental Application); SAT-LOI-20170726-00111 (New Spectrum Satellite, Ltd). As noted above, SpaceX's application for operations in the 29.3-29.5 GHz bands was not accepted for filing.

⁹ In the SpaceX Supplemental Application, SpaceX requests waiver of sections 25.157(e), 25.164(b), 25.145(c), 25.146(i), and, to the extent necessary, restrictions on SpaceX's proposed use of the 19.7-20.2 GHz and 29.3-29.5 GHz bands for NGSO operations in the U.S. and various limitations in the Commission's Schedule S.

Each of the applicants and petitioners filing in this processing round, including OneWeb, proposes an NGSO FSS system that, if approved, would have the same status and the same rights as other participants in the same processing round in case any division of frequencies is required to avoid mutual interference.¹⁰ On June 22, 2017, the Commission adopted an order granting the OneWeb Petition (*OneWeb Order*).¹¹ On November 2, 2017, the Commission adopted orders granting petitions for U.S. market access by Space Norway and Telesat.¹²

4. *Comments.* Telesat Canada (Telesat) and ViaSat, Inc. (ViaSat) filed petitions to deny the SpaceX Application. Telesat's petition is based mainly on concerns related to the impact of the "avoidance of in-line interference" mechanism.¹³ ViaSat echoes concerns about the in-line interference mechanism, and in its petition urges the Commission to deny SpaceX's application unless certain conditions are imposed on the grant.¹⁴ Other satellite operators filed comments expressing concerns regarding SpaceX's orbital debris showing.¹⁵ SES S.A. (SES) and O3b Limited (O3b) stated that SpaceX has not included files with equivalent isotropically radiated power (EIRP) and power flux density (PFD) masks necessary to independently assess the proposed system's compliance with applicable equivalent power flux-density (EPFD limits) and that the Commission should defer action on this proposal pending submission of the relevant PFD and EIRP mask data.¹⁶ SpaceX opposed the petitions to deny and responded to the comments.¹⁷ A number of commenters urge the Commission to hold off acting on the

¹⁰ See *WorldVu Satellites Limited, Petition for Declaratory Ruling Granting Access to the U.S. Market for the OneWeb NGSO FSS System*, Order and Declaratory Ruling, 32 FCC Rcd 5366, 5371-72, para. 11 (2017) (*OneWeb Order*).

¹¹ See *OneWeb Order*, 32 FCC Rcd at 5366, para 1.

¹² *Space Norway AS*, Order and Declaratory Ruling, 32 FCC Rcd 9649 (2017) (*Space Norway Order*); *Telesat Canada*, Order and Declaratory Ruling, 32 FCC Rcd 9663(2017) (*Telesat Canada Order*).

¹³ Telesat argues that SpaceX's NGSO system would interfere with Telesat's NGSO operations because the two systems would operate in overlapping geographical areas on overlapping Ka-band frequencies, and that Telesat has demonstrated that in-line interference mechanisms are unworkable. Furthermore, Telesat states that SpaceX offers no recognition that the Canadian ITU filings that are associated with Telesat's NGSO system have date priority over later ITU filings that may be associated with SpaceX's system band frequencies. Telesat also indicates that grant of SpaceX's application must be conditioned on the outcome of the NGSO rulemaking, as the Commission did in granting OneWeb's NGSO application. Telesat Petition to Deny at 1-5 (filed June 26, 2017). ViaSat argues that reliance on the "avoidance of in-line interference" mechanism in awarding spectrum would actually *harm* the ability of competitive NGSO systems to operate effectively. ViaSat Petition to Deny or Impose Conditions at 75-79 (filed June 26, 2017) (ViaSat Petition to Deny). ViaSat also argues that SpaceX's (and others') requests for waiver of the current and longstanding band segmentation provisions set forth in section 25.157 of the Commission's rules constitute improper and inequitable post-cutoff notice rule changes. ViaSat also cites the potential for aggregate interference from multiple NGSO systems into GSO operations. *Id.* at 8.

¹⁴ See ViaSat Petition to Deny (requesting that Commission condition grant on compliance with the outcome of future rulemakings, limit operations to the parameters specified in the application rather than the limits of what the rules permit, and impose several conditions related to aggregate interference); ViaSat Reply (filed July 14, 2017).

¹⁵ Space Norway Comments at 1-5 (filed June 26, 2017); Space Norway Response at 7-10 (filed July 14, 2017); SES S.A. and O3b Limited Comments at 4-7 (filed Aug. 15, 2016) (SES and O3b Comments). OneWeb also requested further information from SpaceX regarding its plans to mitigate orbital collisions and debris. WorldVu Satellite Limited Comments at 7-15 (filed June 26, 2017) (OneWeb Comments). SES and O3b requested SpaceX to provide further technical information regarding orbital debris and EPFD compliance. SES and O3b Comments at 4-7 (filed June 26, 2017). Spire made a similar request. Spire Comments to SpaceX at 3 (filed June 26, 2017) (Spire Comments).

¹⁶ SES and O3b Comments at 4-5 (filed June 26, 2017).

¹⁷ Space X Consolidated Opposition and Response at 22 (filed July 7, 2017) (SpaceX Opposition). SpaceX agrees with Telesat's request that any authorization granted in this processing round be conditioned upon compliance with rules adopted in the *NGSO NPRM* proceeding, including in-line avoidance mechanisms. SpaceX Opposition at 31.

request for partial waiver of the final implementation milestone in Section 25.164(b).¹⁸ SpaceX also responded to these comments.¹⁹ Finally, EchoStar and Hughes filed reply comments in which they argued that SpaceX's request for waiver of the downlink PFD limits in the 18.8-19.3 GHz band should be denied because it increases the risk of interference to space-to-Earth links that Hughes is authorized to use in the United States, and that grant of this waiver request would change the conditions established by section 25.208(e), upon which Hughes based its decision to operate on a non-interference basis.²⁰

5. *Comments to SpaceX Supplemental Application.* OneWeb and SES/O3b filed comments to the SpaceX Supplemental Application. Similar to its earlier comments, OneWeb argues that the SpaceX FSS constellation would not be able to meet the Commission's milestone and domestic coverage requirements, and thus SpaceX's request for waiver of these requirements should be denied.²¹ OneWeb also argues that SpaceX had not demonstrated that its system will not increase the risk of collision with other operators or casualty risks upon deorbit, and that grant of SpaceX's application should be delayed until it provides quantitative data concerning these risks.²² SES argues that the Commission must condition SpaceX's authorization in the 19.7-20.2 GHz band to not interfere with SES's operations as well as other geostationary satellite orbit (GSO) systems. It further argues that SpaceX's request for waiver of the implementation milestones should be deferred pending the outcome of the NGSO proceedings, and that SpaceX's authorization should include terms and conditions similar to those applied to O3b and other systems.²³ SpaceX filed a response to these comments.²⁴ We address the petitions and comments on both the Application and the Supplemental Application, as well as SpaceX's responses, in the discussion below.

6. *NGSO FSS Order.* On September 26, 2017, following the close of the comment cycle in this proceeding, the Commission adopted a Report and Order updating several rules and policies governing NGSO FSS systems, including the proposed SpaceX system.²⁵ Among other changes, the Commission adopted EPFD limits on NGSO FSS systems operating in portions of the 17.8-20.2 GHz and 27.5-30 GHz frequency bands in order to protect GSO FSS networks. The Commission also adopted a more flexible milestone schedule for NGSO constellations. As these changes are now in effect,²⁶ we consider below their pertinence to the public interest analysis required to act upon the SpaceX Application.

¹⁸ Application, Waiver Requests at 1-2. OneWeb Comments at 3-11; SES and O3b Comments at 10 and Hughes Reply Comments at 2 (filed July 7, 2017). Hughes also opposes waiver of the downlink PFD limits in the 18.8-19.3 GHz band. *Id.* at 3-4.

¹⁹ SpaceX Opposition (filed July 7, 2017). *See also* SpaceX Consolidated Reply Comments at 9 (filed July 14, 2017), wherein SpaceX stated that because it has demonstrated that the requested relief is appropriate in the specific circumstances of this case, it would not be appropriate for the Commission to defer consideration of these issues to the *NGSO NPRM* proceeding as Intelsat suggests.

²⁰ Hughes Reply Comments at 4.

²¹ OneWeb Comments to Supplemental Application at 1-2, 4-8 (filed Nov. 20, 2017).

²² *Id.* at 2-3.

²³ SES/O3b Comments to Supplemental Application (filed Nov. 20, 2017).

²⁴ SpaceX Consolidated Response (filed Dec. 5, 2017).

²⁵ *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 (2017), *recon. pending (NGSO FSS Order)*.

²⁶ These rules became effective January 17, 2018, except the amendments to Sections 25.114, 25.115, 25.146, and 25.164, which contain information collection requirements that have not been approved by The Office of Management and Budget (OMB). *See* 82 Fed. Reg. 59972-01 (Dec. 18, 2017). The Commission will publish a document in the Federal Register announcing such OMB approval and the effective date of these rule amendments.

III. DISCUSSION

7. After review of the record, we conclude that grant of the SpaceX Application, as supplemented,²⁷ will serve the public interest, subject to the requirements and conditions specified herein. Below, we address the various outstanding issues raised by commenters on SpaceX's Application and Supplemental Application. We also address SpaceX's waiver requests. Where appropriate, we defer matters of general applicability to ongoing or potential future rulemakings.

8. *ITU Coordination.* In its Petition to Deny, Telesat observes that international coordination will be required between the SpaceX system and its own NGSO FSS system.²⁸ Telesat argues that, at minimum, any grant to SpaceX should be conditioned upon compliance with this international obligation. In response, SpaceX argues in support of the Commission's avoidance of in-line interference regime, which, it asserts, yields more efficient spectrum sharing results than a regime based solely upon ITU priority.²⁹ We recently declined to adopt Telesat's proposal to tie coordination obligations and licensing conditions directly to ITU filing dates by awarding priority according to those dates,³⁰ and accordingly deny Telesat's petition in so far as it reiterates Telesat's ITU filing date priority proposal. We include a condition requiring SpaceX, like all other NGSO FSS operators, to comply with the spectrum sharing requirements specified in section 25.261 of the Commission's rules with respect to any other NGSO system licensed or granted U.S. market access pursuant to the processing rounds in which SpaceX participated.³¹ We recently adopted changes to section 25.261 that replaced the avoidance of in-line interference methodology for triggering spectrum division (absent coordination) with a default spectrum splitting sharing mechanism that is triggered when the change in system noise temperature caused by interference, or $\Delta T/T$, exceeds a threshold of 6 percent.³² However, we note that outside the United States (*i.e.*, when communications to or from the U.S. territory are not involved) the coexistence between SpaceX's operations and operations of a system that received a grant for access to the U.S. market are governed only by the ITU Radio Regulations as well as the regulations of the country where the earth station is located and are not subject to section 25.261.

9. *EPFD Analysis.* Several commenters suggested that the EPFD analysis provided by SpaceX is insufficient and that the Commission should request a supplemental EPFD analysis.³³ We disagree. We find that SpaceX's demonstrations in its application and associated filings are sufficient to justify grant of its application. Furthermore, SpaceX has provided a revised EPFD analysis using ITU-approved software.³⁴ To ensure that SpaceX will satisfy its EPFD obligations going forward, we condition this grant on SpaceX receiving a favorable or "qualified favorable" rating of its EPFD

²⁷ SpaceX Supplemental Application, IBFS File No SAT-LOA-20170726-00110.

²⁸ Telesat Petition to Deny at 3-4; Telesat Reply (filed July 7, 2017); *see also* ITU Radio Regulations, No. 9.12 (requiring coordination of certain NGSO systems), No. 9.53 (requiring both parties in coordination to "make every possible mutual effort to overcome [coordination] difficulties, in a manner acceptable to the parties concerned"), No. 11.42 (requiring the immediate cessation of harmful interference actually caused to a recorded assignment with which coordination is required but has not been effected).

²⁹ SpaceX Consolidated Reply (dated July 14, 2017) at 9-10.

³⁰ *NGSO FSS Order* at 32 FCC Rcd 7825-26, para. 50.

³¹ *See OneWeb Order*, 32 FCC Rcd at 5377, *see also infra*, para. 45.

³² *NGSO FSS Order* at 32 FCC Rcd 7825, para. 49.

³³ *See* SES and O3b Comments at 3-5; SES and O3b Reply at 2-5 (filed July 14, 2017); OneWeb Comments at 3, 15-16; Hughes Comments at 2-3.

³⁴ Letter from William M. Wiltshire, Counsel to SpaceX, to Marlene H. Dortch, Secretary, Federal Communications Commission (dated July 12, 2017) (SpaceX July 12, 2017 Letter) (indicating that SpaceX has submitted updated data files that would enable interested parties with access to the Transfinite software to review the EPFD analysis for SpaceX's system).

demonstration by the ITU prior to initiation of service.³⁵ Review by the ITU of SpaceX compliance with ITU EPFD limits, using methods now approved by the ITU,³⁶ will provide sufficient assurances beyond the other technical demonstrations that SpaceX has already provided that SpaceX will comply with the EPFD limits specified in Article 22 of the Radio Regulations.

10. As we did in other recent approvals for NGSO FSS operations,³⁷ we are permitting SpaceX to operate up to the PFD and EPFD levels specified in applicable regulations, rather than the levels associated with specific demonstrations in its application. We find this flexibility is warranted given the preliminary nature of the system design, the fact that this grant is conditioned on SpaceX's satisfaction of the ITU's EPFD assessment and the condition that SpaceX cooperate with other NGSO operators to meet limits for aggregate EPFD. We therefore reject ViaSat's arguments that SpaceX should be limited to the levels used in the EPFD demonstration in its application and deny this portion of ViaSat's Petition to Deny.³⁸

11. *Buffer Zone and Orbital Debris.* To avoid collisions with OneWeb satellites, OneWeb requested that grant of SpaceX's application be conditioned on SpaceX maintaining "an approximate 125 kilometer altitude buffer zone (the "Safety Buffer Zone") between its constellation and other NGSO systems," including OneWeb's own NGSO system, subject to coordination.³⁹ As a preliminary matter, the scope of OneWeb's request is unclear and could be interpreted to request a buffer zone that spans altitudes between 1,015 and 1,385 kilometers. Imposition of such a zone could effectively preclude the proposed operation of SpaceX's system, and OneWeb has not provided legal or technical justification for a buffer zone of this size. While we are concerned about the risk of collisions between the space stations of NGSO systems operating at similar orbital altitudes, we think that these concerns are best addressed in the first instance through inter-operator coordination. At this stage, we do not believe it appropriate to specify the methods for effecting coordination, which may involve a wide range of changes in system design and operations. SpaceX will be subject to the same conditions as OneWeb, Telesat Canada, and Space Norway,⁴⁰ including the requirement that it coordinate its physical operations with space stations of NGSO systems operating at similar orbital altitudes. To the extent that SpaceX and other NGSO operators fail to come to an agreement regarding physical coordination, the Commission may intervene as appropriate.

12. An applicant for a space station authorization must submit a description of the design and operational strategies that it will use to mitigate orbital debris, including a statement detailing post-mission disposal plans for space stations at the end of their operating life.⁴¹ SpaceX included an orbital debris mitigation plan in its application.⁴² Thereafter, the Satellite Division (Division) sent a letter to

³⁵ See *infra* para. 40(n).

³⁶ Letter from Francois Rancy, Director, ITU Radiocommunication Bureau, to Administrations of ITU Member States, "Examinations under Resolution 85 (WRC-03)" (Dec. 6, 2016), <https://www.itu.int/md/R00-CR-CIR-0414/en>. SpaceX modified the beta software to reflect the specifics of its system design.

³⁷ See *OneWeb Order, Space Norway Order, Telesat Canada Order* (collectively, "NGSO FSS Commission grants").

³⁸ ViaSat Petition to Deny at 3-8.

³⁹ OneWeb Comments at 12.

⁴⁰ *OneWeb Order*, 32 FCC Rcd at 5378, para. 25(d), *Space Norway Order*, 32 FCC Rcd at 9649, para. 26(c); *Telesat Canada Order*, 32 FCC Rcd at 9663, para. 12.

⁴¹ *Mitigation of Orbital Debris*, Second Report and Order, 19 FCC Rcd 11567, 11619 (2004); 47 CFR § 25.114(d)(14).

⁴² See SpaceX Application, Technical Supplement to Schedule S, Section A.11, at 49-68.

SpaceX requesting additional information regarding its orbital debris mitigation plan.⁴³ On April 20, 2017, SpaceX provided answers to the Division's questions.⁴⁴

13. In its comments, Spire Global (Spire) raises concerns about SpaceX's orbital debris mitigation plan. Specifically, Spire asserts that more information is needed regarding those NGSO applications, including SpaceX's, with post-mission disposal plans through atmospheric re-entry so that existing operators can assess the risk from those disposals.⁴⁵ OneWeb argues that SpaceX fails to provide critical information necessary for other NGSO operators to properly assess the potential for its constellation to become a source of orbital debris.⁴⁶ The National Aeronautics and Space Administration (NASA) also raises the general concern, mainly in response to SpaceX's satellite constellation, that NGSO applicants seeking to deploy a large number of satellites (*i.e.*, over 4,000) may need to ensure a higher degree of reliability in their post-mission disposal operations than NASA's current 90% reliability standard.⁴⁷

14. In its reply, SpaceX agrees that given the number of NGSO systems that may be launched over the next decade, physical coordination between systems may be required.⁴⁸ SpaceX further agrees that operators should share satellite location data and other information that will allow all systems to coexist safely in space.⁴⁹ Regarding OneWeb's concern about collisions between SpaceX satellites, SpaceX states that the tolerances of the specified orbital parameters afford sufficient flexibility to achieve necessary spacing between satellites, and it has designed its spacecraft with the capability to avoid potential collisions, which it can use as necessary to ensure safe operating distances.⁵⁰ SpaceX indicates that it will receive ephemeris data from its own spacecraft, which will provide precise location information and thereby enable SpaceX to operate with a high level of confidence with respect to potential conjunctions. SpaceX notes that it continues to refine its operational strategies to enhance safety, citing "an ongoing simulation corroborating probabilities between information from the Joint Space Operations Center (JSpOC) and the predictions of NASA's Orbital Debris Engineering Model, which is used to analyze collision risks under different maneuver protocols."⁵¹ SpaceX argues that it has provided more detailed information and analysis related to its orbital debris mitigation and end-of-life disposal plans than any other applicant in this processing round, including: (1) a demonstration that SpaceX satellites will re-enter the Earth's atmosphere within approximately one year after completion of their mission – much sooner than the international standard of 25 years, and (2) the inputs and outputs of an assessment using NASA's Debris Assessment Software (DAS), which indicates a level of safety that exceeds the requirements established by NASA and regulatory authorities in other countries.⁵² SpaceX states it is also working directly with NASA on a higher fidelity re-entry analysis, employing NASA's proprietary Object Reentry Survival Analysis Tool (ORSAT), a more comprehensive model that provides

⁴³ See Letter from Jose P. Albuquerque, Chief, Satellite Division, to William M. Wiltshire, Counsel to SpaceX (dated Mar. 21, 2017) (*March 21 Letter*).

⁴⁴ See Letter from William M. Wiltshire, Counsel to SpaceX, to Jose P. Albuquerque, Chief, Satellite Division (dated May 5, 2017).

⁴⁵ Spire Global Comments at 2-5 (filed June 26, 2017).

⁴⁶ OneWeb Comments at 11-15.

⁴⁷ NASA Comments at 2 (filed June 26, 2017).

⁴⁸ SpaceX Consolidated Reply at 9.

⁴⁹ *Id.*

⁵⁰ SpaceX Opposition at 10-11.

⁵¹ *Id.* at 11.

⁵² *Id.* at 7.

a greater level of precision and insight over the standard DAS analysis that can help guide SpaceX as it continues to refine its system and operations.⁵³

15. Although we appreciate the level of detail and analysis that SpaceX has provided for its orbital debris mitigation and end-of-life disposal plans, we agree with NASA that the unprecedented number of satellites proposed by SpaceX and the other NGSO FSS systems in this processing round will necessitate a further assessment of the appropriate reliability standards of these spacecraft, as well as the reliability of these systems' methods for deorbiting the spacecraft.⁵⁴ Pending further study,⁵⁵ it would be premature to grant SpaceX's application based on its current orbital debris mitigation plan. Accordingly, we believe it is appropriate to condition grant of SpaceX's application on the Commission's approval of an updated description of the orbital debris mitigation plans for its system.⁵⁶

16. *Matters Broadly Applicable to NGSO FSS Applications.* Hughes urges the Commission to adopt mechanisms for ensuring that aggregate EPFD limits are met by all NGSO systems authorized in the United States.⁵⁷ ViaSat questions the sufficiency of the EPFD limits proposed by the Commission to protect GSO systems from harmful interference and requests that each NGSO operator be held jointly and severally liable for harmful interference caused to GSO systems until the Commission adopts adequate aggregate EPFD limits and enforcement mechanisms.⁵⁸ Space Norway requests that grant of SpaceX's application be conditioned on SpaceX's implementation of mechanisms to avoid in-line interference with highly elliptical orbit NGSO systems, such as that proposed by Space Norway.⁵⁹ Spire states that the Commission should condition grant of these applications on the outcome of future rulemakings, specifically if the Commission adopts any new orbital debris requirements.⁶⁰

17. All of these comments relate to issues of general applicability that are more appropriately addressed in the context of a rulemaking. Several of these issues were already raised in the then-ongoing rulemaking proceeding concerning NGSO FSS matters⁶¹ that were addressed in a *Report and Order*

⁵³ *Id.* at 6-7.

⁵⁴ NASA Comments (filed June 26, 2017) (noting that (1) 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, and that currently, no consensus exists on what the two reliability numbers should be, and (2) 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).

⁵⁵ In addition to the ongoing work by SpaceX, we also note that NASA identifies two studies, 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 by May of 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 International Space Station. *Id.*

⁵⁶ We have required applicants to file a modification application including updated orbital debris mitigation information in some instances. See, e.g., *Space Norway Order*, 32 FCC Rcd 9649, para. 11; *Telesat Canada Order*, 32 FCC Rcd 9663, para. 14. See also *Northrop Grumman Space & Mission Systems Corp.*, Order and Authorization, 24 FCC Rcd 2330, 2363-64, para. 102 (IB 2009) (*Northrop Grumman Order*); *ContactMEO Communications, LLC*, Order and Authorization, 21 FCC Rcd 4035, 4052-53, para. 47 (IB 2006).

⁵⁷ Hughes Comments at 3.

⁵⁸ ViaSat Petition to Deny (filed June 26, 2017).

⁵⁹ Space Norway Comments at 2.

⁶⁰ Spire Global Comments at 2-5.

⁶¹ *Update to Parts 2 and 25 Concerning Non-Geostationary, Fixed-Satellite Service Systems and Related Matters*, Notice of Proposed Rulemaking, 31 FCC Rcd 13651, 13656-58, paras. 12, 17 (2016) (*NGSO FSS NPRM*).

adopted September 26, 2017.⁶² For example, Hughes and ViaSat express concerns about international EPFD limits and aggregate EPFD enforcement mechanisms, and these concerns have since been addressed in the *NGSO FSS Order*.⁶³ Space Norway's request for a condition requiring SpaceX to protect the Space Norway NGSO system as though it were a GSO space station is in effect a request that the Commission reevaluate its licensing procedures with regard to an entire class of NGSO systems, *i.e.*, those with highly-elliptical orbits. As indicated above, we defer consideration of such broadly applicable matters to future rulemakings, and condition grant of the SpaceX application on the outcome of such rulemaking proceedings, including the most recent NGSO FSS decision.⁶⁴ We note that, as with the *OneWeb Order*, *Telesat Canada Order*, and *Space Norway Order*, grant of the SpaceX application will not prejudice any decision, including a contrary action, in any future rulemaking proceedings.⁶⁵ Rather, decisions of general applicability in such proceedings will be based on the totality of comments and proposals in those proceedings, including SpaceX's.⁶⁶ Accordingly, in addition to being subject to any future proceedings, SpaceX would have to comply with any new orbital debris requirements.

18. *Radio Astronomy.* Out-of-band signals into allocated radio astronomy bands can cause interference to radio astronomy observations.⁶⁷ We also note that radio astronomy as a service frequently makes use of observations (passive) in bands not allocated to the radio astronomy service. This practice is a result of scientifically valuable signals being subject to the Doppler Effect and shifted in frequency outside radio astronomy-allocated bands. Although not a condition to this authorization, SpaceX should be aware of these facts and contact the National Science Foundation Spectrum Management Unit (esm@nsf.gov) to assist with coordination and information on radio astronomy sites.

19. *Conditions.* Below, we condition this grant of authority in response to comments and as warranted in the public interest. These conditions relate to ITU coordination, power limits, avoidance of interference, orbital debris mitigation, future rulemakings, bond and milestone requirements, and other existing requirements in our rules and in footnotes to the Table of Frequency Allocations. We also include specific conditions related to our waiver grants. To the extent that the SpaceX application raises the same concerns as those raised in the recent proceedings for addressing market access for NGSO FSS operations in the United States, *e.g.*, OneWeb, Space Norway, Telesat, we impose substantially identical conditions on SpaceX's grant. In their comments, SES/O3b asks that we impose on any grant for the SpaceX system the same conditions that were imposed on O3b's NGSO FSS constellation.⁶⁸ Since the

⁶² See generally *NGSO FSS Order*.

⁶³ Recently, we considered ViaSat's concerns regarding the sufficiency of existing international EPFD limits and found that although ViaSat had not proposed any new EPFD limits, it would not be advisable to remain without Ka-band EPFD limits in our rules pending such deliberations. Thus we adopted the ITU EPFD limits in the 17.8-30 GHz frequency range and require NGSO FSS licensees to comply with existing aggregate EPFD limits. See *NGSO FSS Order* at 7820-21, para. 35.

⁶⁴ We note that this condition also addresses several comments that requested that grant of SpaceX's application be conditioned on compliance with certain pending and future rulemakings. See *ViaSat Petition to Deny* at 3, 7, 9-10; *Spire Comments* at 3, 5, 7; *Hughes Reply* at 2.

⁶⁵ See, *e.g.*, *NGSO FSS Order*; *Use of Spectrum Bands Above 24 GHz For Mobile Radio Services*, Report and Order and Further Notice of Proposed Rulemaking, 31 FCC Rcd 8014 (2016) (*Spectrum Frontiers R&O and FNPRM*); *Expanding Flexible Use in Mid-Band Spectrum Between 3.7 and 24 GHz*, Notice of Inquiry, 32 FCC Rcd. 6373, 6377 n.14 (2017) (*Mid-Band NOI*).

⁶⁶ To the extent that commenters believe that their concerns are not already addressed by ongoing rulemakings, we remind commenters that they have the option to file petitions for rulemaking with the Commission.

⁶⁷ See, *e.g.* Letter from Harvey S. Liszt, Astronomer and Spectrum Manager, National Radio Astronomy Observatory, to Ajit Pai, Chairman, FCC, (dated Feb. 17, 2018).

⁶⁸ SES/O3b Comments at 8-10. SES/O3b Comments to Supplemental Application at 2.

O3b grant however, the Commission has adopted significant revisions to its rules and policies governing NGSO FSS. The conditions below are consistent with these rule changes.⁶⁹

20. *Waiver Standard.* SpaceX seeks waivers of certain Commission rules.⁷⁰ Generally, the Commission may waive any rule for good cause shown.⁷¹ Waiver is appropriate where the particular facts make strict compliance inconsistent with the public interest.⁷² In making this determination, we may take into account considerations of hardship, equity, or more effective implementation of overall policy on an individual basis.⁷³ Waiver is therefore appropriate if special circumstances warrant a deviation from the general rule and such deviation will serve the public interest.⁷⁴ We address the specific requests for waivers below.

21. *Waivers for Frequency Use.* SpaceX requests waivers of the U.S. Table of Frequency Allocations (Table), to perform NGSO FSS operations in the 17.8-18.6 GHz band.⁷⁵ SpaceX's proposed operations in the 17.8-18.6 GHz band, however, are in conformance with the Table as revised in the *NGSO FSS Order*.⁷⁶ Thus, SpaceX's request for waivers of the Table to perform NGSO FSS operations in the 17.8-18.6 GHz band are moot.

22. SpaceX also requests a waiver of section 25.202(a)(1), n.6, in order to permit SpaceX to operate its user terminal earth stations in the 10.7-11.7 GHz band on a non-conforming, non-interference, unprotected basis.⁷⁷ We believe this request is more appropriately addressed in the context of an earth station application, since the request ultimately concerns the status of earth station operations. Accordingly, we dismiss the waiver request without prejudice to resubmission in connection with an application to operate earth stations with the SpaceX system. We observe, however, that we recently modified our rules concerning the use of the 10.7-11.7 GHz band to permit blanket licensing of receive earth stations on an unprotected basis.⁷⁸

23. *Waivers for 19.7-20.2 GHz.* SpaceX seeks a waiver of the Commission's Ka-band Plan to operate in the 19.7-20.2 GHz frequency band.⁷⁹ The 19.7-20.2 GHz frequency band is allocated to the

⁶⁹ To the extent that O3b is concerned about the status of its current and future operations relative to other NGSO systems, we note that, as a participant in the processing rounds, such concerns will be addressed when the Commission acts on O3b's pending petition. See *O3b Limited*, IBFS File Nos. SAT-AMD-20161115-00116 and SAT-MOD-20160624-00060.

⁷⁰ See *supra*, note 3.

⁷¹ 47 CFR § 1.3.

⁷² *Northeast Cellular Tel. Co. v. FCC*, 897 F.2d 1164, 1166 (D.C. Cir. 1990).

⁷³ *WAIT Radio v. FCC*, 418 F.2d 1153, 1159 (D.C. Cir. 1969), *cert. denied*, 409 U.S. 1027 (1972); *Northeast Cellular*, 897 F.2d at 1166.

⁷⁴ *Northeast Cellular*, 897 F.2d at 1166.

⁷⁵ 47 CFR §§ 2.102(a), 2.106. Non-Federal operations in this band are subject to coordination with Federal systems. 47 CFR § 2.106, n.US334.

⁷⁶ *NGSO FSS Order* at 32 FCC Rcd 7840.

⁷⁷ Application, Waiver Requests at 1-2.

⁷⁸ *NGSO FSS Order* 32 FCC Rcd at 7817, paras. 24-25.

⁷⁹ See *Redesignation of the 17.7-19.7 GHz Frequency Band, Blanket Licensing of Satellite Earth Stations in the 17.7-20.2 GHz and 27.5-30.0 GHz Frequency Bands, and the Allocation of Additional Spectrum in the 17.3-17.8 GHz and 24.75-25.25 GHz Frequency Bands for Broadcast Satellite-Service Use*, Report and Order, 15 FCC Rcd 13443-44, para. 28 (2000) (*2000 18 GHz Band Order*) (removing secondary NGSO FSS allocation in the 19.7-20.2 GHz frequency band).

fixed-satellite service and mobile-satellite service (space-to-Earth) on a primary basis,⁸⁰ however, the Commission's Ka-band Plan designates this band for the use of the GSO FSS, rather than NGSO FSS systems.⁸¹ In the SpaceX Supplemental Application, SpaceX provided technical demonstrations to show that it will comply with international EPFD limits designed to protect GSO networks in the 19.7-20.2 GHz frequency band set forth in Article 22 of the ITU Radio Regulations. In addition, SpaceX states that it will not cause harmful interference to and is willing to accept interference from GSO FSS operators in this frequency band.⁸² SES argues that the Commission must condition SpaceX's authorization in the 19.7-20.2 GHz band to not interfere with SES's operations as well as other GSO systems, to which SpaceX responded.⁸³

24. In light of the proposal that the Commission recently adopted to allow NGSO FSS operations in this band on a secondary basis, subject to certain power limits,⁸⁴ SpaceX's request for waiver of the Commission's Ka-band Plan to operate in the 19.7-20.2 GHz frequency band is moot.

25. *Waiver of Band-Splitting Procedure.* SpaceX seeks to operate in the United States throughout the 10.7-12.7 GHz, 12.75-13.25, 13.85-14.5 GHz, 17.8-18.6 GHz, 18.8-19.3 GHz, 19.7-20.2 GHz, 27.5-29.1 GHz, and 29.5-30 GHz frequency bands. In some of these frequency bands, specifically in those included in the 10.7-12.7 GHz, 12.75-13.25 GHz, 13.75-14.5 GHz, 18.8-19.3 GHz and 28.6-29.1 GHz bands, the Commission has adopted rules and policies to allow shared use of frequencies among NGSO FSS systems by avoidance of interference events.⁸⁵ In other bands, section 25.157(e) of the Commission's rules provides for "available spectrum" to be "divided equally" among the applications granted as the result of a processing round.⁸⁶ This rule presumes that NGSO operators cannot use the same frequencies without causing harmful interference to each other, and therefore must be assigned discrete segments of the requested band. SpaceX requests a waiver of section 25.157(e) to permit it to share the 17.8-18.6 GHz, 19.7-20.2 GHz, 27.5-28.6 GHz, and 29.5-30 GHz bands with other NGSO FSS operators through avoidance of interference events, rather than by assignment of only a portion of these bands.

26. Based on our technical review of the SpaceX Application and of other applications and petitions that were submitted in the OneWeb processing round, we conclude that sharing will be possible between the SpaceX system, the OneWeb system, and other proposed NGSO FSS systems in all of the bands requested by SpaceX. The earth stations that will communicate with the SpaceX constellation will have directional antennas.⁸⁷ This directionality, which permits avoidance of interference with other NGSO FSS systems in the 10.7-12.7 GHz,⁸⁸ 12.75-13.25, 13.85-14.5 GHz, 18.8-19.3 GHz, and 28.6-29.1

⁸⁰ 47 CFR §2.106.

⁸¹ *2000 18 GHz Band Order*, 15 FCC Rcd at 13443-44, para. 28.

⁸² See SAT-LOA-20170726-00110, Waiver Requests at 6-8; Technical Attachment, Section A.7.1.2 and Annex 2.

⁸³ SES/O3b Comments to Supplemental Application; SpaceX Consolidated Response (filed Dec. 5, 2017).

⁸⁴ *NGSO FSS Order*, 32 FCC Rcd at 7813, paras. 9-10.

⁸⁵ 47 CFR § 25.261; *The Establishment of Policies and Service Rules for the Non-Geostationary Satellite Orbit, Fixed Satellite Service in the Ka-band*, Report and Order, 18 FCC Rcd 14708, 14714, para. 18 (2003); *The Establishment of Policies and Service Rules for the Non-Geostationary Satellite Orbit, Fixed Satellite Service in the Ku-band*, Report and Order, 17 FCC Rcd 7841, 7850, para. 27 (2002).

⁸⁶ 47 CFR § 25.157(e).

⁸⁷ Application, Technical Supplement to Schedule S.

⁸⁸ The MVDDS 5G Coalition expresses concerns regarding protection of current and potential future MVDDS operations in the 12.2-12.7 GHz band. See Letter from MVDDS 5G Coalition to Marlene H. Dortch, Secretary, FCC, (dated March 6, 2018). Such concerns are addressed in paragraphs 40(e) and 40(r) below, requiring SpaceX to comply with established pfd limits in this band and subjecting the authorization to modification to conform it to any

(continued....)

GHz bands, also permits avoidance of interference in the 17.8-18.6 GHz, 19.7-20.2 GHz, 27.5-28.6 GHz, and 29.5-30 GHz bands. Thus, because SpaceX's particular system design enables sharing by avoiding interference events in all requested bands, division of available spectrum would be unnecessarily restrictive.

27. Furthermore, we recently adopted changes to the Commission's rules that will apply a spectrum sharing mechanism to all NGSO FSS systems that have sharing capabilities (*e.g.*, directional earth station antennas), regardless of the frequency bands used.⁸⁹ Thus, SpaceX's request for waiver of section 25.157(e) is moot.

28. *Waivers for EPFD Software Code.* Section 25.146 requires NGSO FSS applicants in certain bands to use software to demonstrate that their systems will comply with EPFD limits included in section 25.208.⁹⁰ If software approved by the ITU is not available, applicants must provide the source code used. SpaceX used a beta version of EPFD software in development with the ITU, Transfinite, a final version of which was subsequently approved by the ITU.⁹¹ SpaceX requests waiver of the requirement to provide its source code in light of the proprietary nature of the third-party software, and given that its version had not been approved by the ITU at the time of use.

29. We find good cause for waiver of the source code requirement in sections 25.146(a)(1)(iii), (2)(iii), based on SpaceX's use of this software in development with the ITU, but condition the grant on the requirement that SpaceX satisfactorily undergo the ITU review process of its EPFD demonstration prior to initiation of service. Review by the ITU of SpaceX's compliance with ITU EPFD limits, using methods now approved by the ITU, will provide sufficient additional assurances that SpaceX will comply with the applicable EPFD limits beyond the other technical demonstrations SpaceX has already provided.⁹² Thus, grant of this waiver will not undermine the purpose of the rule to reasonably ensure compliance with the relevant EPFD limits.⁹³

30. *Waiver of 47 CFR § 25.202(g)(1).* We grant SpaceX's request for waiver of section 25.202(g)(1) to permit telemetry, tracking, and command (TT&C) operations in the 13.85-14.0 GHz band, as conditioned. Section 25.202(g)(1) requires that TT&C signals be transmitted within assigned frequency bands, preferably at the band edges. We find that grant of this waiver is warranted. First, the requested band is immediately adjacent to the 14.0-14.5 GHz band used by the SpaceX system for user terminal uplink transmissions and, second, SpaceX anticipates that it will provide TT&C from only two locations in the United States (on the East and West Coasts respectively). In addition, since SpaceX's operations in the 13.85-14.0 GHz band must be coordinated with other spectrum users, this will further reduce the likelihood of interference to other operations.

31. *Waiver of Milestone Requirement.* SpaceX requests waiver of section 25.164(b) of the Commission's rules, which requires NGSO system licensees to launch the space stations, place them into

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future rules or policies adopted by the Commission in pending rulemaking proceedings. *See, e.g.*, Petition of MVDDS 5G Coalition for Rulemaking, RM-11768 (filed Apr. 26, 2016).

⁸⁹ *NGSO FSS Order*, 32 FCC Rcd at 7826, para. 52 (applying the newly adopted section 25.161 to NGSO FSS systems in any frequency band).

⁹⁰ 47 CFR §§ 25.146(a)(1)(iii), (2)(iii), 25.208.

⁹¹ *See* SpaceX July 12, 2017 Letter. Additionally, SpaceX has submitted updated public data files that would enable interested parties with access to the Transfinite software to review the EPFD analysis for SpaceX's system. *Id.*

⁹² *Id.*

⁹³ Some commenters state that additional files with EIRP and PFD masks are necessary to independently assess the proposed systems' compliance with applicable EPFD limits. SES Comments at 4; OneWeb Comments at 19-20. As stated above, SpaceX has submitted updated data files that will allow review of its EPFD analysis. *See supra* para. 9.

the assigned orbits, and operate them in accordance with the station authorization within six years of grant of the license.⁹⁴ SpaceX asks that we apply the six-year milestone only to its initial deployment of 1,600 satellites.⁹⁵ SpaceX states that completing its full constellation of over 4,400 satellites over a six-year period would require a launch cadence of more than 60 satellites per month, beginning on the day the Commission grants a license, which would be impractical, and that deployment of its full constellation is not necessary to allow it to commence delivery of broadband service. SpaceX argues that a limited waiver of section 25.164(b) would not undermine the purpose of the milestone requirements, as it would not result in, facilitate, or encourage spectrum warehousing. Several commenters argue that a waiver of this requirement would give SpaceX an unfair advantage as it would not require SpaceX to deploy its full constellation within the six-year period without further obligation to deploy the rest of its system.⁹⁶

32. We agree with commenters that SpaceX has not provided sufficient grounds for a waiver of the Commission's final implementation milestone requirement. We note that this issue was addressed in the NGSO FSS rulemaking,⁹⁷ and this grant is subject to those rules. Under these new rules, SpaceX's deployment of 1600 satellites would not meet the new 6-year milestone requirement that now requires 50 percent of the total number of satellites in the constellation to be launched and operated no later than 6 years after grant of the authorization. Given that, we deny SpaceX's waiver request. SpaceX can resubmit this request in the future, when it will have more information about the progress of the construction and launching of its satellites and will therefore be in a better position to assess the need and justification for a waiver.

33. *Geographic Coverage Requirements.* SpaceX's requests a partial waiver of sections 25.145(c) and 25.146(i) of the Commission's rules.⁹⁸ Sections 25.145(c) and 25.146(i) require NGSO FSS systems using certain Ka- and Ku-band frequencies, respectively, to provide service coverage to (i) all locations as far north as 70 degrees latitude and as far south as 55 degrees latitude for at least 75% of every 24-hour period and (ii) on a continuous basis throughout the fifty states, Puerto Rico and the U.S. Virgin Islands.⁹⁹ SpaceX states that once fully deployed, the SpaceX system will satisfy these requirements, as it will provide full time coverage to virtually the entire planet.¹⁰⁰ The initial deployment, however, will cover only as far north as 60 degrees latitude. SpaceX argues that its system, when fully deployed, will meet the requirements of these rules, and thus it should be granted a waiver of the geographic coverage requirements for its initial deployment. OneWeb argues that waiver of these

⁹⁴ 47 CFR § 25.164(b).

⁹⁵ Application, Waiver Requests at 8-10. SpaceX indicates that its initial deployment of 1,600 satellites within the six-year period is comparable to the full deployment of many other providers and would allow it to commence service to the public. *Id.*

⁹⁶ OneWeb Comments at 6-7 (stating that permitting some licensees to treat these obligations as optional would undermine the purpose of the rule, allow warehousing and speculation in spectrum allocated for satellite uses, particularly because SpaceX does not propose any follow-up milestones, leaving it completely unaccountable for the remaining two-thirds of its constellation yet to be deployed); Hughes Reply Comments at 3 (concurring with OneWeb's statement); Intelsat Reply Comments at 2-5 (concurring with OneWeb and stating that an appropriate venue for considering revising the six-year milestone requirement is the Commission's currently pending NGSO rulemaking proceeding); SES Comments at 7-8 (agreeing that consideration of SpaceX's milestone waiver should be deferred pending the outcome of the NGSO rulemaking). *See also* OneWeb Comments to Supplemental Application at 1-3, 4-8 (filed Nov. 20, 2017); SES/O3b Comments to Supplemental Application (filed Nov. 20, 2017); SpaceX Consolidated Response (filed Dec. 5, 2017).

⁹⁷ *NGSO FSS Order*, 32 FCC Rcd at 7830-31, para. 67.

⁹⁸ 47 CFR §§ 25.145(c), 25.146(i).

⁹⁹ 47 CFR §§ 25.145(c), 25.146(i).

¹⁰⁰ Application, Waiver Requests at 13.

requirements is not in the public interest and should be denied.¹⁰¹ We find that waivers of sections 25.145(c) and 25.146(i) are unnecessary, since the Commission's geographic service rules apply to the "proposed system", which in the case of SpaceX is the full system of 4,425 satellites that was proposed and authorized. Given that SpaceX's proposed system as a whole will meet the geographic coverage requirements, a waiver of the requirements is not needed for interim stages and we therefore dismiss SpaceX's waiver request.

34. *Section 25.208(e)*. SpaceX states that it does not comply with the PFD limits established in section 25.208(e) for very low elevation angles due to the flawed interference calculation methodology applied in the rule. It argues that the calculation methodology was not designed for (and did not contemplate) larger constellations, and assumes downlink energy from all satellites in operation, not just those that are visible from a particular location that could meaningfully be expected to contribute to interference into a terrestrial FS system, and fails to discount interference from those satellites that are switched off at a particular time or designed not to serve a location at such a low elevation angle.¹⁰² SpaceX further argues that when the calculation methodology is revised to reflect more reasonable operating assumptions for larger systems, it becomes clear that the SpaceX System would not be expected to cause harmful interference into terrestrial FS systems that share the band.¹⁰³ OneWeb urges the Commission to deny SpaceX's request for a waiver of the Commission's downlink PFD limits to ensure that SpaceX's operations do not cause harmful interference to terrestrial operations, criticizes SpaceX's understanding of the applicable PFD limits and states that NGSO FSS systems must comply with the Commission's downlink PFD requirements as described in footnote US334 of the U.S. Table of Frequency Allocations and further reflected in Section 25.208(e) of its rules.¹⁰⁴ Hughes agrees with OneWeb and other commenters that a waiver of section 25.208(e) could have an impact on Hughes' current and future broadband satellite systems, and would contravene the obligations imposed by Article 21 of the ITU Radio Regulations.¹⁰⁵

35. The *NGSO FSS Order* eliminated section 25.208(e), but adopted a new application requirement for NGSO applicants that requires a certification that the NGSO FSS applicant will comply with any applicable PFD levels in Article 21 of the ITU Radio Regulations.¹⁰⁶ Although this provision is not yet effective, the Commission recently affirmed the application of these PFD limits to NGSO FSS systems in the 17.7-19.7 GHz bands.¹⁰⁷ Therefore, rather than considering the request for a waiver of 25.208(e), it is more appropriate to address SpaceX compliance with the ITU PFD limits applicable in the 17.7-19.7 GHz frequency band. In this respect, we agree with several of the points raised by SpaceX, in particular that the ITU limits were derived for constellations up to 840 satellites and under worst case assumptions. The Commission contemplated that it would rely on its waiver policy to address, on a case-by-case basis, whether the ITU PFD limits should be modified for a given large NGSO constellation.¹⁰⁸ However, we find that SpaceX has not provided sufficient information in its application to justify that its operation will adequately protect terrestrial operations in the band under consideration, and thus we deny

¹⁰¹ OneWeb SpaceX Comments at 17-23 (stating that SpaceX is not committed to closing the "Digital Divide" and offers no explanation for its inability to include the satellites required to satisfy the Domestic Coverage Requirement in its Initial Deployment).

¹⁰² See Application, Technical Attachment at 27-33.

¹⁰³ *Id.*

¹⁰⁴ One Web SpaceX Comments at 24.

¹⁰⁵ Hughes Reply Comments at 2, 4.

¹⁰⁶ 47 CFR § 25.146(a)(1). This new certification requirement is subject to review under the provisions of the Paperwork Reduction Act and is not yet effective.

¹⁰⁷ *NGSO FSS Order*, 32 FCC Rcd at 7819, para. 30.

¹⁰⁸ *Id.*

its request for waiver. We recognize that such showing may have to rely on specific operational considerations that may be not fully known at this point in time. Given this, as a condition to this authorization, SpaceX must file a modification application before starting operation with a technical showing that demonstrates that its operation will protect a fixed-service station with the characteristics described in Recommendation ITU-R SF.1483.¹⁰⁹

36. *Schedule S Waiver.* As required by the Commission's rules, SpaceX submitted a completed Schedule S for its application, which contains certain technical information in a prescribed form. This is the first NGSO processing round in which the new version of the Schedule S has been used. SpaceX has found that it cannot accurately describe its system in certain respects due to limitations in Schedule S itself. SpaceX cites four limitations in Schedule S that affected how the Schedule S was completed: (1) the inability to enter for section 25.114(c)(4)(v) both the minimum and maximum saturation flux density (SFD) values for each space station receive antenna; (2) the inability to enter a negative value for the maximum transmit EIRP density value for each beam; (3) the inability to enter a maximum PFD value for any given angle of arrival for NGSO systems operating in the 12.2-12.7 GHz band that is less than -200.0 dBW/m²/BW; and (4) the lack of a means to reflect SpaceX's system architecture for spare satellites.¹¹⁰ To the extent necessary, SpaceX requests that the Commission waive these aspects of Schedule S in light of these limitations. In view of the fact that SpaceX has implemented a workaround for each of these limitations to allow entry of the required information, we find that a waiver of the requirement to complete certain aspects or fields of Schedule S is warranted.

37. *Other.* In the 14-14.2 GHz band, NASA operates Tracking and Data Relay Satellite System facilities at three locations: Guam (latitude 13°36'55" N, longitude 144°51'22" E); White Sands, New Mexico (latitude 32°20'59" N, longitude 106°36'31" W and latitude 32°32'40" N, longitude 106°36'48" W); and Blossom Point, Maryland. For transmissions in the 14-14.2 GHz band from NGSO FSS earth stations located within 125 kilometers of these three sites, earth station operators should take account of these NASA facilities.

IV. CONCLUSION

38. We conclude that grant of the SpaceX Application and Supplemental Application, as conditioned and set forth herein, will serve the public interest by enabling SpaceX to pursue its goal of providing broadband service to consumers in the United States and around the world.

V. ORDERING CLAUSES

39. Accordingly, IT IS ORDERED, that the Application and Supplemental Application filed by Space Exploration Holdings, LLC (SpaceX) and accepted for filing ARE GRANTED IN PART, DISMISSED IN PART, AND DENIED IN PART, as set forth in this Memorandum Opinion, Order and Authorization, pursuant to section 309(a) of the Communications Act of 1934, as amended, 47 U.S.C. § 309(a).

40. IT IS FURTHER ORDERED that this authorization is subject to the following requirements and conditions:

- a. SpaceX must timely provide the Commission with the information required for Advance Publication, Coordination, and Notification of the frequency assignment(s) for this constellation, including due diligence information, pursuant to Articles 9 and 11 of the ITU Radio Regulations. This authorization may be modified, without prior notice, consistent with the coordination of the frequency assignment(s) with other Administrations. See 47 CFR § 25.111(b). SpaceX is responsible for all cost-recovery fees associated with the ITU filings. 47 CFR § 25.111(d).

¹⁰⁹ See section 1 of Annex 1 of Recommendation ITU-R SF.1483.

¹¹⁰ SpaceX Waiver Requests at 16-17.

- b. Operations in the 10.7-11.7 GHz (space-to-Earth) frequency band are authorized up to the applicable power flux-density limits in 47 CFR § 25.208(b), and up to the equivalent power flux-density requirements of Article 22 of the ITU Radio Regulations, as well as Resolution 76 (Rev. WRC-15) of the ITU Radio Regulations.
- c. In the 10.7-11.7 GHz band, operations must be coordinated with the radio astronomy observatories listed in 47 CFR § 2.106, n.US131, to achieve a mutually acceptable agreement regarding the protection of the radio telescope facilities operating in the 10.6-10.7 GHz band. For the purposes of coordination with these listed facilities or the National Radio Quiet Zone, correspondence should be directed to the National Science Foundation Spectrum Management Unit (Email: esm@nsf.gov).
- d. Operations in the 11.7-12.2 GHz (space-to-Earth) frequency band are authorized up to the power flux-density limits in Article 21 of the ITU Radio Regulations, and up to the equivalent power flux-density requirements of Article 22 of the ITU Radio Regulations, as well as Resolution 76 (Rev. WRC-15) of the ITU Radio Regulations.
- e. Operations in the 12.2-12.7 GHz (space-to-Earth) frequency band are authorized up to the power flux-density limits in 47 CFR § 25.208(o) and Article 21 of the ITU Radio Regulations, and up to the equivalent power flux-density requirements of Article 22 of the ITU Radio Regulations, as well as Resolution 76 (Rev. WRC-15) of the ITU Radio Regulations.
- f. Operations in the 12.75-13.25 GHz (Earth-to-space) frequency band must be in accordance with footnote 5.441 to the U.S. Table of Frequency Allocations, 47 CFR § 2.106, n. 5.441, which states that operations in this band are subject to application of the provisions of No. 9.12 for coordination with other non-geostationary-satellite systems in the fixed-satellite service. Non-geostationary-satellite systems in the fixed-satellite service shall not claim protection from geostationary-satellite networks in the fixed-satellite service operating in accordance with the Radio Regulations. Non-geostationary-satellite systems in the fixed-satellite service in the 12.75-13.25 GHz (Earth-to-space) frequency band shall be operated in such a way that any unacceptable interference that may occur during their operation shall be rapidly eliminated.
- g. Operations of non-geostationary-satellite systems in the 12.75-13.25 GHz (Earth-to-space) frequency band are restricted to individually licensed earth stations in accordance with footnote NG57 to the U.S. Table of Frequency Allocations, 47 CFR § 2.106, NG57. In the 13.85-14.5 GHz (Earth-to-space) frequency band reception is permitted for levels up to the equivalent power flux-density requirements of Article 22 of the ITU Radio Regulations.
- h. In the 14.47-14.5 GHz band, operations are subject to footnote US342 to the U.S. Table of Frequency Allocations, 47 CFR § 2.106, n.US342, and all practicable steps must be taken to protect the radio astronomy service from harmful interference.
- i. Space-to-Earth operations in the 17.8-18.6 GHz, 18.8-19.3 GHz, and 19.7-20.2 GHz frequency bands must complete coordination with U.S. Federal systems, in accordance with footnote US334 to the United States Table of Frequency Allocations, 47 CFR § 2.106, prior to being used. The use of space-to-Earth operations in the 17.8-18.6 GHz, 18.8-19.3 GHz, and 19.7-20.2 GHz bands must be in accordance with any signed coordination agreement between SpaceX and U.S. Federal operators. Two weeks prior to the start of any operations in the 17.8-18.6 GHz, 18.8-19.3 GHz, and 19.7-20.2 GHz bands, SpaceX must provide contact information for a 24/7 point of contact for the resolution of any harmful interference to Jimmy Nguyen, Email: Jimmy.Nguyen@us.af.mil.
- j. Operations in the 18.8-19.3 GHz (space-to-Earth) frequency band are authorized up to the power flux-density limits in Article 21 of the ITU Radio Regulations.

k. In the 27.5-28.6 GHz and 29.5-30 GHz (Earth-to-space) frequency bands reception is permitted at levels up to the applicable equivalent power flux-density requirements of Article 22 of the ITU Radio Regulations.

l. Operations in the 27.5-28.35 GHz (Earth-to-space) frequency band are secondary with respect to Upper Microwave Flexible Use Service (UMFUS) operations, except for FSS operations associated with earth stations authorized pursuant to 47 CFR § 25.136, and will comply with any determinations set forth in the Spectrum Frontiers proceeding (GN Docket 14-177).¹¹¹

m. Operations in the 28.35-28.6 GHz and 29.5-30 GHz (Earth-to-space) frequency bands are on a secondary basis with respect to GSO FSS operations.

n. Prior to initiation of service, SpaceX must receive a favorable or “qualified favorable” finding in accordance with Resolution 85 (WRC-03) with respect to its compliance with applicable equivalent power flux-density limits in Article 22 of the ITU Radio Regulations.

o. SpaceX must cooperate with other NGSO FSS operators in order to ensure that all authorized operations jointly comport with the applicable limits for aggregate equivalent power flux-density in the space-to-Earth direction (EPFDdown) contained in Article 22 of the ITU Radio Regulations, as well as Resolution 76 (WRC-03) of the ITU Radio Regulations.

p. Upon finalization of its space station design and prior to initiation of service, SpaceX must seek and obtain the Commission’s approval of a modification containing an updated description of the orbital debris mitigation plans for its system, as discussed in paragraph 15 above.

q. Upon finalization of its space station design and prior to initiation of service, SpaceX must seek and obtain the Commission’s approval of a modification containing a technical showing that demonstrates that its operation will protect a fixed-service station with the characteristics described in Recommendation ITU-R SF.1483, as discussed in paragraph 35 above.

r. This authorization is subject to modification to bring it into conformance with any rules or policies adopted by the Commission in the future. Accordingly, any investments made toward operations in the bands authorized in this order by SpaceX in the United States assume the risk that operations may be subject to additional conditions or requirements as a result of any future Commission actions.

41. IT IS FURTHER ORDERED that SpaceX will be subject to the rules regarding the sharing of ephemeris data in section 25.146(e) of the Commission’s rules, 47 CFR § 25.146(e), once these rules become effective.

42. IT IS FURTHER ORDERED that this authorization is also subject to the following requirements:

a. SpaceX must post a surety bond in satisfaction of 47 CFR §§ 25.165(a)(1) & (b) no later than **April 30, 2018**, and thereafter maintain on file a surety bond requiring payment in the event of a default in an amount, at minimum, determined according to the formula set forth in 47 CFR § 25.165(a)(1); and

b. SpaceX must launch 50 percent of the maximum number of proposed space stations, place them in the assigned orbits, and operate them in accordance with the station authorization no later than **March 29, 2024**, and SpaceX must launch the remaining space stations necessary to complete its authorized service constellation, place them in their assigned orbits, and operate each

¹¹¹ See generally *Spectrum Frontiers R&O and FNPRM*.

of them in accordance with the authorization no later than **March 29, 2027**. 47 CFR § 25.164(b).¹¹²

43. Failure to post and maintain a surety bond will render this grant null and void automatically, without further Commission action. Failure to meet the milestone requirements of 47 CFR § 25.164(b) may result in SpaceX's authorization being reduced to the number of satellites in use on the milestone date. Failure to comply with the milestone requirement of 47 CFR § 25.164(b) will also result in forfeiture of SpaceX's surety bond. By **April 15, 2024**, SpaceX must either demonstrate compliance with its milestone requirement or notify the Commission in writing that the requirement was not met. 47 CFR § 25.164(f).

44. IT IS FURTHER ORDERED that SpaceX's request for waiver of the United States Table of Frequency Allocations, 47 CFR § 2.106 & NG164, IS DISMISSED as MOOT.

45. IT IS FURTHER ORDERED that operations must comply with spectrum sharing procedures among NGSO FSS space stations specified in 47 CFR § 25.261 with respect to any NGSO system licensed or granted U.S. market access pursuant to the processing rounds initiated in Public Notice, DA 16-804 and Public Notice, DA 17-524. Spectrum sharing between SpaceX's operations and operations of NGSO systems granted U.S. market access, where such operations do not include communications to or from the U.S. territory, are governed only by the ITU Radio Regulations and are not subject to Section 25.261.

46. IT IS FURTHER ORDERED that SpaceX's request for waiver of the band segmentation provision in 47 CFR § 25.157(e) IS DISMISSED as MOOT.

47. IT IS FURTHER ORDERED that SpaceX's request for waiver of the source code requirements in 47 CFR § 25.146(a)(1)(iii), (2)(iii), IS GRANTED.

48. IT IS FURTHER ORDERED that the request for waiver of 47 CFR § 25.202(a)(1), n.6, to permit SpaceX to operate its user terminal earth stations in the 10.7-11.7 GHz band on a non-conforming, non-interference, unprotected basis, IS DISMISSED without prejudice to re-filing in connection with such an application.

49. IT IS FURTHER ORDERED that the request for waiver of 47 CFR § 25.202(g)(1) for telemetry, tracking, and command (TT&C) operations in the 13.85-14.0 GHz band is GRANTED. As a condition of the grant of this waiver, SpaceX shall coordinate TT&C operations of its system in the 13.75-14.00 GHz band with all potentially affected operators of other communication systems. Furthermore, any earth station operating with SpaceX's system in the 13.75-14.0 GHz band must comport with the requirements in 47 CFR § 2.106, US356. In the 13.75-14.0 GHz frequency band (Earth-to-space), receiving space stations in the fixed-satellite service must not claim protection from radiolocation transmitting stations operating in accordance with the United States Table of Frequency Allocations.

50. IT IS FURTHER ORDERED that SpaceX's request for waiver of the Commission's Ka-band Plan with regard to the 19.7-20.2 GHz (space-to-Earth) frequency band IS DISMISSED as MOOT. Communications in the 19.7-20.2 GHz frequency band with NGSO FSS systems are on a secondary basis with regard to GSO FSS operations. In addition, such communications must comport with the applicable EFPD limits and requirements in Article 22 of the ITU Radio Regulations.

51. IT IS FURTHER ORDERED that the request for waiver of the downlink PFD limits in 47 CFR § 25.208(e) is DISMISSED AS MOOT for the reasons set forth herein.

52. IT IS FURTHER ORDERED that the request for waiver of the downlink PFD limits provisions in Article 21 of the ITU Radio Regulations is DENIED for the reasons set forth herein.

¹¹² We note that the *NGSO FSS Order* modified section 25.164(b) to offer additional flexibility and requires launch and operation of 50 percent of an authorized system within six years of grant and the remaining satellites within nine years of grant.

53. IT IS FURTHER ORDERED that the request for partial waiver of the final implementation milestone in 47 CFR § 25.164(b) is DENIED for the reasons set forth herein.

54. IT IS FURTHER ORDERED that the request for waiver of geographic service requirements in 47 CFR §§ 25.145(c) and 25.146(i) is DISMISSED AS MOOT for the reasons set forth herein.

55. IT IS FURTHER ORDERED that the request for waiver of the requirement to complete certain aspects or fields of Schedule S is GRANTED for the reasons set forth herein.

56. IT IS FURTHER ORDERED that the Petitions to Deny of Telesat Canada and ViaSat, Inc. ARE GRANTED to the extent that certain conditions requested by Telesat Canada and ViaSat are imposed, as indicated herein, and are otherwise DENIED.

FEDERAL COMMUNICATIONS COMMISSION

Marlene H. Dortch
Secretary

**STATEMENT OF
COMMISSIONER JESSICA ROSENWORCEL**

Re: *Space Exploration Holdings, LLC, Application for Approval for Orbital Deployment and Operating Authority for the SpaceX NGSO Satellite System, IBFS File No. SAT-LOA-20161115-0018; Call Sign S2983; Application for Approval for Orbital Deployment and Operating Authority for the SpaceX NGSO Satellite System Supplement, SAT-LOA-20170726-00110, Call Sign S3018*

A next-generation space race is unfolding. We are seeing new commercial models, players, and technologies coming together to pioneer a wide range of cool satellite services. This is undeniably exciting.

However, this rush to develop new space opportunities requires new rules. Despite the revolutionary activity in our atmosphere, the regulatory frameworks we rely on to shape these efforts are dated. They were designed for a time when going to space was astronomically expensive and limited to the prowess of our political superpowers. No one imagined commercial tourism taking hold, no one believed crowd-funded satellites were possible, and no one could have conceived of the sheer popularity of space entrepreneurship.

Across the board, we need to prepare for the proliferation of satellites in our higher altitudes. In short, we have work to do. There are two places we can start.

First, the FCC has to tackle the growing challenge posed by orbital debris. Today, the risk of debris-generating collisions is reasonably low. But they've already happened—and as more actors participate in the space industry and as more satellites of smaller size that are harder to track are launched, the frequency of these accidents is bound to increase. Unchecked, growing debris in orbit could make some regions of space unusable for decades to come. That is why we need to develop a comprehensive policy to mitigate collision risks and ensure space sustainability.

Second, the FCC must coordinate more closely with other federal actors to figure out what our national policies are for this jumble of new space activity. Right now, the National Space Council is considering policy changes to help promote the growth of the commercial space industry. Their efforts encompass everything from streamlining licenses to reforming export controls to protecting airwaves facilitating space activities. Its membership spans the civil, military, and commercial sectors, including the Secretary of State, Secretary of Defense, Secretary of Transportation, Secretary of Homeland Security, and Director of National Intelligence. Representatives from the Office of Management and Budget, National Aeronautics and Space Administration, and the Joint Chiefs of Staff, among others, also serve on this council. It's an impressive list. But the FCC should have a seat at this table. It's a glaring omission that the agency does not because through our oversight of the airwaves and licensing of satellite services we have an important role ensuring the viability of space for future generations. Cutting the FCC out of this discussion is an unseemly mistake—and one that deserves a fix.