

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

In the Matter of
Space Exploration Holdings, LLC
Request for Modification of the Authorization
for the SpaceX NGSO Satellite System
IBFS File No. SAT-MOD-20200417-00037
Call Signs S2983 and S3018

ORDER AND AUTHORIZATION AND ORDER ON RECONSIDERATION

Adopted: April 23, 2021

Released: April 27, 2021

By the Commission:

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I. INTRODUCTION

1. In this Order and Authorization and Order on Reconsideration (Order), we grant subject to the conditions set forth herein the application¹ of Space Exploration Holdings, LLC (SpaceX) for modification of its license for a non-geostationary orbit (NGSO) fixed-satellite service (FSS) constellation using Ku- and Ka-band spectrum.² Specifically, we modify the license by reducing the number of satellites from 4,409 to 4,408; modifying the primary operational altitude specified for 2,814 satellites, to change it from the 1,100-1,300 km range to the 540-570 km range; modifying the minimum earth station elevation angle for both user beams and gateway beams,³ and by including in the license authority to conduct launch and early orbit phase (LEOP) operations and payload testing during orbit-raising and deorbit of its satellites, consistent with parameters described in the application and related materials. We further conclude that this modification does not create significant interference problems that would warrant treatment of SpaceX's system as if it were filed in a later processing round.⁴ We deny petitions to deny or defer of Viasat, Inc. (Viasat), SES Americom, Inc. and O3B Limited (SES/O3b), Kepler Communications, Inc. (Kepler), and Kuiper Systems LLC. (Kuiper); the "Opposition and Motions for Consultation with Affected Agencies, for Disclosure, for Certification of Suitably Comprehensive Insurance Coverage, for Certification of Indemnity, and to Suspend or Revoke Licenses" of The Balance Group; and the "Petition Pursuant to Section 1.1307" of Viasat.⁵ We also dismiss the request of DISH Network LLC. (DISH) for production of evidence.⁶ Furthermore, we deny Viasat's Petition for Reconsideration of our previous partial grant of this application for ten satellites.⁷ Our action will allow SpaceX to implement safety-focused changes to the deployment of its satellite constellation to deliver

¹ See *Space Exploration Holdings, LLC, Request for Modification of the Authorization for the SpaceX NGSO Satellite System*, IBFS File No. SAT-MOD-20200417-00037, filed April 17, 2020 (SpaceX Third Modification Application).

² See *Space Exploration Holdings, LLC, Application for Approval for Orbital Deployment and Operating Authority for the SpaceX NGSO Satellite System*, Memorandum Opinion, Order and Authorization, 33 FCC Rcd 3391 (2018) (*SpaceX Authorization*).

³ Specifically, SpaceX is authorized to operate with earth station elevation angles as low as 25 degrees for user terminals and gateways, and for gateways in the polar regions it is authorized to operate with earth station elevation angles as low as five degrees.

⁴ SpaceX's authorization was granted pursuant to the Commission's processing round procedures. See *SpaceX Authorization*, 33 FCC Rcd at 3392-93, para. 3. SpaceX's original application was considered as part of the Ku/Ka-band processing round that closed on November 15, 2016. See *id.*; *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) (*2016 Processing Round Public Notice*). SpaceX's original application was also considered as part of a processing round addressing additional frequency bands that closed on July 26, 2017. See *SpaceX Authorization*, 33 FCC Rcd at 3392, para. 3; *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) (*2017 Processing Round Public Notice*).

⁵ See Opposition and Motions of The Balance Group (filed May 26, 2020), as amended by Errata of The Balance Group (filed May 27, 2020) (The Balance Group Opposition); Petition to Deny or Defer of Viasat, Inc. (filed Jul. 13, 2020) (Viasat Petition); Petition to Deny or Defer of SES Americom, Inc. and O3b Limited (filed Jul. 13, 2020) (SES/O3b Petition); Petition to Deny of Kepler Communications, Inc. (filed Jul. 13, 2020) (Kepler Opposition); Petition to Deny and Comments of Kuiper Systems, LLC (filed Jul. 13, 2020) (Kuiper Opposition); Petition Pursuant to Section 1.1307 of Viasat, Inc. (filed Dec. 19, 2020) (Viasat NEPA Petition).

⁶ See Letter from Trey Hanbury, Counsel, DISH Network, LLC., to Marlene H. Dortch, Secretary, FCC (filed Sept. 25) (DISH September 25 Letter Requesting Order of Production of Evidence).

⁷ Petition for Reconsideration of Viasat, Inc. (filed Feb. 8, 2021) (Viasat Recon Petition).

broadband service throughout the United States, including to those who live in areas underserved or unserved by terrestrial systems.

II. BACKGROUND

2. On March 28, 2018, the Commission granted SpaceX authority to deploy and operate an NGSO satellite system comprising 4,425 satellites operating in the Ku- and Ka-bands for provision of FSS.⁸ SpaceX was authorized 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 frequency bands.⁹ The Commission conditioned the grant of SpaceX's application on, among other things, approval of an updated description of the orbital debris mitigation plans for the system.¹⁰ In addition, SpaceX's authorization was conditioned to bring its license into conformance with any future Commission rulemakings.¹¹

3. On April 26, 2019, the International Bureau (Bureau), granted SpaceX's request to modify its initial authorization to: (1) reduce the number of satellites in the constellation from 4,425 to 4,409; (2) operate 1,584 satellites previously authorized to operate at an altitude of 1,150 km at the lower altitude of 550 km; and (3) make related changes to the operations of the satellites in this new lower shell of the constellation.¹² On December 19, 2019, the Bureau granted SpaceX's second modification request to allow it to increase the number of orbital planes authorized for operations of SpaceX's satellites at the 550 kilometer (km) orbital shell, to reduce the number of satellites in each orbital plane, and to reconfigure existing satellites in its constellation accordingly.¹³ The Bureau assessed each of the modification requests in accordance with its *Teledesic Order* precedent,¹⁴ and in both instances found that grant of the modification was in the public interest, and would not materially change the interference environment.¹⁵ Therefore, in neither of these instances did the Bureau conclude that SpaceX's system needed to be considered as part of a later processing round.

4. On April 17, 2020, SpaceX filed the instant application, the Third Modification Application. Pursuant to the Third Modification Application, SpaceX's constellation would consist of the 1,584 satellites previously authorized in the First and Second Modification Orders operating at 550 km, with an inclination of 53 degrees, in 72 orbital planes with 22 satellites per plane; an additional 1,584 satellites operating at 540 km, with an inclination of 53.2 degrees, in 72 orbital planes with 22 satellites

⁸ *SpaceX Authorization*, 33 FCC Rcd at 3391, para.1.

⁹ *See id.* at 3392, para. 2.

¹⁰ *See id.* at 3398, 3406, paras. 15, 40.p.

¹¹ *See id.* at 3406, para. 40.r.

¹² *See Space Exploration Holdings, LLC, Request for Modification of the Authorization for the SpaceX NGSO Satellite System*, Order and Authorization, 34 FCC Rcd 2526 (IB 2019) (*SpaceX First Modification Order*). *See* Petition for Reconsideration and Petition to Condition of WorldVu Satellites Limited, IBFS File Nos. SAT-MOD-20181108-00083, SES-LIC-20190402-00425 through -00427, SES-LIC-20190402-00450, -00451, and -00454 (filed May 28, 2019) and SES-AMD-20190410-00520 through 00525 (filed May 31, 2019) (OneWeb Petition for Reconsideration); *see also* Letter from Nickolas G. Spina, Counsel to Kepler Communications, Inc., to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-MOD-20181108-00083, SAT-MOD-20190830-00087, and SAT-STA-20190924-00098, at 1-2, 5-13 (filed Oct. 15, 2019). OneWeb's petition for reconsideration was granted in part and denied in part, and Kepler's filing was dismissed. *See Space Exploration Holdings, LLC, Request for Modification of the Authorization of the SpaceX NGSO System*, Memorandum Opinion and Order, 35 FCC Rcd 5649 (IB, rel. June 4, 2020).

¹³ *See Space Exploration Holdings, LLC, Request for Modification of the Authorization for the SpaceX NGSO Satellite System*, Order and Authorization, 34 FCC 12307 (IB 2019) (*SpaceX Second Modification Order*).

¹⁴ *See Teledesic LLC*, Order and Authorization, 14 FCC Rcd 2261 (IB 1999) (*Teledesic Order*).

¹⁵ *See SpaceX First Modification Order*, 34 FCC Rcd at 2530, 2536, paras. 9, 27.

per plane; 720 satellites operating at 570 km, with an inclination of 70 degrees, in 36 orbital planes with 20 satellites per plane; 348 satellites operating at 560 km, with an inclination of 97.6 degrees, in 6 orbital planes with 58 satellites per plane; and 172 satellites also operating at 560 km, with an inclination of 97.6 degrees, in 4 orbital planes with 43 satellites per plane.¹⁶ The various altitudes specified are the “center” altitude, with operations occurring with a range of 30 km around that altitude.¹⁷ SpaceX does not seek any modification to the Ku- and Ka-band frequencies currently specified in its license.¹⁸ SpaceX also requests authority to conduct LEOP operations and payload testing during orbit-raising and telemetry, tracking, and command (TT&C) communications during de-orbit of its satellites.¹⁹

5. On June 12, 2020, the SpaceX Third Modification Application was accepted for filing.²⁰ Nearly 200 pleadings have been submitted into the International Bureau Filing System (IBFS) regarding this modification application.²¹ During the public notice period,²² Viasat and SES/O3B submitted petitions to deny or defer; Kepler and Kuiper submitted pleadings titled “petitions to deny,” which we will consider informal objections because they lack an affidavit required by our rules;²³ and The Balance Group submitted an Opposition and Motions for Consultation with Affected Agencies, for Disclosure, for Certification of Suitably Comprehensive Insurance Coverage, for Certification of Indemnity, and to Suspend or Revoke Licenses.²⁴ Spire Global, Inc. (Spire), WorldVu Satellites Limited (OneWeb), and AT&T Services, Inc. (AT&T) filed comments.²⁵ RS Access, LLC (RS Access), DISH, Astroscale U.S. Inc. (Astroscale), the Computer & Communications Industry Association (CCIA) and INCOMPAS, and Go Long Wireless, LTD., Cass Cable TV, Inc., Story Communications, LLC., and Vision Broadband, LLC. (the MVDDS Licensees) filed letters.²⁶ SpaceX responded in a consolidated opposition,²⁷ and also

¹⁶ See SpaceX Third Modification Application, Narrative at 4.

¹⁷ The exceptions to this altitude range are for satellites at the upper range of SpaceX’s selected altitudes, operating with a nominal altitude of 560 km or 570 km. Consistent with the discussion below, those satellites would be required to operate below 580 km, and thus would have an altitude range of +20 km/-30 km and +10 km/-30 km, respectively.

¹⁸ See SpaceX Third Modification Application, Frequency Bands Requested at 1.

¹⁹ See *Id.*, Narrative at 4; 47 CFR §§ 25.282, 25.283.

²⁰ See Policy Branch Information, Space Stations Accepted for Filing, Public Notice, Report No SAT-01472 (IB Sat. Div. Jun. 12, 2020).

²¹ See generally IBFS File No. SAT-MOD-20200417-00037.

²² See 47 CFR §§ 25.151, 25.154.

²³ 47 CFR § 25.154(a)(4), (b)(1).

²⁴ See Viasat Petition; SES/O3B Petition; Kepler Opposition; Kuiper Opposition; The Balance Group Opposition; Viasat NEPA Petition.

²⁵ See Comments of Spire Global, Inc. (filed Jul. 13, 2020) (Spire Comments); Comments of WorldVu Satellites Limited, Debtor-in-Possession (filed Jul. 13, 2020) (OneWeb Comments); Comments of AT&T Services, Inc. (filed Jul. 13, 2020) (AT&T Comments).

²⁶ See Letter from V. Noah Campbell, RS Access, LLC, to Marlene H. Dortch, Secretary, FCC (filed Jun. 11, 2020) (RS Access Letter); Letter from Jeffrey Blum, Executive Vice President External and Legislative Affairs, DISH Network, LLC., to Marlene H. Dortch, Secretary, FCC (filed Jun. 16, 2020) (DISH Letter); Letter from Charity Weeden, Vice President Global Space Policy, Astroscale U.S. Inc., to Marlene H. Dortch, Secretary, FCC (filed Jun. 30, 2020) (Astroscale Letter); Letter from Vann Bentley, Policy Counsel, Computer & Communications Industry Association, to Marlene H. Dortch, Secretary, FCC (filed Jul. 13, 2020) (CCIA/INCOMPAS Letter); Letter from Bruce E. Fox, Go Long Wireless, to Marlene H. Dortch, Secretary, FCC (filed Aug. 14, 2020) (MVDDS Licensees Letter).

submitted specific responses to DISH,²⁸ Viasat,²⁹ Hughes,³⁰ RS Access,³¹ Kuiper,³² SES/O3B,³³ and the Balance Group.³⁴ Astroscale, Viasat, AT&T, Kuiper, Kepler, OneWeb, SES/O3b, and the American

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²⁷ See Consolidated Opposition and Response of Space Exploration Holdings, LLC. (filed Jul. 27, 2020) (SpaceX Consolidated Opposition); Opposition of Space Exploration Holdings LLC to Petition Pursuant to Section 1.1307(c) of Viasat, Inc. (filed Jan. 6, 2021) (SpaceX Opposition to Viasat NEPA Petition).

²⁸ See DISH Letter; Letter from David Goldman, Director Satellite Policy, Space Exploration Technologies Corp., to Marlene H. Dortch, Secretary, FCC (filed Jun 29, 2020) (SpaceX June 29 Response to DISH); Letter from Jeffrey Blum, Executive Vice President External and Legislative Affairs, DISH Network, LLC., to Marlene H. Dortch, Secretary, FCC (filed Jul. 14, 2020) (DISH July 14Response to SpaceX); Letter from Irene Rodriguez, DISH Network LLC., to Marlene H. Dortch, Secretary, FCC (filed Aug. 6, 2020) (DISH August 6 Response to SpaceX); DISH September 25 Letter Requesting Order of Production of Evidence; Letter from David Goldman, Director of Satellite Policy, Space Exploration Technologies Corp., to Marlene H. Dortch, Secretary, FCC (filed Oct. 1, 2020) (SpaceX October 1 Response to DISH); Letter from David Goldman, Director of Satellite Policy, Space Exploration Technologies Corp., to Marlene H. Dortch, Secretary, FCC (filed Oct. 15, 2020) (SpaceX October 15 EPFD Notice); Ex Parte Presentation of DISH Network, LLC (filed Dec. 31, 2020) (DISH December 31 Ex Parte); Ex Parte Presentation of DISH Network LLC (filed Jan. 5, 2021) (DISH January 5 Ex Parte); Ex Parte Presentation of DISH Network LLC (filed Jan. 11, 2021) (DISH January 11 Ex Parte); Ex Parte Presentation DISH Network LLC. (filed Feb. 10, 2021) (DISH February 10 Ex Parte); Letter from Jeffrey Blum, Executive Vice President External and Legislative Affairs, DISH Network, LLC, to Marlene H. Dortch, Secretary, FCC (filed Feb. 15, 2021) (DISH February 15 Letter); Request for Protective Order of DISH Network LLC (filed Feb. 23, 2021) (DISH Request for Protective Order); Ex Parte Presentation of DISH Network LLC. (filed Feb. 24, 2021) (DISH February 24 Ex Parte); Letter from David Goldman, Director Satellite Policy, Space Exploration Technologies Corp., to Marlene H. Dortch, Secretary, FCC (filed Feb. 25, 2021) (SpaceX February 25 2021 Response to DISH); Letter from Jeffrey Blum, Executive Vice President External and Legislative Affairs, DISH Network, LLC., to Marlene H. Dortch, Secretary, FCC (filed Mar. 4, 2021) (DISH March 4 Response to SpaceX); Ex Parte Presentation of DISH Network LLC (filed Mar. 8, 2021) (DISH March 8 Ex Parte); Ex Parte Presentation of DISH Network LLC (filed March. 9, 2021) (DISH March 9 Ex Parte); Letter from David Goldman, Director of Satellite Policy, Space Exploration Technologies Corp., to Marlene H. Dortch, Secretary, FCC (filed March 9, 2021) (SpaceX March 9 Response to DISH); Letter from Jeffrey Blum, Executive Vice President External and Legislative Affairs, DISH Network, LLC, to Marlene H. Dortch, Secretary, FCC (filed Mar. 17, 2021) (DISH March 17 Response to SpaceX); Letter from David Goldman, Director of Satellite Policy, Space Exploration Technologies Corp., to Marlene H. Dortch, Secretary, FCC (filed March 18, 2021) (SpaceX March 18 Response to DISH); Ex Parte Presentation of DISH Network LLC. (filed Mar. 22, 2021) (DISH March 22 2021 Ex Parte); Letter from Jeffrey Blum, Vice President, External and Legislative Affairs, DISH Network LLC, to Marlene H. Dortch, Secretary, FCC (filed Mar. 24, 2021) (DISH March 24 Response to SpaceX); Letter from Jeffrey Blum, Vice President, External and Legislative Affairs, DISH Network LLC., to Marlene H. Dortch, Secretary, FCC (filed Mar. 25, 2021) (DISH March 25 Letter); Letter from Jeffrey Blum, Executive Vice President, External and Legislative Affairs, DISH Network LLC., to Marlene H. Dortch, Secretary, FCC (filed Apr. 6, 2021) (DISH April 6 Letter); Ex Parte Presentation of DISH Network LLC. (filed Apr. 14, 2021) (DISH April 14 Ex Parte); Letter from Jeffrey Blum, Executive Vice President, External and Legislative Affairs, DISH Network LLC., to Marlene H. Dortch, Secretary, FCC (filed Apr. 19, 2021) (DISH April 19 Letter); Ex Parte Presentation of DISH Network LLC (filed Apr. 22, 2021) (DISH April 22 Ex Parte); Letter from, Pantelis Michalopoulos, Counsel, DISH Network LLC., to Marlene H. Dortch, Secretary, FCC (filed Apr. 23, 2021) (DISH April 23 12 GHz Letter); Letter from Jeffrey Blum, Executive Vice President, External and Legislative Affairs, DISH Network LLC., to Marlene H. Dortch, Secretary, FCC (filed Apr. 23, 2021) (DISH April 23 EPFD Letter).

²⁹ See Letter from Christopher J. Murphy, Associate General Counsel, Viasat, to Jose P. Albuquerque, Chief, Satellite Division (filed Jun. 8, 2020) (Viasat June 8 Letter); Letter from Christopher J. Murphy, Associate General Counsel, Viasat, Inc., to Marlene H. Dortch, Secretary, FCC (filed Jun. 24, 2020) (Viasat June 24 Response to SpaceX); Letter from Christopher J. Murphy, Associate General Counsel, Viasat, Inc., to Marlene H. Dortch, Secretary, FCC (filed Jul. 2, 2020) (Viasat July 2 Response to SpaceX); Letter from Christopher J. Murphy, Associate General Counsel, Viasat, Inc., to Marlene H. Dortch, Secretary, FCC (filed Jul. 20, 2020) (Viasat July 20 response to SpaceX); Letter from Amy R. Mehlman, Vice President U.S. Government Affairs and Policy, Viasat, Inc., to Marlene H. Dortch, Secretary, FCC (filed Sept. 17, 2020) (Viasat September 17 Letter); Ex Parte Presentation of Viasat, Inc. (filed Sept. 23, 2020) (Viasat September 23 Ex Parte); Letter from Amy R. Mehlman, Vice President U.S. Government Affairs and Policy, Viasat, Inc., to Marlene H. Dortch, Secretary, FCC (filed Sept.

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25, 2020) (Viasat September 25 Response to SpaceX); Letter from Amy R. Mehlman, Vice President U.S. Government Affairs and Policy, Viasat, Inc., to Marlene H. Dortch, Secretary, FCC (filed Oct. 5, 2020) (Viasat October 5 Response to SpaceX); Ex Parte Presentation of Viasat, Inc. (filed Oct. 29, 2020) (Viasat October 29 Ex Parte); Ex Parte Presentation of Viasat, Inc. (filed Nov. 19, 2020) (Viasat November 19 Ex Parte); Letter from Amy R. Mehlman, Vice President U.S. Government Affairs and Policy, Viasat, Inc., to Marlene H. Dortch, Secretary, FCC (filed Dec. 8, 2020) (Viasat December 8 Letter); Ex Parte Presentation of Viasat, Inc. (filed Dec. 21, 2020) (Viasat December 21 ex Parte); Letter from David Goldman, Director Satellite Policy, Space Exploration Technologies Corp., to Marlene H. Dortch, Secretary, FCC (filed Dec. 30, 2020) (SpaceX December 30 Response to Viasat); Ex Parte Presentation of Viasat, Inc. (filed Jan. 7, 2021) (Viasat January 7 Ex Parte); Letter from Amy R. Mehlman, Vice President U.S. Government Affairs and Policy, Viasat, Inc., to Marlene H. Dortch, Secretary, FCC (filed Jan. 15, 2021) (Viasat January 15 Letter); Letter from David Goldman, Director of Satellite Policy, Space Explorations Technologies Corp., to Marlene H. Dortch, Secretary, FCC (filed Feb. 4, 2021) (SpaceX NEPA Response); Ex Parte Presentation of Viasat Inc. (filed Feb. 8, 2021) (Viasat February 8 Ex Parte); Ex Parte Presentation of Viasat, Inc. (filed Feb. 12, 2021) (Viasat February 12 Ex Parte); Letter from Amy R. Mehlman, Vice President U.S. Government Affairs and Policy, Viasat, Inc., to Marlene H. Dortch, Secretary, FCC (filed Feb. 18, 2021) (Viasat February 18 Response to SpaceX); Letter from Amy R. Mehlman, Vice President U.S. Government Affairs and Policy, Viasat, Inc., to Jessica Rosenworcel, Acting Chairwoman, Brendan Carr, Commissioner, Geoffrey Starks, Commissioner, and Nathan Simington, Commissioner, FCC (filed Feb. 22, 2021) (Viasat February 22 Letter); Letter from David Goldman, Director of Satellite Policy, Space Explorations Technologies Corp., to Marlene H. Dortch, Secretary, FCC (filed Mar. 2, 2021) (SpaceX March 2 Response to Viasat); Letter from David Goldman, Director of Satellite Policy, Space Explorations Technologies Corp., to Marlene H. Dortch, Secretary, FCC (filed Mar. 11, 2021) (SpaceX March 11 Response to Viasat); Letter from Amy R. Mehlman, Vice President U.S. Government Affairs and Policy, Viasat, Inc., to Marlene H. Dortch, Secretary, FCC (filed Mar. 16, 2021) (Viasat March 16 Letter); Ex Parte Presentation of Viasat, Inc. (filed Mar. 23, 2021) (Viasat March 23 Ex Parte); Letter from Amy R. Mehlman, Vice President U.S. Government Affairs, Viasat, Inc., to Marlene H. Dortch, Secretary, FCC (filed Mar. 26, 2021) (Viasat March 26 Letter); Letter from Amy R. Mehlman, Vice President U.S. Government Affairs and Policy, Viasat, Inc. to Marlene H. Dortch, Secretary, FCC (filed Apr. 5, 2021) (Viasat April 5 Letter); Letter from Amy R. Mehlman, Vice President U.S. Government Affairs and Policy, Viasat, Inc. to Marlene H. Dortch, Secretary, FC C (filed Apr. 12, 2021) (Viasat April 12 Conditions Letter); Letter from Amy R. Mehlman, Vice President U.S. Government Affairs and Policy, Viasat, Inc. to Marlene H. Dortch, Secretary, FCC (filed Apr. 12, 2021) (Viasat April 12 LEO Letter); Letter from Amy R. Mehlman, Vice President U.S. Government Affairs and Policy, Viasat, Inc. to Marlene H. Dortch, Secretary, FC C (filed Apr. 12, 2021) (Viasat April 12 Collision Risk Letter); Letter from Amy R. Mehlman, Vice President U.S. Government Affairs and Policy, Viasat, Inc. to Marlene H. Dortch, Secretary, FC C (filed Apr. 12, 2021) (Viasat April 12 Look Angles Letter); Letter from Amy R. Mehlman, Vice President U.S. Government Affairs and Policy, Viasat, Inc. to Marlene H. Dortch, Secretary, FC C (filed Apr. 12, 2021) (Viasat April 12 Failure Rates Letter); Ex Parte Presentation of Viasat Inc. (filed Apr. 13, 2021) (Viasat April 13 Ex Parte); Ex Parte Presentation of Viasat Inc. (filed Apr. 14, 2021) (Viasat April 14 Ex Parte); Letter from Amy R. Mehlman, Vice President U.S. Government Affairs and Policy, to Marlene H. Dortch, Secretary, FCC (filed Apr. 16, 2021) (Viasat April 16 Ex Parte); Letter from Amy R. Mehlman, Vice President U.S. Government Affairs and Policy, to Marlene H. Dortch, Secretary, FCC (filed Apr. 19, 2021) (Viasat April 19 Letter); Ex Parte Presentation of Viasat Inc. (filed Apr. 21, 2021) (Viasat April 21 Ex Parte); Letter from Amy R. Mehlman, Vice President U.S. Government Affairs and Policy, to Marlene H. Dortch, Secretary, FCC (filed Apr. 21, 2021) (Viasat April 21 Letter); Ex Parte Presentation of Viasat, Inc. (filed Apr. 22, 2021) (Viasat April 22 Ex Parte); Ex Parte Presentation of Viasat, Inc. (filed Apr. 26, 2021) (Viasat April 26 Ex Parte).

³⁰ See Letter from Jennifer A. Manner, Senior Vice President Regulatory Affairs, Hughes Network Systems, LLC, to Marlene H. Dortch, Secretary, FCC (filed September 21, 2020) (Hughes September 21 Ex Parte); Letter from David Goldman, Director of Satellite Policy, Space Exploration Technologies Corp., to Marlene H. Dortch, Secretary, FCC (filed Sept. 29, 2020) (SpaceX September 29 Response to GSO Operators); Letter from Jennifer A. Manner, Senior Vice President Regulatory Affairs, Hughes Network Systems, LLC, to Marlene H. Dortch, Secretary, FCC (filed Feb. 5, 2021) (Hughes February 5 Letter); Ex Parte Presentation of Hughes Network Systems, LLC (filed Mar. 5, 2021) (Hughes March 5 Ex Parte); Letter from David Goldman, Director of Satellite Policy, Space Exploration Technologies Corp., to Marlene H. Dortch, Secretary, FCC (filed Mar. 11, 2021) (SpaceX March 11 Response to Hughes); Letter from Jennifer Manner, Senior Vice President Regulatory Affairs, Hughes Network Systems, to Marlene H. Dortch, Secretary, FCC (filed Apr. 5, 2021) (Hughes April 5 Letter); Letter from Jennifer A. Manner, Senior Vice President Regulatory Affairs, Hughes Network Systems, LLC, to Marlene H. Dortch, Secretary, FCC

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(filed Apr. 12, 2021) (Hughes April 12 Letter); Ex Parte Presentation of Hughes Network Systems, LLC. (filed Apr. 20, 2021) (Hughes April 20 Ex Parte); Ex Parte Presentation of Hughes Network Systems, LLC. (filed Apr. 21, 2021) (Hughes April 21 Carr Ex Parte); Ex Parte Presentation of Hughes Network Systems, LLC. (filed Apr. 21, 2021) (Hughes April 21 Simington Ex Parte).

³¹ See RS Access Letter; Letter from David Goldman, Director of Satellite Policy, Space Exploration Technologies Corp., to Marlene H. Dortch, Secretary, FCC (filed Jul. 10, 2020) (SpaceX July 10 Response to RS Access); Ex Parte Presentation of RS Access, LLC (filed Feb. 8, 2021) (RS Access February 8 Ex Parte); Ex Parte Presentation of RS Access, LLC (filed Feb. 19, 2021) (RS Access February 19 Ex Parte); Ex Parte Presentation of RS Access LLC (filed Feb. 26, 2021) (RS Access February 26 Ex Parte); Ex Parte Presentation of RS Access LLC (filed Mar. 15, 2021) (RS Access March 15 Ex Parte); Ex Parte Presentation of RS Access LLC. (filed Apr. 9, 2021) (RS Access April 9 Ex Parte); Ex Parte Presentation of RS Access LLC. (filed Apr. 23, 2021) (RS Access April 23 Ex Parte).

³² See Ex Parte Presentation of Kuiper Systems, LLC (filed May 1, 2020) (Kuiper May 1 Ex Parte); Ex Parte Presentation of Kuiper Systems, LLC (filed May 22, 2020) (Kuiper May 22 Ex Parte); Ex Parte Presentation of Kuiper Systems, LLC (filed Jun. 1, 2020) (Kuiper June 1 Ex Parte); Ex Parte Presentation of Kuiper Systems, LLC (filed Aug. 18, 2020) (Kuiper August 18 Ex Parte); Ex Parte Presentation of Kuiper Systems, LLC (filed Sept. 2, 2020) (Kuiper September 2 Ex Parte); Letter from David Goldman, Director of Satellite Policy, Space Exploration Technologies Corp., to Marlene H. Dortch, Secretary, FCC (filed Sept. 3, 2020) (SpaceX September 3 Response to Kuiper); Ex Parte Presentation of Kuiper Systems, LLC (filed Sept. 17, 2020) (Kuiper September 17 Ex Parte); Ex Parte Presentation of Kuiper Systems, LLC (filed Sept. 24, 2020) (Kuiper September 24 Ex Parte); Ex Parte Presentation of Kuiper Systems, LLC (filed Sept. 30, 2020) (Kuiper September 30 Ex Parte); Ex Parte Presentation of Kuiper Systems, LLC (filed Oct. 6, 2020) (Kuiper October 6 Ex Parte); Letter from David Goldman, Director of Satellite Policy, Space Exploration Technologies Corp., to Marlene H. Dortch, Secretary, FCC (filed Oct. 9, 2020) (SpaceX October 9 Response to Kuiper); Ex Parte Presentation of Kuiper Systems, LLC (filed Oct. 9, 2020) (Kuiper October 9 Ex Parte); Ex Parte Presentation of Kuiper Systems, LLC (filed Oct. 19, 2020) (Kuiper October 15 Ex Parte); Ex Parte Presentation of Kuiper Systems, LLC (filed Oct. 19, 2020) (Kuiper October 16 Ex Parte); Letter from David Goldman, Director of Satellite Policy, Space Exploration Technologies Corp., to Marlene H. Dortch, Secretary, FCC (filed Oct. 29, 2020) (SpaceX October 29 Response to Kuiper); Letter from Mariah Dodson Shuman, Counsel, Kuiper Systems, LLC, to Marlene H. Dortch, Secretary, FCC (filed Nov. 6, 2020) (Kuiper November 6 Response to SpaceX); Ex Parte Presentation of Kuiper Systems, LLC (filed Nov. 17, 2020) (Kuiper November 17 Ex Parte); Letter from David Goldman, Director of Satellite Policy, Space Exploration Technologies Corp., to Marlene H. Dortch, Secretary, FCC (filed Nov. 17, 2020) (SpaceX November 17 Letter); Letter from Mariah Dodson Shuman, Counsel, Kuiper Systems, LLC to Marlene H. Dortch, Secretary, FCC (filed Nov. 20, 2020) (Kuiper November 20 Letter); Ex Parte Presentation of Kuiper Systems, LLC (filed Nov. 24, 2020) (Kuiper November 24 Ex Parte); Ex Parte Presentation of Kuiper Systems, LLC (filed Dec. 3, 2020) (Kuiper December 3 Ex Parte); Ex Parte Presentation of Kuiper Systems, LLC (filed Dec. 23, 2020) (Kuiper December 23 Ex Parte); Ex Parte Presentation of Kuiper Systems, LLC (filed Feb. 4, 2021) (Kuiper February 4 Ex Parte); Letter from Mariah Dodson-Shuman, Counsel, Kuiper Systems, LLC, to Marlene H. Dortch, Secretary, FCC (filed Feb. 4, 2021) (Kuiper February 4 Letter); Ex Parte Presentation of Kuiper Systems, LLC (filed Feb. 11, 2021) (Kuiper February 11 Ex Parte); Ex Parte Presentation of Kuiper Systems, LLC (filed Feb. 22, 2021) (Kuiper February 22 Ex Parte); Ex Parte Presentation of Kuiper Systems LLC (filed Feb. 25, 2021) (Kuiper February 25 Ex Parte); Letter from David Goldman, Director Satellite Policy, Space Exploration Technologies Corp., to Marlene H. Dortch, Secretary, FCC (filed Feb. 25, 2021) (SpaceX February 25 Response to Kuiper); Ex Parte Presentation of Kuiper Systems LLC (filed Mar. 16, 2021) (Kuiper March 16 Ex Parte); Ex Parte Presentation of Kuiper Systems, LLC. (filed Mar. 23, 2021) (Kuiper March 23 Ex Parte); Letter from Mariah Dodson Shuman, Counsel, Kuiper Systems LLC, to Marlene H. Dortch, Secretary, FCC (filed Mar. 31, 2021) (Kuiper March 31 Letter); Ex Parte Presentation of Kuiper Systems, LLC (filed Apr. 5, 2021) (Kuiper April 5 Ex Parte); Letter from Mariah Dodson Shuman, Counsel, Kuiper Systems LLC., to Marlene H. Dortch, Secretary, FCC (filed Apr. 7, 2021) (Kuiper April 7 Letter); Ex Parte Presentation of Kuiper Systems LLC (filed Apr. 14, 2021) (Kuiper April 14 Ex Parte); Ex Parte Presentation of Kuiper Systems LLC. (filed Apr. 15, 2021) (Kuiper April 15 Ex Parte); Ex Parte Presentation of Kuiper Systems LLC (filed Apr. 19, 2021) (Kuiper April 19 Ex Parte).

³³ See Ex Parte Presentation of SES Americom, Inc. and O3b Limited (filed Sept. 10, 2020) (SES/O3b September 10 Ex Parte); Ex Parte Presentation of SES Americom, Inc. (filed Oct. 13, 2020) (SES October 13 Ex Parte); Letter from Suzanne Malloy, Vice President Regulatory Affairs, SES Americom and O3b Limited, to Marlene H. Dortch,

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Astronomical Society also filed Reply comments.³⁵ A significant number of *ex parte* presentations and additional letters were also filed in response to this application outside of the public notice period.³⁶

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Secretary, FCC (filed Oct. 21, 2020) (SES/O3b October 21 Letter); Letter from David Goldman, Director of Satellite Policy, Space Exploration Technologies Corp., to Marlene H. Dortch, Secretary, FCC (filed Nov. 13, 2020) (SpaceX November 13 Response to SES/O3b); Ex Parte Presentation of SES Americom and O3b Limited (filed Nov. 23, 2020) (SES/O3b November 17 Ex Parte); Ex Parte Presentation of SES Americom and O3b Limited (filed Nov. 23, 2020) (SES/O3b November 23 Ex Parte); Letter from Suzanne Malloy, Vice President Regulatory Affairs, O3b Limited, to Marlene H. Dortch, Secretary, FCC (filed Jan. 29, 2021) (SES/O3b January 29 Letter); Letter from David Goldman, Director of Satellite Policy, Space Exploration Technologies Corp., to Marlene H. Dortch, Secretary, FCC (filed Feb. 22, 2021) (SpaceX February 22 Response to SES/O3b); Ex Parte Presentation of SES/O3b (filed Feb. 26, 2021) (SES/O3b February 26 Ex Parte); Letter from Suzanne Malloy, Vice President Regulatory Affairs, O3B Limited, to Marlene H. Dortch, Secretary, FCC (filed Mar. 22, 2021) (SES/O3b March 22 Letter); Ex Parte Presentation of SES Americom Inc. and O3b Limited (filed Mar. 23, 2021) (SES/O3b March 23 Ex Parte); Ex Parte Presentation of SES Americom Inc. and O3b Limited (filed Mar. 30, 2021) (SES/O3b March 30 Ex Parte); Ex Parte Presentation of SES Americom Inc. and O3b Limited (filed Apr. 6, 2021) (SES/O3b April 6 Ex Parte); Letter from Suzanne Malloy, Vice President Regulatory Affairs, SES Americom Inc. and O3b Limited, to Marlene H. Dortch, Secretary, FCC (filed Apr. 21, 2021) (SES/O3b April 21 Letter); Ex Parte Presentation of SES Americom Inc. and O3B Limited (filed Apr. 23, 2021) (SES/O3b April 23 Ex Parte).

³⁴ See The Balance Group Opposition; Reply of Space Exploration Holdings, LLC (filed June 8, 2020) (SpaceX June 8 Reply to The Balance Group); Reply of the Balance Group (filed Jun. 16, 2020) (The Balance Group June 16 Reply to SpaceX).

³⁵ See Letter from Charity Weeden, Vice President Global Space Policy, Astroscale U.S., Inc., to Marlene H. Dortch, Secretary, FCC (filed Aug. 6, 2020) (Astroscale Reply); Reply of WorldVu Satellites Limited, Debtor-in-possession (filed Aug. 7, 2020) (OneWeb Reply); Reply of Kuiper Systems, LLC (filed Aug. 7, 2020) (Kuiper Reply); Reply of Viasat, Inc. (filed Aug. 7, 2020) (Viasat Reply); Reply of AT&T Services, Inc. (filed Aug. 7, 2020) (AT&T Reply); Reply of SES Americom, Inc. and O3b Limited (filed Aug. 7, 2020) (SES/O3b Reply); Reply of Kepler Communications, Inc. (filed Aug. 7, 2020) (Kepler Reply); Reply of the American Astronomical Society (filed Jan. 7, 2021) (American Astronomical Society Reply); Reply of Viasat, Inc. in Support of Petition Pursuant to Section 1.1307 (filed Jan. 19, 2021) (Viasat NEPA Reply).

³⁶ See Ex Parte Presentation of Space Exploration Holdings, LLC (filed May 6, 2020) (SpaceX May 6 Ex Parte); Ex Parte Presentation of Space Exploration Holdings, LLC (filed Jun. 3, 2020) (SpaceX June 3 Ex Parte); SpaceX June 18 Ex Parte; Ex Parte Presentation of Space Exploration Holdings, LLC (filed Jul. 31, 2020) (SpaceX July 31 Ex Parte); Ex Parte Presentation of Space Exploration Holdings, LLC (filed Sept. 3, 2020) (SpaceX September 3 Ex Parte); Ex Parte Presentation of Space Exploration Holdings, LLC (filed Sept. 14, 2020) (SpaceX September 14 Ex Parte); Ex Parte Presentation of Space Exploration Holdings, LLC (filed Sept. 18, 2020) (SpaceX September 18 Ex Parte); Letter from Dr. Jonathan McDowell, Harvard and Smithsonian Center for Astrophysics, to Marlene H. Dortch, Secretary, FCC (filed Sept. 21, 2020) (McDowell Letter); Ex Parte Presentation of Space Exploration Holdings, LLC (filed Sept. 23, 2020) (SpaceX September 23 Ex Parte); Letter from Amy R. Mehlman, Vice President U.S. Government Affairs and Policy, Viasat, Inc., to Marlene H. Dortch, Secretary, FCC (filed Sept. 24, 2020) (Viasat Response to McDowell Letter); Ex Parte Presentation of Space Exploration Holdings, LLC (filed Oct. 5, 2020) (SpaceX October 5 Ex Parte); Ex Parte Presentation of Space Exploration Holdings, LLC (filed Oct. 15, 2020) (SpaceX October 15 Ex Parte); Ex Parte Presentation of Space Exploration Holdings, LLC (filed Oct. 20, 2020) (SpaceX October 20 Ex Parte); Letter from Sean Williams, Director of Government Affairs, Pacific Dataport, Inc., to Marlene H. Dortch, Secretary, FCC (filed Nov. 25, 2020) (Pacific Dataport Letter); Ex Parte Presentation of Space Exploration Holdings, LLC (filed Dec. 4, 2020) (SpaceX December 4 Ex Parte); Letter from Jacob Calderwood to Marlene H. Dortch, Secretary, FCC (filed Dec. 5, 2020) (Jacob Calderwood December 5 Letter); Ex Parte Presentation of Space Exploration Holdings, LLC (filed Dec. 7, 2020) (SpaceX December 7 Ex Parte); Ex Parte Presentation of Space Exploration Holdings, LLC (filed Dec. 9, 2020) (SpaceX December 9 Ex Parte); Ex Parte Presentation of Space Exploration Holdings, LLC (filed Dec. 15, 2020) (SpaceX December 15 Ex Parte); Ex Parte Presentation of Space Exploration Holdings, LLC (filed Dec. 21, 2020) (SpaceX December 21 Ex Parte); Ex Parte Presentation of Space Exploration Holdings, LLC (filed Dec. 28, 2020) (SpaceX December 28 Ex Parte); Ex Parte Presentation of Space Exploration Holdings, LLC (filed Jan. 5, 2021) (SpaceX January 5 Ex Parte); Ex Parte Presentation of Space Exploration Holdings, LLC (filed Jan. 19, 2021) (SpaceX January 19 Ex Parte); Ex Parte

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6. On November 17, 2020, SpaceX submitted a letter requesting the Bureau expedite grant of the Third Modification Application, through a partial grant if necessary, in order to facilitate deployment of Starlink satellites into sun synchronous polar orbits at 560 km.³⁷ On January 8, 2021, the Bureau granted SpaceX authority, with conditions, to deploy ten satellites into orbit with an altitude of 560 km and inclination of 97.6 degrees, which enabled SpaceX to take advantage of an upcoming launch opportunity. The Bureau deferred a number of other issues raised on the record to a future order addressing the entire modification request, and we address those issues in this order.³⁸ Additionally,

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_____ Presentation of Space Exploration Holdings, LLC (filed Jan. 22, 2021) (SpaceX January 22 Ex Parte); Letter from Joel M. Thomas, to Marlene H. Dortch, Secretary, FCC (filed Jan. 26, 2021) (Joel Thomas Letter); Letter from John Wallace, Alaska Technologies, to Marlene H. Dortch, Secretary, FCC (filed Jan. 26, 2021) (Alaska Technologies Letter); Letter from Jonah Koonce to Marlene H. Dortch, Secretary, FCC (filed Jan. 27, 2021) (Jonah Koonce Letter); Ex Parte Presentation of Space Exploration Holdings, LLC (filed Feb. 1, 2020) (SpaceX February 1 Ex Parte); Ex Parte Presentation of WorldVu Satellites Limited (filed Feb. 10, 2021) (OneWeb February 10 Ex Parte); Ex Parte Presentation of World Vu Satellites Limited, (filed Feb. 17, 2021) (OneWeb February 17 Ex Parte); Letter from Jacob Calderwood to Marlene H. Dortch, Secretary, FCC (filed Feb. 19, 2021) (Jacob Calderwood February 19 Letter); Ex Parte Presentation of Space Exploration Holdings LLC (SpaceX February 22 Ex Parte); Letter from Roberta Townsend Vennel, Kodiak Archipelago Rural Regional Leadership Forum, to Jessica Rosenworcel, Acting Chairwoman, FCC (filed Feb. 24, 2021) (Kodiak Archipelago Letter); Ex Parte Presentation of WorldVu Satellites Limited, (filed Feb. 25, 2021) (OneWeb February 25 Ex Parte); Ex Parte Presentation of Space Exploration Holdings, LLC (filed Mar. 1, 2021) (SpaceX March 1 Ex Parte); Ex Parte Presentation of SpaceX Exploration Holdings LLC (filed Mar. 4, 2021) (SpaceX March 4 Ex Parte); Letter from Vernon Samson to Marlene H. Dortch, Secretary, FCC (filed Mar. 6, 2021) (Vernon Samson Letter); SpaceX March 8 Ex Parte; Letter from David Goldman, Director of Satellite Policy, Space Exploration Technologies Corp., to Marlene H. Dortch, Secretary, FCC (filed Mar. 9, 2021) (SpaceX March 9 Letter); Ex Parte Presentation of WorldVu Satellites Limited (filed March 10, 2021) (OneWeb March 10 Ex Parte); Letter from Brian D. Weimer, Counsel, WorldVu Satellites Limited, to Marlene H. Dortch, Secretary, FCC (filed Mar. 15, 2021) (OneWeb March 15 Letter); Ex Parte Presentation of Space Exploration Holdings, LLC (filed Mar. 16, 2021) (SpaceX March 16 Ex Parte); Letter from Michael P. Williams, Sr., Chief, Akiak IRA Council, to Jessica Rosenworcel, Acting Chairwoman, FCC (filed Mar. 19, 2021) (Akiak Native Community Letter); Ex Parte Presentation of WorldVu Satellites Limited (filed Mar. 29, 2021) (OneWeb March 29 Ex Parte); Ex Parte Presentation of WorldVu Satellites Limited (filed Apr. 1, 2021) (OneWeb April 1 Ex Parte); Ex Parte Presentation of Space Exploration Holdings, LLC. (filed Apr. 2, 2021) (SpaceX April 2 Ex Parte); Ex Parte Presentation of WorldVu Satellites Limited (filed Apr. 12, 2021) (OneWeb April 12 Ex Parte); Ex Parte Presentation of WorldVu Satellites Limited (filed Apr. 14, 2021) (OneWeb April 14 Ex Parte); Letter from Nickolas G. Spina, Kepler Communications, Inc., to Marlene H. Dortch, Secretary, FCC (filed Apr. 16, 2021) (Kepler April 16 Letter); Ex Parte Presentation of Space Exploration Holdings, LLC (filed April 20, 2021) (SpaceX April 20 Ex Parte); Letter from Professor Andrew Lawrence to Marlene H. Dortch, Secretary, FCC (filed Apr. 21, 2021) (Andrew Lawrence Letter); Letter from Brian D. Weimer, Counsel, WorldVu Satellites Limited, to Marlene H. Dortch, Secretary, FCC (filed Apr. 21, 2021) (OneWeb April 21 Letter); Letter from Carey Hahnier to Marlene H. Dortch, Secretary, FCC (filed Apr. 26, 2021) (Carey Hahnier Letter).

³⁷ See SpaceX November 17 Letter at 2-3 (specifying six orbital planes with 58 satellites in each, at 560 km altitude). Several letters were filed responding specifically to SpaceX's requesting partial expedited grant. See Viasat November 19 Ex Parte; Viasat December 8 Letter; SES/O3b November 23 Ex Parte; Kuiper November 24 Ex Parte; Kuiper December 3 Ex Parte; Kuiper December 23 Ex Parte; Kepler December 4 Letter; Pacific Dataport Letter; SpaceX December 4 Ex Parte; SpaceX December 7 Ex Parte; SpaceX December 9 Ex Parte; SpaceX December 15 Ex Parte; SpaceX December 21 Ex Parte; SpaceX January 5 Ex Parte; Jacob Calderwood December 5 Letter.

³⁸ See *Space Exploration Holdings, LLC, Request for Modification of the SpaceX NGSO System, Order and Authorization*, DA 21-34, 2021 WL 118618 (IB, granted in part and deferred in part Jan. 8, 2021) (*SpaceX Third Modification Ten-Satellite Grant*). In this partial grant the Bureau also granted SpaceX's request for waiver of certain requirements in the Schedule S form. *Id.* at paras. 16-17.

Viasat has filed a petition for reconsideration of this partial grant.³⁹

III. DISCUSSION

7. After review of the record, we conclude that grant of the SpaceX Third Modification Application 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. Where appropriate, and consistent with prior authorizations for SpaceX's system, we defer matters of general applicability to ongoing or potential future rulemakings.

A. Public Interest Determination

8. Section 25.117 of the Commission's rules governs the modification of space station licenses and provides generally that modifications of space station authorizations will be granted except under certain circumstances.⁴⁰ One of these exceptions is when "granting the modification request would not serve the public interest, convenience, and necessity."⁴¹ In interpreting this provision, the Bureau has stated that, "[i]f the proposed modification does not present any significant interference problems and is otherwise consistent with Commission policies, it is generally granted."⁴² Therefore we consider whether the request will serve the public interest, convenience, and necessity.

9. SpaceX argues grant of its modification is in the public interest, as it is reducing its satellites' altitude to improve space safety, reducing its power flux density (PFD) emissions to improve the interference environment, and lowering its elevation angles to improve the customer experience.⁴³ Additionally, several individuals, businesses, and organizations from Alaska submitted letters in the docket urging the Bureau to act on the SpaceX modification to allow SpaceX to begin deployment of its Starlink service in Alaska.⁴⁴ These filings discuss the scarcity of reliable internet service, the extreme expense of the internet service that is available, the difficulties of maintaining that service, and the effect this has on Alaska communities.⁴⁵ They argue the Starlink service will finally bring ubiquitous internet connectivity within reach for these areas.⁴⁶

10. Viasat, Hughes, and Kuiper challenge SpaceX's claims. Viasat and Hughes argue that SpaceX's claims of the public interest benefits of its system are unsubstantiated and should not rely on them as justification for grant of the SpaceX Third Modification Application.⁴⁷ Viasat argues that SpaceX has not provided analysis demonstrating how the latency has changed by reducing the satellites'

³⁹ See Viasat Recon Petition; see also Opposition to Petition or Reconsideration of Space Exploration Holdings, LLC, filed Feb. 23, 2021 (SpaceX Recon Opposition); Reply of Viasat in Support of Petition for Reconsideration (filed Mar. 5, 2021) (Viasat Recon Reply).

⁴⁰ 47 CFR § 25.117.

⁴¹ 47 CFR §25.117(d)(2)(ii).

⁴² *SpaceX First Modification Order*, at para. 9 (quoting *Teledesic Order*, 14 FCC Rcd at 2264, para. 5).

⁴³ See SpaceX September 3 Ex Parte at 1; SpaceX September 18 Ex Parte at 1.

⁴⁴ See Jacob Calderwood December 5 Letter; Jacob Calderwood February 19 Letter; Alaska Technologies Letter; Joel Thomas Letter; Jonah Koonce Letter; Kodiak Archipelago Letter; Vernon Samson Letter; Akiak Native Community Letter; Carey Hahnier Letter.

⁴⁵ See Jacob Calderwood December 5 Letter; Jacob Calderwood February 19 Letter; Alaska Technologies Letter; Joel Thomas Letter; Jonah Koonce Letter; Kodiak Archipelago Letter; Vernon Samson Letter; Akiak Native Community Letter; Carey Hahnier Letter.

⁴⁶ See Jacob Calderwood December 5 Letter; Jacob Calderwood February 19 Letter; Alaska Technologies Letter; Joel Thomas Letter; Jonah Koonce Letter; Kodiak Archipelago Letter; Vernon Samson Letter; Akiak Native Community Letter; Carey Hahnier Letter.

⁴⁷ See Viasat Petition at 47-48; Viasat Reply at 42-45; Hughes September 21 Ex Parte at 1.

operating altitude, and therefore this assertion by SpaceX does not justify the modification.⁴⁸ Viasat also argues that SpaceX's system, as currently authorized, can provide service worldwide, including to polar regions, as it is authorized for 1,225 satellites in high-inclination (greater than 70 degree) orbits, and therefore SpaceX's claim that the modification will allow it to increase its service areas is untrue.⁴⁹

11. Viasat and Kuiper further challenge SpaceX's claim that the Third Modification Application will improve space safety. Viasat argues, for example, that satellites from other systems will have to transit through the more densely-populated orbits where SpaceX satellites would operate.⁵⁰ Kuiper similarly argues that while there may be public interest benefits to reducing SpaceX's satellite altitude for the constellations located at its original altitude, these benefits are negated by the harm to the public interest caused by placing 2,824 more satellites in the 540-570 km orbital shell, which it views as already congested.⁵¹

12. As described in more detail below, we conclude that grant of the SpaceX Third Modification Application is in the public interest. Based on our review, we agree with SpaceX that the modification will improve the experience for users of the SpaceX service, including in often-underserved polar regions. We conclude that the lower elevation angle of its earth station antennas and lower altitude of its satellites enables a better user experience by improving speeds and latency.⁵² Additionally, a number of the satellites being deployed pursuant to this modification are satellites orbiting at high inclinations, which are uniquely able to provide improved service to higher latitude regions.⁵³ As noted below, deployment to a lower altitude guarantees removal of satellites from orbit within a relatively short period of time, and consequently has beneficial effects with respect to orbital debris mitigation. We also note that this decision is taken under the existing satellite precedent and licensing framework and does not address, and is not intended to resolve, any additional issues or concerns that may arise related to the Rural Digital Opportunity Fund program.⁵⁴

13. Grant of the SpaceX Ku- and Ka-band NGSO system, as modified, will improve service to remote and underserved areas, including polar regions, and will facilitate the deployment of the Starlink system overall. We conclude that operations at the lower altitude will have beneficial effects with respect to orbital debris mitigation. We also find that SpaceX's modification will not present significant interference problems, as assessed under Commission precedent. We address these issues in more detail below.

B. Radiofrequency Interference

14. Commenters raised concerns regarding the effect SpaceX's system, as modified, would have on other NGSO systems, geostationary orbit (GSO) satellite systems, and multichannel Video Distribution Data systems (MVDDS) operations.

1. Interference to Other NGSO Systems and Processing Round Placement

15. SES/O3b, Kuiper, Viasat, Kepler, OneWeb, and DISH all claim that the SpaceX Third

⁴⁸ See Viasat Petition at 47. Viasat further argues that SpaceX has not demonstrated the latency and download speeds that it claims. See Viasat September 17 Ex Parte at 2-4; Hughes September 21 Ex Parte at 1; Viasat September 25 Ex Parte at 1-2; Viasat October 5 Response to SpaceX at 2-6.

⁴⁹ See Viasat Petition at 47-48.

⁵⁰ See *id.* at 48.

⁵¹ See Kuiper Opposition at 10-11.

⁵² See SpaceX September 3 Ex Parte at 1; SpaceX September 18 Ex Parte at 1.

⁵³ See SpaceX Third Modification Application, Narrative at II, 3- 4 (specifying 520 satellites will operate in orbits that will serve polar regions).

⁵⁴ See *e.g.* Viasat April 26 Ex Parte Letter.

Modification is a complete redesign of SpaceX's authorized system that will substantially increase interference into other systems. They argue that, consistent with the Bureau's precedent, specifically the Bureau's decision in the *Teledesic Order*,⁵⁵ SpaceX's modified system should not be treated as if authorized in the Commission's Ku-/Ka-band processing rounds that closed in November 2016 (the 2016 Processing Round)⁵⁶ and July 2017 (the 2017 Processing Round)⁵⁷ but instead should be considered as part of the Ku-/Ka-band processing round that closed in May 2020 (the 2020 Processing Round).⁵⁸ These operators argue that the processing round framework is designed to promote regulatory certainty, and therefore allowing operators like SpaceX to modify their systems so substantially and still remain part of their original processing round—in SpaceX's case the 2016 Processing Round—will destroy that certainty.⁵⁹ SpaceX argues that, unlike for amendments, there is no distinction between major and minor modifications in the Commission's rules, and the relevant precedent under the *Teledesic Order* is to consider the requested modification's impact on the overall interference environment, and not whether the modification creates new interference geometries.⁶⁰ SpaceX claims that its system, far from increasing interference into other systems, will in fact improve the overall interference environment.⁶¹ SpaceX further argues that forcing its system to become part of the 2020 Processing Round would be counter to the public interest and would effectively preclude operators from modifying their systems, exactly what the *Teledesic Order* sought to prevent.⁶²

a. Modifications and the Significant Interference Standard

16. As noted, our rule governing the modification of space station licenses states that “applications for modifications of space station authorizations will be granted,” unless one of several enumerated exceptions applies, none of which are potentially relevant here except for the provision

⁵⁵ See generally *Teledesic Order*.

⁵⁶ See *2016 Processing Round Public Notice*.

⁵⁷ See *2017 Processing Round Public Notice*.

⁵⁸ See *Cut-off Established for Additional NGSO FSS Applications or Petitions for Operations in the 10.7-12.7 GHz, 12.75-13.25 GHz, 13.85-14.5 GHz, 17.7-18.6 GHz, 18.8-20.2 GHz, and 27.5-30 GHz Band*, Public Notice, Report No. SPB-279, DA 20-325 (Mar. 24, 2020). See SES/O3b Petition at 15; SES/O3b Reply at 11, 17; SES/O3b October 13 Ex Parte at 2; SES/O3b November 17 Ex Parte, Attachment 1 at 1; SES/O3b January 29 Letter at 1, 2, 9-11; SES/O3b February 26 Ex Parte at 1, Attachment B at 1, 4; SES/O3b March 22 Letter; SES/O3b March 23 Ex Parte; SES/O3b April 21 Letter at 1-2; Kuiper Opposition at 28-29; Kuiper Reply at 11-14; Kuiper August 18 Ex Parte at 1, 2; Kuiper September 2 Ex Parte at 2; Kuiper September 17 Ex Parte at 2; Kuiper September 24 Ex Parte at 1; Kuiper September 30 Ex Parte at 2; Kuiper October 6 Ex Parte at 2; Kuiper October 9 Ex Parte at 1, 3-5; Kuiper October 15 Ex Parte at 2; Kuiper October 16 Ex Parte at 1, 3-5; Kuiper November 6 Response to SpaceX at 2; Kuiper February 4 Letter at 5-10; Kuiper February 4 Ex Parte at 1, 3, 5; Kuiper February 11 Ex Parte at 1, 3, 5; Kuiper February 22 Ex Parte at 1, 3, 5; Kuiper February 25 Ex Parte at 1, 3, 5; Kuiper March 16 Ex Parte at 1, 3, 5; Kuiper March 23 Ex Parte; Viasat Petition at 44, 48-49; Viasat Reply at 30-32; Viasat February 8 Ex Parte at 3; Viasat February 12 Ex Parte at 3; Kepler Opposition at 2, 11; Kepler Reply at 23-24; OneWeb Comments at 8-9; OneWeb February 10 Ex Parte at 2-3, 5; OneWeb February 17 Ex Parte at 5-7; OneWeb February 25 Ex Parte at 5; OneWeb March 10 Ex Parte at 5; OneWeb March 15 Letter at 1-2, 10-11; OneWeb April 12 Ex Parte at 5; DISH February 15 Letter at 7-8.

⁵⁹ See, e.g., SES October 13 Ex Parte at 2; SES/O3B November 17 Ex Parte, Attachment 1 at 1; SES/O3B January 29 Letter at 2, 9-11; Kuiper Opposition at 29-30; Kuiper Reply at 11-14; Kuiper August 18 Ex Parte at 2; Kuiper September 2 Ex Parte at 2; Kuiper October 6 Ex Parte at 2; Kuiper October 9 Ex Parte at 1, 3; Kuiper November 6 Response to SpaceX at 3; Kuiper February 4 Letter at 1-4.

⁶⁰ See SpaceX February 22 Response to SES/O3B at 1-2; SpaceX March 9 Letter at 1-3.

⁶¹ See SpaceX February 22 Ex Parte at 2; SpaceX March 1 Ex Parte at 1; SpaceX March 8 Ex Parte at 1.

⁶² See SpaceX September 3 Response to Kuiper at 3; SpaceX October 9 Response to Kuiper at 1, 2-3; SpaceX January 19 Ex Parte, Attachment B at 2.

stating that the modification will not be granted if it “would not serve the public interest, convenience, and necessity.”⁶³ In the context of applications to modify authorized NGSO systems that were originally subject to modified processing round procedures, the Bureau has interpreted this provision, including in its *Teledesic Order*, to include the following determination: “[i]f the proposed modification does not present any significant interference problems and is otherwise consistent with Commission policies, it is generally granted[,]” but if the modification “presents significant interference problems, [the Bureau] would treat the modification as a newly filed application and would consider the modification application in a subsequent satellite processing round.”⁶⁴ While we are not bound by this Bureau-level precedent in considering the instant decision, we conclude that this focus on the public interest in avoiding significant radiofrequency interference is consistent with the purpose of the Commission’s processing round procedure, which is designed to establish the interference environment in which participants in the processing round could reasonably anticipate they would be entitled to operate their systems.⁶⁵ Under the Bureau’s decision in the *Teledesic Order*, if a modification would “present significant interference problems,” grant of the modification would not be in the public interest, and that the application should instead be treated as a newly-filed application for processing round purposes.⁶⁶ The Bureau has affirmed this standard in several applications, including its grant of SpaceX’s first modification application for its Ku- and Ka-band authorized system (*SpaceX First Modification Order*).⁶⁷ We apply the same standard in this Commission-level decision, for the reasons set forth in the *Teledesic Order*.⁶⁸

17. The question of treating SpaceX’s modification as a “newly filed application” for processing round purposes is relevant to SpaceX’s status vis-à-vis other NGSO FSS systems in the same frequency bands. In connection with grant of certain NGSO FSS systems pursuant to processing round procedures, the Commission has adopted rules for sharing spectrum as between systems in the same processing round.⁶⁹ NGSO FSS space station applications granted with a condition to abide by these sharing rules must coordinate with each other in good faith with respect to the use of commonly

⁶³ 47 CFR § 25.117(d)(2)(ii). None of the other exceptions in Section 25.117(d)(2) appear to be relevant, and none have been raised in connection with SpaceX’s modification request.

⁶⁴ *Teledesic Order*, 14 FCC Rcd at 2264, para. 5.

⁶⁵ See *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, 7829, para. 61 (2017) (*NGSO FSS Report and Order*) (“The purpose of the recent processing rounds was to establish a sharing environment among NGSO systems, to provide a measure of certainty in lieu of adopting an open-ended requirement to accommodate all future applicants.”).

⁶⁶ *Teledesic Order*, 14 FCC Rcd at 2264, para. 5.

⁶⁷ See e.g., *SpaceX First Modification Order*, 34 FCC Rcd at 2529, para. 9.

⁶⁸ Two petitions for rulemaking have been filed that raise issues related to modification of NGSO systems and the *Teledesic Order* standard, but we have not made any decisions regarding these petitions, and at this time, find no reason to depart from the existing Bureau-level precedent. On April 30, 2020, SpaceX filed a petition for rulemaking to revise and clarify the Commission’s spectrum sharing rules for NGSO FSS systems. SpaceX Petition for Rulemaking, Revision of Section 25.261 of the Commission’s Rules to Increase Certainty in Spectrum Sharing Obligations Among Non-Geostationary Orbit Fixed-Satellite Service Systems, RM-11855 (filed Apr. 30, 2020). SpaceX proposes that the Commission codify protection rights for NGSO FSS systems from those systems authorized through a later processing round, and clarify or revise the spectrum selection priority among NGSO FSS systems authorized through the same processing round. See *id.* On July 9, 2020, Kuiper filed a petition for rulemaking to specify types of modifications to an authorized NGSO FSS system which would presumptively be considered in a later processing round. Kuiper Petition for Rulemaking, Modernization of Section 25.117 of the Commission’s Rules for Modifications of NGSO FSS Systems in the New Space Age, RM-11861 (filed July 9, 2020).

⁶⁹ 47 CFR § 25.261; see generally *NGSO FSS Report and Order*, 32 FCC Rcd 7809.

authorized frequencies.⁷⁰ If a coordination agreement is not in place between two or more NGSO FSS satellite systems, a default spectrum-splitting procedure applies.⁷¹ These rules apply as between NGSO systems authorized in the same processing round. When it updated these procedures in 2017, the Commission explained that it would limit the default spectrum-splitting procedure to qualified applicants in a processing round, and that treatment of later applicants with respect to systems approved in a prior processing round would be on a case-by-case basis.⁷² In this case, as part of a later processing round, the Commission authorized Kuiper to deploy an NGSO FSS system, and Kuiper is required to coordinate to prevent harmful interference to operational systems licensed or granted U.S. market access in previous NGSO FSS processing rounds.⁷³ In the event that Kuiper is not able to reach a coordination agreement with operators authorized in previous processing rounds, Kuiper must submit a showing for approval demonstrating that its operations will not cause harmful interference to any operational system licensed or granted U.S. market access in the relevant earlier processing rounds.⁷⁴ The question of whether SpaceX's NGSO system, as modified, is treated as part of the 2016/2017 or 2020 processing round will affect how SpaceX's system is conditioned with respect to coordination and spectrum vis-à-vis those systems authorized in the 2016/2017 Processing Rounds as well as Kuiper and any other systems authorized as part of the 2020 Processing Round.

18. Our rules do not differentiate between minor or major modifications, and there is no provision requiring a “major” modification to be moved to a future processing round.⁷⁵ As commenters have recognized, in the grant of SpaceX's first modification, the Bureau found that SpaceX's modification would not significantly worsen the interference environment because the reduction in the number of satellites meant “the number of spatial configurations that have the potential for generating interference between SpaceX and any other NGSO FSS system in the same processing round is expected to remain approximately unchanged.”⁷⁶ While SpaceX's Third Modification will also slightly reduce the number of satellites in the Starlink constellation, from 4,409 to 4,408, our review of the interference analyses provided by SpaceX and other operators demonstrates that the SpaceX Third Modification will contain spatial configurations and potential for generating new interference events into other NGSO FSS systems. However, the *Teledesic Order* inquiry does not end there – the existence of new spatial configurations and new potential interference events does not automatically require placing SpaceX in the 2020 Processing Round. SpaceX is correct to note that the appropriate standard under the *Teledesic Order* is to consider the modification's effect on the overall interference environment. In the case of the *Teledesic Order*, the Bureau considered a modification that involved a reduction in the number of satellites and an increase in the altitude of those satellites, among other changes.⁷⁷ The Bureau concluded that the increased operating altitude for the satellites would tend to worsen the interference environment by increasing the number of satellites visible in the sky, but the reduction in the number of satellites would tend to decrease the interference the system caused.⁷⁸ The Bureau determined that the decrease in interference caused by the reduction in satellites sufficiently offset the increased interference caused by

⁷⁰ 47 CFR § 25.261(b).

⁷¹ 47 CFR § 25.261(c).

⁷² *NGSO FSS Report and Order*, 32 FCC Rcd at 7829, para. 61.

⁷³ *Id.* at 8334, para. 34.

⁷⁴ *Id.* at 8341, para. 50.

⁷⁵ See 47 CFR § 25.117. See also *Teledesic Order*, 14 FCC Rcd at 2266-67, para. 12 (noting that the Commission generally takes a flexible approach when considering modifications to space station licenses, and has not promulgated a rule distinguishing between minor or major modifications to space station licenses).

⁷⁶ See *SpaceX First Modification Order*, 34 FCC Rcd at 2530, para. 9.

⁷⁷ See *Teledesic Order*, at 2262, para. 3.

⁷⁸ See SpaceX March 9 Letter at 3.

the increase in operating altitude, and therefore Teledesic's proposed modification would not worsen the overall interference environment.⁷⁹ For the reasons discussed below, we find that, similar to the *Teledesic Order* determination, the SpaceX Third Modification will not present significant interference problems, since potential increased interference in some instances would be offset by diminished interference overall, and we grant the modification without need to treat the modification as a newly filed application. We will continue to consider SpaceX's Ku- and Ka-band system, as modified, part of the 2016/2017 Processing Rounds.

b. Analysis of Overall NGSO Interference Environment

19. *Question of "Significant Interference Problems."* In support of its modification, SpaceX notes that it is requesting to slightly reduce the overall number of satellites in its system, that fewer satellites would be visible from any point in the United States, and that because the satellites would be operating at lower altitudes, they will be able to transmit and receive at lower effective isotropic radiated power (EIRP).⁸⁰ SpaceX states that to maintain coverage with the satellites at the lower altitudes, SpaceX would use a minimum elevation angle as low as 25 degrees for user beams, and that SpaceX will generally observe the same 25 degree minimum elevation angle for gateway beams,⁸¹ except for satellites operating at higher inclinations, which would observe a minimum elevation angle of five degrees for gateways located above 62 degrees latitude.⁸² As part of its application, SpaceX provided an analysis of the proposed modification's effect on downlink and uplink interference, stating that it had evaluated the effect on the interference environment using characteristics of three NGSO systems that had been authorized – OneWeb for Ku-band and Telesat and O3b for Ka-band.⁸³

20. A number of parties disagree with SpaceX's analysis with respect to the interference environment. SES/O3b, Kuiper, Viasat, Kepler, OneWeb, and RS Access argue that grant of the SpaceX Third Modification Application will increase the number of in-line interference events because of its proposed lower elevation angles and doubling of the number of satellites communicating with each gateway earth station simultaneously.⁸⁴ SES/O3b and Kuiper also argue SpaceX's redesigned antennas and wider beam footprints would worsen the interference environment and eliminate earth station separation as an interference mitigation technique.⁸⁵ OneWeb and Kepler request specific conditions

⁷⁹ See *Teledesic Order*, at 2267, para. 13; SpaceX March 9 Letter at 3.

⁸⁰ SpaceX Third Modification Application, Narrative at 8-9. See also SpaceX October 29 Response to Kuiper at 2; SpaceX November 6 Response to SES/O3B at 2; SpaceX January 19 Ex Parte at 1; SpaceX January 22 Ex Parte at 1; SpaceX February 1 Ex Parte at 1.

⁸¹ SpaceX Third Modification Application, Technical Attach at 4.

⁸² *Id.* at 7.

⁸³ See *id.*, Annex 1, A1-1.

⁸⁴ See SES/O3b Petition at 6-9; SES/O3B Reply at 4-10; SES October 13 Ex Parte at 2; SES/O3b October 21 Letter at 1-3; SES/O3b November 17 Ex Parte, Attachment 1 at 2; SES/O3b January 29 Letter at 2, 3-6; SES/O3b February 26 Ex Parte, Attachment B at 2-3; Kuiper Opposition at 13-15, 17-20; Kuiper Reply at 15-16; Kuiper August 18 Ex Parte at 2; Kuiper September 2 Ex Parte at 2; Kuiper September 24 Ex Parte at 1, 6-9; Kuiper October 6 Ex Parte at 2; Kuiper October 9 Ex Parte at 4-9; Kuiper October 16 Ex Parte at 4-9; Kuiper November 17 Ex Parte at 1-2, 5, Slide 4-6, 14-15, 17; Kuiper November 20 Letter at 1-2, Slides 1-2; Kuiper February 4 Ex Parte at 1, 4; Kuiper February 11 Ex Parte at 1, 4; Kuiper February 22 Ex Parte at 1, 4; Kuiper February 25 Ex Parte at 1, 4; Kuiper March 16 Ex Parte at 1, 4; Viasat July 2 Response to SpaceX at 1; Viasat February 8 Ex Parte at 30; Viasat February 12 Ex Parte at 30; Kepler Opposition at 3, 5, 6; OneWeb Comments at 8-9; OneWeb February 10 Ex Parte at 3-5; OneWeb February 17 Ex Parte, Attachment at 5-7; OneWeb February 25 Ex Parte at 3-5; RS Access Letter at 4.

⁸⁵ See SES/O3b Petition at 9-10; SES/O3b Reply at 11-16; SES/O3b October 21 Letter at 2; SES/O3b January 29 Letter at 2, 7-9; SES/O3b February 26 Ex Parte, Attachment B at 2-3; Kuiper Opposition at 23-26; Kuiper Reply at 15-24; Kuiper August 18 Ex Parte at 2; Kuiper September 2 Ex Parte at 2; Kuiper September 24 Ex Parte at 6-9; Kuiper October 9 Ex Parte at 6-9; Kuiper October 16 Ex Parte at 6-9; Kuiper November 17 Ex Parte at 1-2; Kuiper
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requiring SpaceX to select satellites to avoid in-line interference events between itself and the OneWeb and Kepler systems, respectively.⁸⁶ SpaceX argues the number of satellites communicating with earth stations simultaneously is irrelevant; rather the issue according to SpaceX is how many satellites are in view at any given time, because operators will not know which satellites are actively communicating and so will have to take all satellites in view into account when conducting coordination.⁸⁷ SpaceX admits that taken on its own, operating with a lower elevation angle would tend to increase in-line events, as more satellites would be “visible” from the perspective of a particular earth station location, but SpaceX argues that reducing its satellites’ operating altitude will actually reduce the number of satellites “visible”, and more than offsets the increase in geometric in-line events caused by the reduction in elevation angle.⁸⁸ Specifically, SpaceX acknowledges there would be more potential interference events as a result of operations at the lower elevation angles between 25 and 40 degrees, but posits there will also be significantly fewer interference events at the most optimal angles higher than 40 degrees, offsetting any new events resulting from the lower elevation angles.⁸⁹ Furthermore, according to SpaceX, its ability to reduce power flux density (PFD) emissions from the satellites at the reduced satellite operational altitude will also improve the interference environment.⁹⁰ For the Ku-band downlinks, SpaceX states that even with the lower satellite altitudes, it will still maintain the same PFD at the Earth’s surface in the Ku-band, resulting from a decrease in PFD levels at the satellites.⁹¹ For the Ka-band downlinks, SpaceX states that it will reduce PFD levels by 7 dB.⁹² SpaceX argues its beam footprints will be smaller because of the modification, not larger as SES/O3b and Kuiper suggest.⁹³ SpaceX believes that gateway earth station separation is still a viable interference mitigation technique and is prepared to coordinate with other operators.⁹⁴ While the modification will generate new interference events, SpaceX argues that, taken

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November 17 Ex Parte at 2-3, Slides 8-9; Kuiper November 20 Letter at 1-2; Kuiper February 4 Ex Parte at 1, 7; Kuiper February 11 Ex Parte at 1, 7; Kuiper February 22 Ex Parte at 1, 7; Kuiper February 25 Ex Parte at 1; Kuiper March 16 Ex Parte at 1, 7; OneWeb Comments at 11, 13-14; OneWeb March 15 Letter at 7-10.

⁸⁶ See OneWeb April 12 Ex Parte, Attachment at 6; OneWeb April 14 Ex Parte at 2; Kepler April 16 Letter at 2-3.

⁸⁷ See SpaceX October 29 Ex Parte at 5; SpaceX January 19 Ex Parte at 6; SpaceX February 25 Response to Kuiper at 10-11. SpaceX argues that in the absence of an agreement to share detailed beam pointing information as between two NGSO operators, i.e., when the default spectrum splitting procedure applies, *see* 47 CFR § 25.261, an NGSO operator cannot know which satellites are active or not, and therefore an operator must assume that every satellite of another NGSO system that is in view could potentially cause or experience inline interference. *See, e.g.*, SpaceX February 25 Response to Kuiper

⁸⁸ See SpaceX September 3 Ex Parte, Attachment A; SpaceX September 18 Ex Parte, Attachment A; SpaceX October 29 Response to Kuiper at 2-9; SpaceX November 6 Response to SES/O3b at 2; SpaceX November 13 Response to SES/O3b at 5-6; SpaceX January 19 Ex Parte at 4, 5; SpaceX February 22 Response to SES/O3b at 2-3, 10; SpaceX February 25 Response to Kuiper at 6-10.

⁸⁹ See SpaceX February 22 Response to SES/O3b at 2, 4-5; SpaceX February 25 Response to Kuiper at 8-9.

⁹⁰ See SpaceX February 22 Response to SES/O3b at 5-6, 10; SpaceX February 25 Response to Kuiper at 11-14.

⁹¹ SpaceX Consolidated Opposition at 32.

⁹² *Id.*

⁹³ See SpaceX September 3 Ex Parte, Attachment A; SpaceX September 18 Ex Parte, Attachment A; SpaceX October 29 Response to Kuiper at 5; SpaceX November 13 Response to SES/O3b at 2-5, 7-9; SpaceX January 19 Ex Parte at 5-6, 9; SpaceX February 22 Response to SES/O3b at 5-30; SpaceX February 25 Response to Kuiper at 11-16, 28-32.

⁹⁴ See SpaceX October 29 Response to Kuiper at 2, 8-10; SpaceX November 13 Response to SES/O3b at 5; SpaceX January 19 Ex Parte at 7; SpaceX February 22 Response to SES/O3b at 11-13. For example, with respect to the O3b system, SpaceX argues that because of the reduced PFD, the SpaceX downlink beam PFD footprint will become smaller as a result of the modification. *See, e.g.*, SpaceX February 22 Response to SES/O3b at 10-11. SpaceX further argues that O3b’s operations, rather than SpaceX’s modification, would be the limiting factor in the success

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together, the changes proposed will in fact improve the overall interference environment.⁹⁵

21. With respect to the issues raised by the other NGSO operators, including SES/O3b, Viasat, OneWeb, and Kuiper, we agree that grant of the SpaceX Third Modification Application would result in new interference to other NGSO systems in certain areas where previously interference did not exist. In applying the Bureau's decision in the *Teledesic Order*, however, we conclude that grant of the SpaceX modification would not create "any significant interference problems." Specifically, after analyzing the technical arguments in the record, we conclude that the lower altitude of the satellites will in fact result in fewer satellites in view, and therefore will result in fewer in-line interference events with respect to other NGSO operators,⁹⁶ even if the number of active satellites in view of a particular earth station is increased. We observe that by lowering the earth station elevation angle, more of the sky is visible from the perspective of the earth station, and as a result more satellites may be visible.⁹⁷ However, when the satellite altitude is lowered, the satellites will need to be closer to the earth station in order to be within view, and therefore lowering the altitude of the satellites helps to offset the fact that additional satellites may be visible due to the lower elevation angles, in turn offsetting the potential increase in in-line interference events.⁹⁸ We also conclude that the reduced satellite PFD at the satellites enabled by operating the satellites at lower altitudes will help to offset the potential for increased interference.⁹⁹ Consistent with our conclusion that the number of in-line events overall will not increase, we decline to adopt any conditions requiring SpaceX to prevent in-line interference events with OneWeb, Kepler, or any other individual operator. We conclude that the modification will not create any significant interference problems to other systems or significantly increase interference potential to future systems. In connection with this finding, we also address some additional arguments specific to certain NGSO operators below.

22. SpaceX and Kuiper debate in a series of filings what demonstrations SpaceX must provide with respect to the changes in the interference environment for the Kuiper system.¹⁰⁰ SpaceX argues that Kuiper is attempting to force first processing round licensees like SpaceX to protect later processing round licensees like Kuiper, when in fact Commission rules and conditions on Kuiper's authorization clearly require Kuiper to protect SpaceX from interference.¹⁰¹ Kuiper argues SpaceX's

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of earth station separation as an interference mitigation technique. *Id.* at 12-14. We encourage operators to coordinate to resolve interference concerns.

⁹⁵ See SpaceX Consolidated Opposition at 20, 26-29; SpaceX October 29 Response to Kuiper at 2-4; SpaceX November 13 Response to SES/O3b at 8-10; SpaceX January 19 Ex Parte at 1, Attachment B at 4-5; SpaceX January 22 Ex Parte at 1, Attachment A at 6-7; SpaceX February 1 Ex Parte at 1, Attachment A at 4-5; SpaceX February 22 Ex Parte at 2; SpaceX February 22 Response to SES/O3b at 10; SpaceX February 25 Response to Kuiper at 10, 21-25.

⁹⁶ We do note, however, that Kepler's system presents slightly different issues, and those are addressed below.

⁹⁷ See SpaceX February 22 Response to SES/O3b at 2-5, 10; SpaceX February 25 Response to Kuiper at 5-10.

⁹⁸ See SpaceX February 22 Response to SES/O3b at 2-5, 10; SpaceX February 25 Response to Kuiper at 5-10.

⁹⁹ See SpaceX February 22 Response to SES/O3b at 5-6, 10; SpaceX February 25 Response to Kuiper at 11-14.

¹⁰⁰ See SpaceX Consolidated Opposition at 21-22; SpaceX September 3 Response to Kuiper at 1, 2; SpaceX October 9 Response to Kuiper at 1-4; SpaceX October 29 Response to Kuiper at 1; SpaceX December 21 Ex Parte at 1; SpaceX January 19 Ex Parte at 1, Attachment B at 2; SpaceX January 22 Ex Parte at 1, Attachment A at 2; SpaceX February 1 Ex Parte at 1, Attachment A at 2; SpaceX February 22 Ex Parte at 2; SpaceX February 25 Response to Kuiper at 1-5; SpaceX April 2 Ex Parte at 4.

¹⁰¹ See *Kuiper Systems, LLC, Application for Authority to Deploy and Operate a Ka-band Non-Geostationary Satellite Orbit System*, 35 FCC Rcd 8324, 8341, para. 50 (2020) ("We fully anticipate that all parties will negotiate in good faith, and Kuiper will be able to reach a coordination agreement with operators authorized in previous processing rounds. In the event this does not happen, Kuiper must make a showing demonstrating to the

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interpretation conflicts with precedent in the *Teledesic Order*, which states that a modification will be evaluated with respect to all pending and licensed NGSO constellations using the same spectrum.¹⁰² We agree with Kuiper that, consistent with the *Teledesic Order*, we must take into consideration Kuiper's system when evaluating SpaceX's proposed modification. In the *Teledesic Order*, the Bureau stated that it would evaluate the proposed modification and potential for significant interference with respect to all NGSO FSS applications, including those in a later processing round, and consistent with our application of the *Teledesic Order* rationale to this modification we take this same approach.¹⁰³ However, consistent with the discussion above regarding the overall effect on the interference environment, we conclude that, taking into consideration the overall interference environment, the requested modification will not create any significant interference problems with Kuiper, as a later processing round system.

23. *Kepler's Arguments Regarding In-line Events.* Kepler raises a slightly different concern. Kepler states that the restructuring of orbital planes in the SpaceX constellation has concentrated more satellites in northern regions, which is a key service area for Kepler's operations.¹⁰⁴ Kepler's satellites operate in high-inclination sun-synchronous orbits, and SpaceX now proposes to place 520 satellites into orbits closely aligned with Kepler's, both in altitude and inclination,¹⁰⁵ and Kepler's analysis finds that SpaceX's modification would increase the number of in-line interference events.¹⁰⁶ Kepler argues that the sample victim systems SpaceX used in its initial interference analysis - OneWeb, Telesat, and O3b - are not representative of Kepler's system and did not take into account the effect of the restructuring of its orbital planes or its decreased minimum elevation angle.¹⁰⁷ Kepler's user terminals operate with a minimum elevation angle of 10 degrees, while OneWeb's operate with a minimum elevation angle of 40 degrees, so Kepler argues that it is more sensitive to SpaceX's modified minimum elevation angle.¹⁰⁸ Kepler conducted its own analysis of the interference environment, taking all these factors into account and using the same assumptions SpaceX used in its analysis, and Kepler concludes that the third SpaceX modification would significantly worsen the interference environment with respect to Kepler's system.¹⁰⁹ Kepler found that even if it used minimum elevation angles of 40 degrees, the increase in interference would be notable, but at its actual minimum elevation angle of 10 degrees, the increase in interference is substantial, and the interference worsened at higher latitudes.¹¹⁰

24. SpaceX responds that any arguable increase in the number or duration of in-line events on Kepler's uplinks is irrelevant as a practical matter, since the interference caused by Kepler to SpaceX's uplinks even under SpaceX's existing authorization will require the two systems to split shared spectrum at all times in the absence of a coordination agreement, with or without the requested SpaceX

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Commission that its operations will not cause harmful interference to any operational system licensed or granted U.S. market access in the July 2016 Processing Round and the May 2017 Processing Round.”).

¹⁰² See Kuiper September 24 Ex Parte at 4; Kuiper October 9 Ex Parte at 4; Kuiper October 16 Ex Parte at 4.

¹⁰³ *Teledesic Order* at 2265, 2272, para. 7, 23.

¹⁰⁴ See Kepler Opposition at 3.

¹⁰⁵ A small number of these SpaceX satellites have already been deployed, pursuant to the Bureau's partial grant of the modification related to deployment of ten satellites in January 2021. See *SpaceX Third Modification Ten-Satellite Grant*.

¹⁰⁶ See Kepler Opposition at 3-7.

¹⁰⁷ *Id.* at 5-6.

¹⁰⁸ See *id.* at 6.

¹⁰⁹ See *id.* at 7-11.

¹¹⁰ See *id.* at 9-11.

modification.¹¹¹ SpaceX also provided analysis of simulations it conducted to assess interference between the Kepler and SpaceX systems.¹¹² Kepler argues that SpaceX did not deny its modification would generate increased interference into Kepler's system.¹¹³ Kepler alleges that its system will trigger the band-splitting mechanism 2.1% of the time, not 100% of the time as SpaceX claims.¹¹⁴ On the other hand, Kepler argues that SpaceX's modification will cause the band-splitting mechanism to be triggered 46.1% of the time, more than two thousand times higher than what would otherwise be triggered by Kepler's system.¹¹⁵ Kepler also argues that interference does not occur everywhere, and if Kepler's uplinks trigger the band-splitting mechanism, that does not automatically mean the band-splitting mechanism is triggered in the downlink direction.¹¹⁶ SpaceX again argues that the separation angles are in fact driven by interference from Kepler into the SpaceX uplink, so the modification causes no significant change to the interference environment for Kepler.¹¹⁷ We note first that the band-splitting mechanism would only be triggered in the absence of coordination, and on this point, Kepler agrees with SpaceX that an optimal solution will ultimately come out of specific coordination agreements between operators.¹¹⁸ Kepler's concern appears to be that it would not experience the same effect to its system as SpaceX in the event of band-splitting, because SpaceX has so many more satellites.¹¹⁹ Since, as discussed below, SpaceX has agreed to accept additional uplink interference from Kepler that results from this modification, which appears to be the primary issue from Kepler's perspective, and that a number of the concerns Kepler raises regarding band-splitting would only be present in the absence of a coordination agreement, we conclude that the modification does not create any significant interference problems with Kepler.

25. *Gateways.* OneWeb argues that an additional outcome of SpaceX's proposal to lower the operational altitude of 2,824 satellites from 1,100-1,330 km to 540-570 km is that it will significantly increase the number of SpaceX gateway sites in the United States in order to provide the same level of service.¹²⁰ According to OneWeb, this will increase the probability of a SpaceX gateway earth station being collocated, or nearly collocated, with other NGSO operators' gateway earth stations, thereby "materially worsening" the NGSO interference environment in the Ka-band. OneWeb argues that in fact SpaceX is deliberately collocating its gateway earth stations with those of OneWeb to cause coordination between the operators to fail.¹²¹ We note that typically in issuing a space station grant we do not limit the number of gateway earth stations that can be deployed and did not limit the number of gateways in our prior SpaceX grants. Therefore, there would be nothing to prevent SpaceX from deploying a similar number of gateways to communicate with satellites in its previously requested orbits. We observe that the number of gateway earth stations used by any system would naturally grow for any system as the

¹¹¹ SpaceX Consolidated Opposition at 23-24, 26-27. SpaceX argues that the interference Kepler's earth stations would cause to SpaceX uplinks exceeds the 6 percent $\Delta T/T$ in-line event trigger (in this case -12.2 dB interference-to-noise ratio) for spectrum splitting under section 25.261 at all times. *Id.* at 23; see 47 CFR § 25.261(c). See also SpaceX Consolidated Opposition, Appendix A at A-6.

¹¹² See SpaceX Consolidated Opposition, Appendix A at A-3.

¹¹³ See Kepler Reply at 6.

¹¹⁴ See *id.* at 6-11.

¹¹⁵ See *id.* at 10-11.

¹¹⁶ See *id.* at 14-15; see also OneWeb Reply at 15-18.

¹¹⁷ See SpaceX January 19 Ex Parte Attach., at 12..

¹¹⁸ See Kepler Opposition at 2.

¹¹⁹ See, e.g., *id.* at 6.

¹²⁰ OneWeb Reply at 13.

¹²¹ See OneWeb April 12 Ex Parte, Attachment at 7.

system expands, and OneWeb was not entitled to expect that SpaceX would be operating with a certain number of gateway earth stations. Moreover, operations with additional gateway earth stations can provide more frequency reuse and capacity.

26. *Parabolic Antennas.* In more recent pleadings, OneWeb and Kuiper raise additional concerns that SpaceX has clandestinely redesigned certain satellite antennas from phased-array antennas to a more “parabolic-like” antenna technology to communicate with gateways and/or has incorrectly represented antenna patterns in its technical analyses related to the third modification.¹²² OneWeb argues the change in antenna materially affects the PFD levels produced on the ground.¹²³ OneWeb states that the PFD is lower close to the center of the beam because of SpaceX’s reduction in PFD emissions, but it increases with distance away from the center at all elevation angles, and could be as much as nine dB higher.¹²⁴ Kuiper argues that in providing a comparison of the interference environment, SpaceX has incorrectly used the antenna pattern associated with its Third Modification Application in its comparative analysis of the pre-modification and post-third modification interference environments.¹²⁵ SpaceX confirms that it is using parabolic antennas for Ka-band gateway transmissions, but argues this upgrade was not clandestine and that it has complied and will continue to comply with all Commission rules, including applicable PFD and EPPD limits.¹²⁶ The antenna pattern SpaceX used in its Third Modification Application is the antenna pattern recommended by the International Telecommunication Union (ITU) for low-earth orbit systems, which SpaceX states more accurately reflects SpaceX’s hardware, but is still “conservative relative to measured antenna patterns.”¹²⁷ SpaceX argues the impact of the redesigned antenna on the interference environment is negligible.¹²⁸ Kuiper responds to SpaceX’s explanation by objecting to the fact that SpaceX has confirmed it is already operating with redesigned antennas prior to receiving authorization for its modified antenna specifications.¹²⁹ Kuiper argues that contrary to SpaceX’s assertion, its redesigned antennas will have far more than a negligible impact on the interference environment—specifically, Kuiper submitted diagrams of the interference patterns which it says “speak for themselves.”¹³⁰

27. First, we decline to address in this SpaceX Third Modification the arguments regarding the extent to which SpaceX is currently authorized to operate using parabolic antennas for Ka-band gateway transmissions. Questions as to whether SpaceX is not in compliance with this current authorization present concerns that go beyond the scope of this SpaceX Third Modification Application. Second, we conclude that the use of parabolic antennas SpaceX plans on satellites that are authorized by this Third Modification will not cause any significant interference problems. SpaceX states that it has included the antenna beam patterns for the parabolic antenna as part of its filings and analyses since it filed the modification.¹³¹ Thus, we have relied on those technical specifications as part of the above analysis where we find that there will not be any significant interference issues. We see no reason to

¹²² See OneWeb March 15 Letter at 2-5; OneWeb April 12 Ex Parte, Attachment at 4; Kuiper February 4 Ex Parte at 1; Kuiper February 11 Ex Parte at 1; Kuiper February 22 Ex Parte at 1; Kuiper February 25 Ex Parte at 1; Kuiper March 16 Ex Parte at 10.

¹²³ See OneWeb March 15 Letter at 5-7; OneWeb April 12 Ex Parte, Attachment at 4.

¹²⁴ See OneWeb March 15 Letter at 6-7

¹²⁵ Kuiper March 16 Ex Parte at 10.

¹²⁶ See SpaceX April 2 Ex Parte at 3-4.

¹²⁷ SpaceX April 2 Ex Parte at 3.

¹²⁸ See *id.* at 3.

¹²⁹ See Kuiper April 7 Letter at 1.

¹³⁰ See *id.*

¹³¹ See SpaceX April 2 Ex Parte at 3.

revisit this analysis since the technical specifications have not changed. Therefore, we conclude that the communications with a parabolic, rather than phased array antenna, will not cause any significant interference problems.

28. Viasat urges us to condition this grant to require SpaceX to share detailed information on its system's operating parameters, including "the number of beams on each satellite, the number of channels per beam, the number of co-frequency reuses, as well as satellite and earth station masks (especially with regard to sidelobes)."¹³² Viasat argues that SpaceX does not have authority or technical ability to utilize all "look angles" simultaneously and that this information is essential to providing a baseline of operating parameters to allow others to design systems in the future.¹³³ Viasat further requests that if SpaceX does not share this information, that the Commission exclude replacement authority from this modification.¹³⁴ We decline to adopt Viasat's open-ended information sharing condition, as we already have a process in place for NGSO satellite applicants to provide information on the record with respect to their proposed systems, including detailed technical information required under the Commission's rules. In addition, there is a process under the rules for applicants to amend applications and licensed systems to request modification. Viasat has not provided a compelling reason to deviate from our well-established satellite application, amendment, and modification rules, or those related to authority for deployment and operation of technically-identical replacement satellites. Viasat's argument also appears to overly broadly interpret a statement by SpaceX on the effect of the modification on the overall interference environment.¹³⁵ Kuiper requests that we condition this grant to require SpaceX to share beam pointing information – in other words, which satellites are pointing at a particular earth station and the frequencies being used at a particular moment in time.¹³⁶ Kuiper states that this will assist with the coordination process.¹³⁷ We similarly decline to adopt Kuiper's specific suggested condition. We note, however, that on an ongoing basis under the Commission's good faith coordination requirement, SpaceX and all other NGSO operators already have an obligation – at the appropriate time - to facilitate the mutual exchange of data on an ongoing basis to ensure operational compatibility and to identify potential interference events in advance.¹³⁸

29. *Increased Interference to SpaceX.* A number of parties argue that grant of the SpaceX Third Modification would increase SpaceX's susceptibility to interference from other NGSO systems.¹³⁹

¹³² Viasat April 12 Conditions Letter, Attachment at 1; Viasat April 13 Ex Parte, Attachment at 1; Viasat April 14 Ex Parte, Attachment at 1; *See also* Viasat April 12 Look Angle Letter.

¹³³ *See* Viasat April 12 Conditions Letter, Attachment at 2; Viasat April 13 Ex Parte, Attachment at 2; Viasat April 14 Ex Parte, Attachment at 2; Viasat April 12 Look Angle Letter.

¹³⁴ *See* Viasat April 19 Letter at 5.

¹³⁵ *See* Viasat April 26 Ex Parte Presentation at 9 (interpreting SpaceX's statement about considering satellites in view for purposes of comparing numbers of potential in-line interference events as meaning that SpaceX claims to "own" the entire field of view).

¹³⁶ *See* Kuiper April 15 Ex Parte.

¹³⁷ *See id.*

¹³⁸ *See NGSO FSS Order*, 32 FCC Rcd at 7825, para. 48; *see also Kuiper Order*, 35 FCC Rcd at 8341, para. 49.

¹³⁹ *See* SES/O3b Petition at 11-14; Kuiper Opposition at 21-23; OneWeb Comments at 8-9; OneWeb March 15 Letter at 9. These parties argue that SpaceX's proposed reduction in elevation angles, while maintaining the sensitivity of its space stations, will leave SpaceX's Ku- and Ka-band satellite receivers open to interference, especially if earth station separation is used. *See* SES/O3b Petition at 11-14; SES/O3b January 29 Letter at 9-10; OneWeb Comments at 16-19, 20-25; Kuiper Opposition at 21-23; Kuiper November 17 Ex Parte at 5, slides 10, 12-13; Kuiper November 20 Letter at 1-2, slides 1-2. OneWeb also argues that the proposed reduction in SpaceX's PFD emission would leave its Ka-band earth station gateways more susceptible of interference. OneWeb Comments at 16-19, 20-25;

SES/O3b and OneWeb express concern that this increased susceptibility of SpaceX's systems will carry significant operational costs, and OneWeb requests the Bureau condition any grant of this application on SpaceX being required to accept any increased interference caused by its modification.¹⁴⁰ After analyzing its susceptibility to interference, SpaceX says it is willing to accept any additional interference from other NGSO systems authorized in the 2016 Processing Round resulting from this modification compared to its current authorization.¹⁴¹ Kuiper argued that SpaceX had not acquiesced to a condition requiring it to accept increased interference from Kuiper.¹⁴² SpaceX has since agreed to accept interference from the Kuiper system as well with respect to its Ka-band uplinks, where operating SpaceX's satellites at lower altitudes will potentially make SpaceX more susceptible to interference.¹⁴³

30. We conclude that there is the potential for increased interference to SpaceX's system as a result of the modification, but since SpaceX has agreed to accept the additional interference, and will accept this grant subject to such potential additional interference, as conditioned, we also conclude that the potential for additional interference into the SpaceX system does not weigh against grant of the modification in this instance. Any alteration to the interference environment resulting from increased SpaceX susceptibility to interference is mitigated by the fact that SpaceX is willing to accept the additional interference, including from the Kuiper system, to the extent that the modification has increased interference into SpaceX's system.

31. We note that OneWeb challenges whether SpaceX is in fact able to accept additional interference resulting from its Third Modification. OneWeb calculated with the proposed modification SpaceX could experience ten to thirteen dB in increased interference and notes that it does not understand how SpaceX, or any NGSO operator, could accept that much more interference.¹⁴⁴ OneWeb also argues that with respect to inter-operator coordination, coordination conditions and operational limitations agreed to by SpaceX and another NGSO operator concerning the currently authorized SpaceX system would be fundamentally different from the conditions arising from the coordination of a "more interference-sensitive environment."¹⁴⁵ At this time, we decline to second-guess SpaceX's statement that it is able to accept any additional interference resulting from the modification—OneWeb's arguments appear to be speculative on this point—and SpaceX would be in the best position to know whether it is able to operate its system with potentially increased interference, consistent with the conditions in this modification grant. Thus, absent evidence that SpaceX cannot accept additional interference resulting from this modification, we find that a condition requiring SpaceX to accept such interference is sufficient in this case.

2. Interference into GSO Systems

32. SpaceX certifies that, as required by the Commission's rules,¹⁴⁶ its NGSO constellation, as modified, will comply with the applicable Ku- and Ka-band equivalent power flux-density (EPFD)

¹⁴⁰ See SES/O3b Petition at 11-14; OneWeb Comments at 16, 19-20; OneWeb Reply at 18-22.

¹⁴¹ See SpaceX Consolidated Opposition at 20-25; SpaceX January 19 Ex Parte at 2, 8; SpaceX March 9 Letter at 3.

¹⁴² See Kuiper September 24 Ex Parte at 5; Kuiper October 9 Ex Parte at 7.

¹⁴³ See SpaceX April 15 Letter at 9 (noting that SpaceX agrees to accept interference from the Kuiper system with respect to its Ka-band uplinks, where operating SpaceX's satellites at lower altitudes will potentially make SpaceX more susceptible to interference). SpaceX argues that the baseline level of interference has not been established from Kuiper into SpaceX's system – and we condition this grant such that a baseline can be established. See *id.*

¹⁴⁴ See OneWeb March 15 Letter at 9-10.

¹⁴⁵ *Id.*

¹⁴⁶ 47 CFR § 25.146.

limits set forth in Article 22 of the ITU Radio Regulations.¹⁴⁷ In the *First SpaceX Modification*, the Bureau granted SpaceX's request for waiver of the requirement to receive a "favorable" or "qualified favorable" finding from the ITU with respect to compliance with the applicable EPFD limits prior to commencing operations.¹⁴⁸ The Bureau retained the requirement, however, that SpaceX receive the "favorable" or "qualified favorable" finding from the ITU, and in the case of an unfavorable finding, adjust its operations to satisfy the ITU requirements.¹⁴⁹

33. *General Concerns Regarding Compliance with EPFD Limits.* In connection with the SpaceX Third Modification Application, several parties raise concerns with SpaceX's ITU filings and its compliance with EPFD limits generally.¹⁵⁰ Viasat and Hughes assert that it is unclear from the Third Modification Application if SpaceX is basing its EPFD certification on the "single entry" value of its constellation as a whole or if it is aggregating the "single entry" values of each of the several individual NGSO ITU filings for Starlink.¹⁵¹ Viasat argues that aggregating single entry EPFD values from the separate ITU filings for Starlink would mean SpaceX was claiming single-entry status from two or more SpaceX-controlled ITU filings for the same NGSO system and would constitute an impermissible attempt to emit more power than the ITU and Commission's rules permit.¹⁵² Similarly, Kepler and Hughes request that SpaceX indicate which of its ITU filings represent the third modification application.¹⁵³ According to Viasat, even assuming the parts of SpaceX's system covered by different ITU filings operated cooperatively to prevent interference, the system as a whole would exceed the ITU's EPFD limits.¹⁵⁴ Viasat, Hughes, and Kepler request that SpaceX provide more information on its ITU filings, including the masks for each ITU filing associated with this application, as well as further technical demonstrations that it will comply with applicable EPFD limits.¹⁵⁵ Hughes also requests the Commission condition grant of this modification such that SpaceX must obtain a "favorable" or "qualified favorable" finding from the ITU, and "the finding must explicitly indicate that the joint effect of multiple ITU filings related to [SpaceX's] constellation was taken into account when verifying compliance with applicable EPFD limits."¹⁵⁶ Furthermore, Hughes requests the Commission require SpaceX to identify all ITU

¹⁴⁷ SpaceX Third Modification Application, Technical Attach. at 15 (citing 47 CFR § 25.146(a)(2)); *see, e.g.*, SpaceX June 29 Response to DISH at 2.

¹⁴⁸ *First SpaceX Modification*, 34 FCC Red at 2536.

¹⁴⁹ *Id.*

¹⁵⁰ *See, e.g.*, Viasat Petition at 37-43; Kepler Reply at 24-25. Viasat and Kepler appear to raise these issues generally with respect to SpaceX's compliance with applicable ITU RR Article 22 EPFD limits, across a variety of frequency bands.

¹⁵¹ *See* Viasat Petition at 40; Viasat December 21 Ex Parte at 9; Viasat January 7 Ex Parte at 9; Viasat February 8 Ex Parte at 30; Viasat February 12 Ex Parte at 30; Hughes April 12 Letter at 3. Viasat also cites SpaceX's request for special temporary authority in June 2020, in which SpaceX requests authority to use higher power limits to more easily acquire its satellites at the lower altitudes to which they are initially deployed and states it will comply with EPFD limits only most of the time, as evidence that SpaceX will not comply with EPFD limits when operating its constellation under this third modification. *See* Viasat Petition at 38-39 (citing Space Exploration Holdings, LLC., Request for Special Temporary Authority, IBFS File No. SAT-STA-20200610-00071, Narrative at 1-2 (filed June 10, 2020)). SpaceX has clarified that it does not seek authority in this modification to operate with higher power for certain communications during orbit-raising, and this issue is discussed in further detail below. *See* SpaceX Consolidated Opposition at 33, n.98; SpaceX April 2 Ex Parte at 4.

¹⁵² *See* Viasat Petition at 40-41; Viasat February 8 Ex Parte at 30; Viasat February 12 Ex Parte at 30; Hughes April 12 Letter at 3.

¹⁵³ *See* Kepler Reply at 34-35; Hughes April 12 Letter at 3.

¹⁵⁴ *See* Viasat Petition at 41-43; *see also* Hughes April 12 Letter at 3.

¹⁵⁵ *See* Viasat Petition at 44; Kepler Reply at 24-25; Hughes April 12 Letter at 3.

¹⁵⁶ *See* Hughes April 12 Letter at 2.

filings associated with its satellite constellation and confirm that the EPFD filings provided to Hughes and other operators reflects SpaceX's complete system prior to any grant of its third modification application.¹⁵⁷

34. SpaceX states that it has conducted its EPFD analysis based on procedures and software approved by the ITU, and has every incentive to ensure that this analysis has been performed properly because if the ITU were to determine that SpaceX's system would exceed the applicable EPFD limits, SpaceX would have to revise its operations to come into compliance with those limits.¹⁵⁸ The Commission has incorporated by reference ITU EPFD limits into its rules, including for the Ku- and Ka-band and, as noted, requires that NGSO FSS licensees and grantees communicate a "favorable" or "qualified favorable" finding by the ITU Radiocommunication Bureau regarding compliance with applicable ITU EPFD limits.¹⁵⁹ Given the condition in SpaceX's license, as modified, requiring that SpaceX receive the "favorable" or "qualified favorable" finding from the ITU, and in the case of an unfavorable finding, adjust its operations to satisfy the ITU requirements,¹⁶⁰ we agree that SpaceX has "every incentive" to ensure that its EPFD analysis has been performed properly – and we also conclude that the ITU is in the best position to determine whether SpaceX appropriately relied on multiple ITU filings in its analysis. Therefore, we do not see the need to further address the parties' claims with respect to aggregation of "single entry" values from separate ITU filings, or to condition the grant as Hughes requests.

35. *EPFD Limits Applicable to the 12.2-12.7 GHz Frequency Band.* DISH and AT&T express concern that SpaceX's system, as modified, would exceed ITU and Commission EPFD limits specifically into Ku-band direct broadcast satellite (DBS) receivers in the 12.2-12.7 GHz band.¹⁶¹ To protect DBS operators, AT&T argues, the Bureau should not permit SpaceX to commence operations under this proposed third modification until it has obtained the "favorable" or "qualified favorable" finding from the ITU.¹⁶² AT&T also requests the Bureau condition any grant of SpaceX's third modification to require SpaceX to remedy interference into DBS systems immediately upon notification of such interference.¹⁶³ Finally, AT&T requests the Bureau consider SpaceX's modification in the context of aggregate EPFD limits, including applications for NGSO licenses and modifications recently filed in the 2020 Processing Round, and condition any further modification of SpaceX's license on SpaceX "demonstrating how it has 'cooperated' with other U.S. licensees and market access grantees to determine if the aggregate limit has been met."¹⁶⁴

36. In response to these assertions, SpaceX reiterates that it has certified that it will comply

¹⁵⁷ See *id.*

¹⁵⁸ SpaceX Consolidated Opposition at 33. SpaceX also notes in its consolidated opposition that it has provided Viasat the EPFD data files. *Id.*

¹⁵⁹ 47 CFR § 25.146(c).

¹⁶⁰ *First SpaceX Modification Order*, 34 FCC Rcd at 2536, para. 28.

¹⁶¹ See DISH Letter at 1; DISH July 14 Response to SpaceX at 3-5; DISH February 10 Ex Parte at 1; AT&T Comments at 3.

¹⁶² See AT&T Comments at 3-6 (citing 47 CFR § 25.146(c)); AT&T Reply at 1-4. As noted, the Commission had conditioned SpaceX's original authorization on SpaceX receiving a "favorable" or "qualified favorable" finding from the ITU with respect to compliance with applicable ITU RR Article 22 limits prior to commencing operations, but subsequently this condition was modified in the First SpaceX Modification, to permit SpaceX to commence operations prior to this finding, provided that SpaceX adjust its operations to satisfy the ITU requirements in the event that it does not receive a "favorable" or "qualified favorable" finding. *First SpaceX Modification*, 34 FCC Rcd at 2536, para. 28.

¹⁶³ See AT&T Comments at 3, 6; AT&T Reply at 6-7.

¹⁶⁴ See AT&T Comments at 3, 6-7.

with EPFD limits to protect DBS services,¹⁶⁵ that it has used approved ITU software and methodologies to conduct its EPFD analysis and presented its results in its application¹⁶⁶ and that AT&T's request regarding protection of DBS incumbents against any increase in interference is "inconsistent with the international accord holding that operating within the EPFD limits provides sufficient protection to GSO systems."¹⁶⁷

37. DISH further argues that SpaceX has failed to demonstrate its EPFD emissions will not exceed what a standard DBS antenna can tolerate.¹⁶⁸ On September 25, 2020, DISH filed a letter requesting the Bureau require SpaceX to produce its EPFD analysis for DISH's examination with no limitations on the type of analysis DISH may perform with that data,¹⁶⁹ and SpaceX provided DISH with its EPFD data.¹⁷⁰ Following this exchange, DISH states that it has reviewed SpaceX's EPFD data and submits a technical study allegedly showing that SpaceX's proposed modification would exceed applicable EPFD limits in the 12.2-12.7 GHz band and cause harm to DBS customers in the United States.¹⁷¹ DISH argues that SpaceX's EPFD analysis has utilized the incorrect assumption that the value of "Nco," a factor used in ITU EPFD analysis to represent the number of co-frequency, co-polarization satellite beams transmitting to a given point on the Earth's surface simultaneously, is one, which according to DISH means that only one satellite beam will transmit to a given spot on the Earth's surface at a time.¹⁷² DISH speculates that SpaceX will transmit between two and ten, if not more, co-frequency beams in the 12.2-12.7 GHz band, and therefore an Nco value of four or six is more appropriate.¹⁷³ SpaceX states that its use of an Nco value of one is not merely an input for its EPFD analysis, but reflects the way SpaceX in fact has operated its system and the method by which it will continue to operate its system in the future.¹⁷⁴ SpaceX also states that it entirely avoids communications with its satellites when they are near the geostationary arc, specifically to avoid causing interference to systems like DISH's.¹⁷⁵ DISH further argues that if the SpaceX modification is granted, it should not include the 12 GHz band.¹⁷⁶

38. DISH also submits an analysis which, according to DISH, demonstrates that even with an

¹⁶⁵ See SpaceX June 29 Response to DISH at 1-2.

¹⁶⁶ See *id.* at 2.

¹⁶⁷ SpaceX Consolidated Opposition at 32.

¹⁶⁸ See DISH Letter at 1, 5; DISH July 14 Response to SpaceX at 3, 5; DISH December 31 Ex Parte at 2; DISH January 5 Ex Parte at 2.

¹⁶⁹ See DISH September 25 Letter Requesting Order of Production of Evidence at 1-2, 6-7.

¹⁷⁰ See SpaceX October 15 EPFD Notice. The Bureau had not taken any action on DISH's request at that point.

¹⁷¹ See DISH February 15 Letter at 1; DISH February 24 Ex Parte at 1-2; DISH March 8 Ex Parte at 2; DISH March 9 Ex Parte at 2; DISH March 17 Response to SpaceX at 1, 2.

¹⁷² See, e.g., DISH February 15 Ex Parte at 2, 3, Attachment at 4-5; DISH March 8 Ex Parte at 2; DISH March 9 Ex Parte at 2; DISH March 17 Response to SpaceX at 1, 2, 6; DISH April 14 Ex Parte at 1-2.

¹⁷³ See DISH February 15 Letter at 2, 4, 5, Attachment at 4-5; 14-15, 20; DISH March 8 Ex Parte at 2; DISH March 9 Ex Parte at 2. In support of this assertion, DISH points to several aspects of SpaceX's proposed service - including that one satellite beam would allow for 200-300 Mbps speeds, and that SpaceX promises ten Gbps speeds for every user. See DISH March 4 Response to SpaceX at 3-4. DISH provided a variety of additional technical arguments on this point regarding SpaceX's Nco value.

¹⁷⁴ See SpaceX March 16 Ex Parte at 2 (stating that Nco=1 for Ku-band operations is not just an analytical input for analysis but actually reflects the way SpaceX operates its system); SpaceX March 18 Response to DISH at 1; SpaceX April 2 Ex Parte at 1-2.

¹⁷⁵ See SpaceX February 25 Response to DISH at 2; SpaceX March 9 Response to DISH at 1-2).

¹⁷⁶ See DISH March 8 Ex Parte at 2; DISH March 9 Ex Parte at 2; DISH March 17 Response to SpaceX at 1, 2-3; DISH April 14 Ex Parte at 4.

Nco value of one, SpaceX's system will exceed the EPFD limits in the 12.2-12.7 GHz band across the United States.¹⁷⁷ SpaceX argues that the methodology DISH uses in this analysis to show SpaceX will exceed the EPFD limits with an Nco value of one is not ITU-approved.¹⁷⁸ DISH further argues that SpaceX does not address how it will meet demand with only one co-frequency satellite beam, and it is concerned, along with Viasat, that when SpaceX is forced to choose between complying with the EPFD limits and meeting demand under its obligations as a winner in the Rural Digital Opportunity Fund auction, SpaceX will choose to violate the EPFD limits.¹⁷⁹ If SpaceX can indeed meet demand with a Nco value of one, DISH argues this demonstrates SpaceX's need for the 12.2-12.7 GHz band is attenuated compared with the vast amount of spectrum it is also authorized to use.¹⁸⁰ DISH argues the Commission should deny the modification, or else grant it with specific conditions requiring it to: (1) "not use more than one satellite beam from any of its satellites in the same frequency in the same or overlapping areas at a time;" (2) be "subject to any findings the Commission may make about the method for determining EPFD limits compliance and the operational requirements for avoiding interference into DBS systems consistent with international footnote R.R. 5.487A;" and (3) "submit under an appropriate protective order sufficient information about its operations to permit DBS licensees to assess compliance with the condition."¹⁸¹

39. A certification of compliance with EPFD limits is what is required by our rules, and we are satisfied with SpaceX's certification that it will not violate ITU EPFD limits relevant to the 12.2-12.7 GHz band. We find that SpaceX has addressed DISH's inquiry regarding whether an Nco value of one is reflective of the way that SpaceX operates its system, and condition this grant accordingly. As noted, DISH asks us to condition SpaceX's grant to require that SpaceX "not use more than one satellite beam from any of its satellites in the same frequency in the same or overlapping areas at a time."¹⁸² SpaceX has stated on the record that an Nco value of one, as an input value for how many co-frequency simultaneously transmitting satellites will service a given point on Earth, actually reflects the way it operates its system.¹⁸³ SpaceX has also agreed to the condition proposed by DISH that SpaceX not use more than one satellite beam from any of its satellites in the same frequency in the same or overlapping areas at a time.¹⁸⁴ We condition this grant accordingly.

¹⁷⁷ See DISH March 17 Response to SpaceX at 2, 4; DISH March 24 Response to SpaceX; DISH March 25 Letter; DISH April 6 Letter at 1; DISH April 14 Ex Parte at 2, 3; See also DISH April 23 EPFD Letter (submitting an additional study in which DISH states that based on its own analysis, SpaceX would not meet the EPFD limits even with a "nominal" Nco of 1).

¹⁷⁸ See SpaceX March 18 Response to DISH at 1-2. DISH argues its analysis is based on real-world information, which the Commission has found is preferable to simulations, and use of ITU software is not mandated by the international Radio Regulations—it is only a recommendation. See DISH April 14 Ex Parte at 2-3.

¹⁷⁹ See DISH April 6 Letter at 2; DISH April 14 Ex Parte at 2, 3; see also Viasat April 5 Letter; Viasat April 12 Letter at 1; Viasat April 26 Ex Parte.

¹⁸⁰ See DISH April 6 Letter at 3.

¹⁸¹ See DISH April 6 Letter at 3-4; DISH April 14 Ex Parte at 4. DISH also requests that the Commission add to the SpaceX license conditions a requirement that SpaceX must "cease operations as a result of any future Commission actions on related matters, including the pending rulemaking proceeding regarding the 12.2-12.7 GHz band,[] SpaceX's Petition for designation as an eligible telecommunications carrier,[] and SpaceX's application for modification of its blanket earth station license to permit operation of earth stations in motion ("ESIMs")." *Id.* at 4. We address the arguments regarding the Commission's pending *12 GHz NPRM* below, and the basis for the other portions of this condition, which reference the Commission's Rural Digital Opportunity Fund auction and a pending earth station application, are not clear from DISH's filing. *Id.*

¹⁸² DISH April 6 Letter at 3-4.

¹⁸³ See, e.g., SpaceX March 18 Response to DISH.

¹⁸⁴ SpaceX April 15 Letter at 4.

40. Having addressed the input parameters for the ITU EPFD analysis, we refer to section 25.146 of the Commission's rules, which incorporates findings by the ITU Radiocommunication Bureau regarding compliance with ITU EPFD limits.¹⁸⁵ Contrary to DISH's assertion, we will not depart from the Commission's determination as a general matter in the *NGSO FSS Report and Order* that applicants may certify their compliance with ITU EPFD limits.¹⁸⁶ The Commission concluded that it could rely on ITU Radiocommunication Bureau review as a technical matter, including requiring applicants to use the ITU-approved validation software to assess compliance with EPFD limits.¹⁸⁷ Although DISH alleges that SpaceX cannot meet the EPFD limits even using the input of an Nco of one based on its own analysis, the relevant analysis under the Commission's rules is analysis using ITU-approved software. For these reasons we also reject DISH's proposed condition that SpaceX be "subject to any findings the Commission may make about the method for determining EPFD limit compliance and the operational requirements for avoiding interference into DBS systems consistent with international footnote R.R. 5.487A."¹⁸⁸ DISH essentially asks us to condition SpaceX's grant explicitly on the possibility that the Commission may reconsider or revise the Commission's decision in the *NGSO FSS Report and Order*, which we decline to do at this time. In the event that we were to revise our applicable rules, we find that the more general condition language in SpaceX's license, included as part of this modification as well, is sufficient. Similarly, DISH's request that we require SpaceX to "submit under an appropriate protective order sufficient information about its operations to permit DBS licensees to assess compliance with the condition" would be at odds with the Commission's determination in the *NGSO FSS Report and Order*, reflected in section 25.146(c) of the Commission's rules, that applicants must submit the input data files used for the ITU validation software, and that an ITU determination of "favorable" or "qualified favorable" is sufficient for the Commission to assess compliance with EPFD limits.¹⁸⁹

41. We further see no reason to revoke our previously-granted waiver of section 25.146(c), and accordingly, we will continue to condition this grant consistent with the prior modifications to require SpaceX to provide the underlying data for its EPFD analysis to any interested party. We similarly decline AT&T's requested condition on this grant to require SpaceX to "demonstrate" how it has coordinated with other systems to assess whether the aggregate EPFD limits have been met.¹⁹⁰ SpaceX's license is already conditioned to require such coordination, and it is not clear how some type of demonstration of coordination would be assessed by the Commission or otherwise add to the existing requirement. Additionally, we decline to condition this grant of modification to require that if any DBS operator notify SpaceX that its system is causing actual interference in excess of the certified limit, SpaceX should be required to immediately remedy the interference. We find this is unnecessary given the existing condition that SpaceX's operations in the 12.2-12.7 GHz band are authorized only 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.

42. Finally, as SpaceX has provided its EPFD input data files to DISH, we dismiss DISH's request for production of evidence as moot.¹⁹¹

43. *EPFD Limits Applicable to the 19.7-20.2 GHz Frequency Band.* SES/O3b and Hughes

¹⁸⁵ 47 CFR § 25.146(c).

¹⁸⁶ See *NGSO FSS Report and Order*, 32 FCC Rcd at 7822, para. 41.

¹⁸⁷ *Id.*

¹⁸⁸ The Table of Frequency Allocations includes footnote 5.487A, which states, among other things, that NGSO systems in the FSS in the 12.2-12.7 GHz band "shall be operated in such a way that any unacceptable interference that may occur during their operation shall be rapidly eliminated." See 47 CFR § 2.106, footnote 5.487A.

¹⁸⁹ *NGSO FSS R&O*, 32 FCC Rcd at 7822, para. 41; 47 CFR § 25.146.

¹⁹⁰ See AT&T Reply Comments at 7.

¹⁹¹ See DISH Letter Requesting Order of Production of Evidence at 1.

also raise concerns regarding compliance with EPFD limits in the Ka-band, in particular, with respect to the 19.7-20.2 GHz band.¹⁹² SES/O3b and Hughes argue that SpaceX used an Nco of one when conducting its EPFD analysis, but the SpaceX modification states that up to eight satellites will be communicating with an earth station at any one time, similar to DISH's concerns, raising questions as to whether SpaceX will in fact comply with applicable EPFD limits in this band.¹⁹³ {[

]} SpaceX explains that its Nco value for its satellites in the 17.8-18.6 GHz band was for the modification granted in 2019 and is eight for the current modification, reflecting its proposed change in operations, but it is using an Nco of one in the 19.7-20.2 GHz band because the EPFD limits are more stringent, requiring SpaceX to limit the number of satellites communicating with an earth station simultaneously in that band to one.¹⁹⁸ SpaceX agrees operating four or eight satellites simultaneously in the 19.7-20.2 GHz band would violate the EPFD limits, and does not propose to operate its gateways with more than one satellite at a time using a given frequency in the 19.7-20.2 GHz band.¹⁹⁹ Hughes nevertheless contends SpaceX has not shown it will comply with EPFD limits in the 19.7-20.2 GHz band and requests that we require that SpaceX "may not use more than one satellite beam for satellite transmissions on the same frequency to the same or overlapping areas at a time."²⁰⁰ SpaceX agrees to this condition,²⁰¹ and we adopt it here. Hughes also requests that we subject SpaceX to any findings the Commission may make about the method for determining EPFD limit compliance and the operating requirements for avoiding unacceptable interference into GSO FSS systems.²⁰² For the same reasons as discussed in connection with DISH's proposed conditions above, we decline to condition SpaceX's grant on a change in our rules regarding EPFD limit compliance, as Hughes requests.²⁰³

44. *Potential for Additional Interference to GSO Systems.* Apart from the questions of Nco and EPFD limits, SES/O3b and DISH argue that SpaceX's application would increase interference into

¹⁹² See SES/O3b Petition at 15-17; Hughes March 5 Ex Parte; Hughes April 12 Letter.

¹⁹³ See SES/O3b Petition at 16; SES October 13 Ex Parte at 3; SES/O3b October 21 Letter at 2-3; SES/O3b November 17 Ex Parte, Attachment 1 at 3; Hughes March 5 Ex Parte at 1, 2.

¹⁹⁴ See Hughes February 5 Letter at 1.

¹⁹⁵ See *id.* at 1-2.

¹⁹⁶ See *id.* at 1, Attachment A.

¹⁹⁷ See *id.* at 2, Attachment A.

¹⁹⁸ See SpaceX November 13 Response to SES/O3b at 1-2; SpaceX March 11 Response to Hughes at 1.

¹⁹⁹ See SpaceX March 11 Response to Hughes at 1, 2.

²⁰⁰ See Hughes April 12 Letter at 1-2.

²⁰¹ SpaceX April 15 Letter at 5.

²⁰² Hughes April 12 Letter at 1-2.

²⁰³ We also decline to include in the conditions Hughes' suggested language to specify SpaceX secondary operations in the 19.7-20.2 GHz band with respect to GSO FSS, since we have not included this specific language in prior SpaceX authorization conditions. See Hughes April 12 Letter at 1.

GSO satellite systems. SES/O3b argues that the increased scan angles proposed for SpaceX's satellites would create large grating lobes that, in addition to potentially impacting earth stations serving the O3b NGSO network, could cause interference into earth stations serving SES's GSO satellites.²⁰⁴ SpaceX responds that the phased array antennas used on its satellites have been specifically designed with small enough spacing between antenna elements to operate at the highest frequency and largest scan angle proposed by SpaceX in its modification application, without producing grating lobes that would direct Ka-band energy in unexpected directions and potentially affect earth stations communicating with GSO satellites.²⁰⁵ Although SES/O3b challenges this assessment in its reply comments, it appears in later filings to focus instead on the mainlobe size as a source of interference effects.²⁰⁶ In general, SpaceX states that the modified constellation will have the same sidelobe levels as the previously authorized constellation, and ultimately SES/O3b appears to agree with this assessment.²⁰⁷ Given that lack of any evidence on this point in the record, we have no reason to doubt SpaceX's assertion that its phased array antennas are designed not to produce excessive grating lobes.

45. SES/O3b also claims that SpaceX has modified the GSO avoidance angle in its modification to 18 degrees, while SpaceX previously specified a GSO avoidance angle of 22 degrees.²⁰⁸ SpaceX admits that it has adjusted its GSO avoidance angle, but consistent with its original authorization, states that it has done so within the EFPD limits.²⁰⁹ SpaceX observes that the Commission did not require any specific GSO avoidance angle as part of its original authorization.²¹⁰ We conclude that so long as SpaceX is in compliance with EFPD limits, SpaceX may operate with a GSO avoidance angle of 18 degrees.

46. As to the remainder of the arguments regarding interference to GSOs, we note that the analysis is similar to that of our analysis above related to NGSO systems, including with respect to the O3b NGSO constellation, which would have similar geometries to GSO satellites for purposes of the interference analysis. SES/O3b also observes that SpaceX stated it would reduce its PFD emissions to account for the greater Nco of eight in the 17.8-18.6 GHz band, but SES/O3b argues that the decrease in PFD emissions has no impact on the factor that is actually driving the increased risk of interference – SpaceX's decision to lower its earth station elevation angles.²¹¹ SpaceX suggests that taken together, its reduced altitude, lower elevation angles, and reduced PFD emissions will result in no increased interference into GSO systems and argues that SES/O3b is not analyzing the effects of all these proposals together.²¹² Given the similarities in analysis as between the interference environment for GSO and NGSO satellites in this particular context, we reference the analysis in our discussion above, and find that the reduction in SpaceX's earth station antenna elevation angles, which would, without other mitigating proposals, tend to increase interference, is offset by the proposed reduction in altitude of SpaceX's satellites and the decreased PFD emissions.

47. DISH also argues that lowering the altitude of all of the SpaceX satellites and increasing the number of orbital planes in which they operate will have the effect of tightening a net of satellites

²⁰⁴ See SES/O3b Petition at 15-16; SES/O3b Reply at 17-19.

²⁰⁵ SpaceX Consolidated Opposition at 32.

²⁰⁶ See, e.g., SES/O3b October 21 Letter at 2.

²⁰⁷ *Id.*

²⁰⁸ See *id.*

²⁰⁹ See SpaceX September 3 Ex Parte, Attachment A; SpaceX September 18 Ex Parte, Attachment A; SpaceX November 13 Response to SES/O3b at 2-3; SpaceX January 19 Ex Parte, Attachment B at 3.

²¹⁰ SpaceX November 13 Letter at 2-3.

²¹¹ See SES/O3b October 21 Letter at 3.

²¹² See SpaceX January 19 Ex Parte, Attachment B at 9.

around the Earth, placing more SpaceX satellites in between DBS GSO satellites and the Earth's surface and increasing the power levels of the constellation.²¹³ SpaceX clarified that, contrary to DISH's claim that lowering the elevation of SpaceX's satellites will tighten the net of satellites around the Earth and result in more SpaceX satellites between DBS satellites and earth stations, SpaceX's reduction in altitude will actually result in fewer satellites being visible to its earth stations at any one time, and so to the extent that one considers a satellite in view from a given location to be "in between" that location and a GSO satellite, the modification therefore has the opposite effect to what DISH predicts.²¹⁴ We find that given the lower altitude of the SpaceX satellites following the modification, from the perspective of a GSO earth station, there should be a wider separation angle from the inline event on average, and any inline event would be for a shorter time period, as the SpaceX satellite would appear to be moving faster as viewed on the ground than when at a higher orbital altitude. Therefore, we find that the SpaceX Third Modification will not increase interference into GSO satellite systems.

3. Compatibility with Terrestrial 5G and the 12 GHz Rulemaking

48. RS Access, CCIA and INCOMPAS, DISH, and the MVDDS Licensees argue that grant of the application would hinder the Commission's ability to authorize 5G services in the 12 GHz band.²¹⁵ Several parties argue that while sharing might be possible between MVDDS operators and the SpaceX system as currently authorized, sharing would become impossible between terrestrial 5G services and SpaceX's constellation, as modified, particularly because of SpaceX's proposed lower elevation angles and its proposed doubling of the number of satellites interacting with each gateway earth station.²¹⁶ RS Access, CCIA and INCOMPAS, and the MVDDS Licensees argue that SpaceX already has access to 14,050 megahertz of spectrum—the 12.2-12.7 GHz band is only 3.6% of that spectrum—and that SpaceX has been on notice about the potential for a rulemaking on the 12.2-12.7 GHz band. They further argue that the Commission is able to grant SpaceX's modification while preserving the 12.2-12.7 GHz band for terrestrial 5G.²¹⁷ RS Access therefore requests the Bureau exclude the 12.2-12.7 GHz band from SpaceX's license, or else require SpaceX to operate at elevation angles of 40 degrees in the 12.2-12.7 GHz band.²¹⁸ Alternatively, now that the *12 GHz NPRM* has been published, RS Access requests the Bureau delay action on SpaceX's application until the 12 GHz rulemaking is complete.²¹⁹

²¹³ See DISH Letter at 4; DISH December 31 Ex Parte at 2; DISH January 5 Ex Parte at 2.

²¹⁴ See SpaceX June 29 Response to DISH at 3-4. In response to DISH, SpaceX also notes that the majority of the satellites in view above the horizon from any site in the United States would not be located in the direction of the equatorial GSO arc, and that SpaceX and other NGSO FSS operators typically observe an exclusion zone around the GSO arc in which their satellites will not operate. *Id.* at 4, n.12.

²¹⁵ See RS Access Letter at 1-2, 4-6 (citing Petition for MVDDS 5G Coalition for Rulemaking, RM-11768 (filed Apr. 26, 2016)); RS Access February 8 Ex Parte at 1; RS Access February 19 Ex Parte, Attachment at 2-3; RS Access February 26 Ex Parte at 1; RS Access March 15 Ex Parte, Exhibit B at 2-4; CCIA/INCOMPAS Letter at 1; DISH July 14 Reply to SpaceX at 1, 5-6; DISH December 31 Ex Parte at 1; DISH January 5 Ex Parte at 1; DISH January 11 Ex Parte at 1; DISH March 8 Ex Parte at 1-2; DISH March 9 Ex Parte at 1; MVDDS Licensees Letter at 1, 5. See also *Expanding Flexible Use of the 12.2-12.7 GHz Band*, Notice of Proposed Rulemaking, FCC 21-13 (2021) (*12 GHz NPRM*); MVDDS Licensees Letter at 1.

²¹⁶ See RS Access Letter at 3-6; RS Access February 8 Ex Parte, Attachment A at 1-3; RS Access February 11 Ex Parte, Attachment A at 1-3; RS Access February 26 Ex Parte, Attachment A at 1-3; RS Access March 15 Ex Parte, Exhibit B at 3.

²¹⁷ RS Access Letter at 2, 3, 8; RS Access February 8 Ex Parte, Attachment A at 1-4; RS Access February 11 Ex Parte, Attachment A at 1-3; RS Access February 26 Ex Parte, Attachment A at 1-3; RS Access March 15 Ex Parte, Exhibit B at 2-4; CCIA/INCOMPAS Letter at 2; MVDDS Licensees Letter at 3-5.

²¹⁸ See RS Access Letter at 5-6; RS Access April 9 Ex Parte at 1; RS Access April 23 Ex Parte at 2-3.

²¹⁹ See RS Access February 8 Ex Parte at 1; RS Access February 26 Ex Parte at 1; RS Access March 15 Ex Parte, Exhibit B at 3-4.

49. SpaceX argues that these commenters' claims to the 12.2-12.7 GHz band for terrestrial 5G services are speculative, that it is a crucial band for SpaceX's service, and that its authorization is already subject to a condition requiring it to comply with all future Commission rulemakings, should the Commission act on the MVDDS rulemaking petition.²²⁰ SpaceX also argues that technical analysis in the record shows that sharing between terrestrial 5G and the SpaceX system as currently authorized would also be impossible, and so the modification is immaterial to that discussion.²²¹ RS Access argues that when these studies were filed in the record, NGSO FSS systems were envisioned to utilize Earth station antennas with elevation angles so low they would cover the entire sky, from horizon to horizon, but the "mega-constellations" being developed can use much higher elevation angles because satellites are always in view overhead, and this blocks interference from terrestrial systems in the same band.²²² According to RS Access, therefore, SpaceX's reduction in elevation would render sharing much more difficult.²²³

50. We recently released the *12 GHz NPRM*, which assesses the potential for terrestrial 5G use of the band.²²⁴ We decline to prejudge any aspects of the 12 GHz rulemaking proceeding by either commenting on the ability of terrestrial and satellite operators to share spectrum in the frequency band more generally, or by denying the requested modification that would include authorization to use the 12.2-12.7 GHz band. We also decline to delay action on this modification until the 12 GHz rulemaking is concluded. As with prior grants, we condition this grant, subject to any modification necessary to bring it into conformance with future actions in Commission rulemakings, including but not limited to the 12 GHz proceeding, which is expressly referenced in the ordering clauses below.²²⁵ Therefore, SpaceX proceeds at its own risk.

51. With respect to DISH's recent letter requesting a Protective Order "to propound certain additional questions to the NGSO system proponents,"²²⁶ we decline to grant DISH's request in the context of this application proceeding. DISH presents its request as one connected to the *12 GHz NPRM*,²²⁷ rather than specific issues related to the SpaceX Third Modification Application.²²⁸ For

²²⁰ See SpaceX Consolidated Opposition at 34-35; SpaceX July 10 Response to RS Access at 2, 4; SpaceX December 21 Ex Parte at 1, 2; SpaceX December 28 Ex Parte at 2.

²²¹ See SpaceX Consolidated Opposition at 34-35; SpaceX July 10 Response to RS Access at 2-3 (citing Letter from Allison Minea, DISH Network LLC and South.com LLC, to Marlene H. Dortch, Secretary, FCC, RM-11768, at 3 (dated Dec. 2, 2019)); Reply Comments of the MVDDS 5G Coalition, RM-11768, Appendix A at 3 (dated Jun. 23, 2016); Comments of the MVDDS 5G Coalition, RM-11768, Attachment I at 2 (dated Jun. 8, 2016); SpaceX January 19 Ex Parte, Attachment B at 10; SpaceX January 22 Ex Parte, Attachment A at 11; SpaceX March 1 Ex Parte at 2; SpaceX March 8 Ex Parte at .

²²² See RS Access February 8 Ex Parte, Attachment A at 1-2; RS Access February 11 Ex Parte, Attachment A at 1-2; RS Access February 26 Ex Parte, Attachment A at 1-2; RS Access March 15 Ex Parte, Exhibit B at 2-3. DISH also indicated that advances in technology over the last five years have made sharing between NGSO FSS and MVDDS systems feasible. See DISH March 17 Response to SpaceX at 5.

²²³ See RS Access February 8 Ex Parte, Attachment A at 1-2; RS Access February 11 Ex Parte, Attachment A at 1-2; RS Access February 26 Ex Parte, Attachment A at 1-2; RS Access March 15 Ex Parte, Exhibit B at 2-3.

²²⁴ See *Expanding Flexible Use of the 12.2-12.7 GHz Band*, Notice of Proposed Rulemaking, FCC 21-13 (2021) (*12 GHz NPRM*).

²²⁵ See *infra* para. 97.w; *SpaceX Authorization*, 33 FCC Rcd at 3399, 3401-02 para. 17 ("we note that, as with the *OneWeb Order*, *Telesat Canada Order*, and *Space Norway Order*, grant of the SpaceX application will not prejudge any decision, including a contrary action in any future rulemaking proceeding."), nn.65, 88 (2018). See also *SpaceX Third Modification Ten-Satellite Grant* at *3, para. 9 n. 27.

²²⁶ DISH February 23 Request for Protective Order at 1; see also DISH April 23 12 GHz Letter (filing in this proceeding arguments more generally related to the 12 GHz proceeding).

²²⁷ See 12 GHz NPRM.

example, DISH states that it is listing “questions and information requests that DISH believes the Commission would find highly probative to the issues teed up for evaluation in the 12 GHz rulemaking,”²²⁹ In its request, DISH states that SpaceX has not claimed that the information requested by DISH would be “irrelevant or unhelpful to the Commission in its... review of SpaceX’s proposed modification[.]” but provides no rationale or argument as to why this information would be relevant to review of the SpaceX Third Modification Application.²³⁰ We decline to make any determination on DISH’s request to the extent that it is relevant to the *12 GHz NPRM* more generally, but we deny DISH’s request in the context of processing this modification application.

4. Protection of Ka-Band Terrestrial Systems

52. In accordance with the conditions on its original authorization, SpaceX submitted a showing demonstrating that it will protect terrestrial fixed stations in the Ka-band with the characteristics described in recommendation ITU-R SF.1483.²³¹ SpaceX asks the Bureau to determine that it has satisfied the condition on its original authorization.²³² OneWeb states it has analyzed SpaceX’s showing and agrees SpaceX will be able to protect terrestrial fixed stations in the Ka-band, and supports SpaceX’s request that the Bureau find SpaceX has satisfied this condition.²³³ We agree SpaceX’s showing demonstrates it will protect terrestrial fixed stations in the Ka-band and find SpaceX has satisfied this condition.

C. Orbital Debris

53. SpaceX’s original authorization for its Ku- and Ka-band system was conditioned upon Commission approval of an updated description of the orbital debris mitigation plans for its system.²³⁴ As part of SpaceX’s first modification application, SpaceX submitted an updated description and analysis of its orbital debris mitigation plans.²³⁵ In the *SpaceX First Modification Order* the Bureau concluded that the orbital debris mitigation plan was sufficient with regard to the 1,584 satellites in SpaceX’s constellation that it was requesting to operate at 550 km, as part of its modification request.²³⁶ SpaceX’s plan concerning avoiding collisions with large objects (both active satellites and debris) involved three main elements, recognizing that such risks can be reduced by maneuvering to avoid predicted collisions and by removing objects from orbit after their mission is complete. First, SpaceX indicated that its satellites would have propulsion and would be maneuverable.²³⁷ Second, SpaceX indicated that it would take steps to reduce collision risk for satellites that reach the end of their mission by lowering the altitude

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²²⁸ RS Access also asks that we condition this grant on receipt of information about SpaceX’s antenna performance specifications, to help operators better understand coexistence opportunities between NGSO FSS and 5G in the 12.2-12.7 GHz band. RS Access April 23 Ex Parte at 2. We decline to condition this grant as requested by RS Access since similarly this request appears more related to issues that are part of the 12 GHz proceeding.

²²⁹ DISH February 23 Request for Protective Order at 2.

²³⁰ *Id.*

²³¹ See SpaceX Third Modification Application, Technical Attachment at 17; SpaceX Authorization at para. 35.

²³² See SpaceX Third Modification Application, Technical Attachment at 17; SpaceX Authorization at para. 35.

²³³ See OneWeb Comments at 2-3.

²³⁴ *SpaceX Authorization*, 33 FCC Rcd at 3398, 3407, paras. 15, 40p.

²³⁵ *SpaceX First Modification Order*, 34 FCC Rcd at 2532, para. 18.

²³⁶ *Id.* at 2536, 2538, paras. 26, 32p. This determination was also based on information provided by SpaceX concerning measures it had taken to reduce to zero the calculated casualty risk from satellite debris that survives re-entry into the Earth’s atmosphere. *Id.* at 2535-2536, n.1. That information is equally applicable to the spacecraft proposed for deployment pursuant to this modification.

²³⁷ SpaceX First Modification Application, Technical Attachment at 39.

of the satellites in order to hasten atmospheric re-entry, and by continuing active collision avoidance for as long as possible during the disposal phase.²³⁸ Third, as a result of the reduction in altitude to the 550 km range, even if not maneuverable SpaceX satellites would, due to higher atmospheric drag at that altitude, comply with the so-called “25 year rule” that a satellite operating in Low Earth Orbit should be removed from orbit within no more than 25 years after the conclusion of its mission.²³⁹ SpaceX also indicated it would deploy satellites to an initial altitude of approximately 350 km in order to ensure that any satellites that are not able to maneuver upon deployment are in a low orbit from which “passive” atmospheric re-entry can be expected within months.²⁴⁰ SpaceX relies on the same considerations in this modification for altitudes ranging from 540 km to 570 km.²⁴¹ In response to SpaceX’s modification application, a number of parties expressed concerns about the orbital debris mitigation information SpaceX provided in its application and the consequences of grant of SpaceX’s third modification on space safety and the orbital debris environment.²⁴²

54. *Framework for Analysis.* In several respects, the concerns raised relate to the scale of the over-all constellation deployment, taking into account the 1,594 satellites already authorized for deployment and the 2,814 satellites for which SpaceX seeks a modified altitude, particularly with respect to collision risk and potential operational effects on other systems. Because our decisions concerning prior modifications did not address such concerns, we address them here. In addition, although we agree with SpaceX that specification of a lower altitude provides for operations that present considerably lower risk than at the higher altitude, all other things being equal,²⁴³ we do not ascribe any public interest weight to reduction in risk relative to a constellation configuration that was only conditionally authorized, in particular one conditionally authorized subject to further review on precisely the issues addressed here. Instead, our review is guided by an assessment of the constellation configuration for which SpaceX seeks authorization, based on available factual information and taking into consideration relevant research and debris mitigation considerations identified for large constellations in relevant research and sources such as the U.S. Government Orbital Debris Mitigation Standard Practices (ODMSP).²⁴⁴ We believe this approach is preferable in that it evaluates the proposed operations based on objective benchmarks, rather than through a comparison with an earlier proposed system.

55. The ODMSP contains a provision specifically focused on large constellations (100 or more operational spacecraft cumulative). The ODMSP provision on large constellations focuses primarily on disposal of spacecraft at the end of their mission, and identifies immediate removal from orbit as the preferred method for disposal, with another option being delayed re-entry utilizing atmospheric drag to remove the satellite from orbit as soon as practicable, but in any event within 25

²³⁸ Id. at 39-40.

²³⁹ See U.S. Government Orbital Debris Mitigation Standard Practices, November 2019 Update, at p. 5, Section 4.-1.b. Available at: https://orbitaldebris.jsc.nasa.gov/library/usg_orbital_debris_mitigation_standard_practices_november_2019.pdf (ODMSP). SpaceX submitted information indicating that its satellites can be expected to re-enter passively from that range in approximately five years. First Modification Application, Technical Attachment at 39-40.

²⁴⁰ See *SpaceX February 22 Ex Parte at 1-2*.

²⁴¹ SpaceX Third Modification Application, Narrative at 2.

²⁴² See e.g., Viasat Petition, Kuiper Opposition, Kepler Opposition, Spire Comments; SES/O3B Petition; OneWeb Comments; Astroscale Letter; Kuiper May 1 Ex Parte; Viasat June 8 Letter.

²⁴³ This observation is also amply supported by modeling studies of large constellations. See, e.g., J.-C. Liou, et al. “NASA ODPO’s Large Constellation Study”, *Orbital Debris Quarterly News*, Vol. 22 (3), pp. 4-7, 2018; Hugh G. Lewis, “Evaluation of debris mitigation options for a large constellation” First International Orbital Debris Conference (Houston, 2019), available at: <https://www.hou.usra.edu/meetings/orbitaldebris2019/orbital2019paper/pdf/6069.pdf>

²⁴⁴ See generally ODMSP.

years. While the ODMSP specifies an acceptable probability of successful postmission disposal for a single spacecraft as 0.9, the ODMSP identify the need for additional measures for spacecraft in a large constellation. “Each spacecraft in a large constellation should have a probability of successful postmission disposal at a level greater than 0.9 with a goal of 0.99 or better.” The ODMSP also provides that the “successful postmission disposal threshold,” should be based on factors such as mass, collision probability, orbital location, and other relevant parameters.

56. As discussed in greater detail below, we conclude that SpaceX’s updated orbital debris mitigation plan is sufficient, subject to certain conditions to provide for ongoing review and potential revision of license terms, including suspension of deployment if necessary, if targets for reliable operation and disposal are not met. This grant is also subject to the outcome of the Commission’s orbital debris proceeding²⁴⁵ and any other relevant rulemakings. We discuss first the question of collision risk.

57. With respect to collision risk, we focus on three specific areas in which parties raise concerns about SpaceX’s debris mitigation plans. First, a number of parties express concerns about SpaceX’s plans to reduce collision risk by using a collision avoidance process in which SpaceX continuously assesses the trajectories of Starlink satellites and executes collision avoidance maneuvers when needed. This is accomplished through “autonomous” processes in which computers on individual satellites calculate the need for a maneuver based on their own position readings as well as data received from the ground, and execute the maneuver using a pre-programmed routine in the event a maneuver is needed. These parties express skepticism about the effectiveness of this approach. Second, parties raise concerns about the reliability of Starlink spacecraft, noting that failed spacecraft will not be maneuverable and cannot avoid collisions, and given the large number of spacecraft planned for deployment, even a relatively low failure rate could present significant collision risk. Finally, several parties focus on the difficulties and risks of having more than one large constellation operate within an altitude “shell” or altitude range. We address each of these issues in turn.

58. *Maneuverability.* In prior cases, including in the SpaceX first modification, there has been an approach of assuming collision risk to be zero or near zero for spacecraft that have a maneuver capability and a process for identifying the need for and executing collision avoidance maneuvers, unless there is evidence that the assumption is not warranted.²⁴⁶ This approach follows a similar assumption made for purposes of assessing collision risk in NASA’s Debris Assessment Software, which is intended to provide a generalized assessment of collision risk based on the spatial density of objects in the regions of space where a spacecraft will orbit. SpaceX states that it intends to conduct active maneuvers to avoid collisions with both debris and other spacecraft throughout the life of its satellites, including through the deorbit phase until the spacecraft can no longer be controlled due to atmospheric turbulence, and states that because of its system’s capabilities, the assumption of zero or near zero risk is warranted. Viasat and Kepler argue there was not enough information on the maneuverability of SpaceX’s satellites.²⁴⁷ Astroscale, Viasat, Kepler, and OneWeb also argue that satellites with propulsion should not be considered to have zero or near-zero collision risk, as propulsion cannot reduce collision risk to zero, and residual risk across a large constellation such as SpaceX’s could be significant.²⁴⁸ We recognize, as

²⁴⁵ A number of the issues related to large constellation collision risk, for example, are a subject of the Commission’s FNPRM in the ongoing orbital debris proceeding, IB Docket 18-313. See, e.g., *Orbital Debris R&O and FNPRM*, 35 FCC Rcd at 4226-31, para. 155-163.

²⁴⁶ *Orbital Debris Report and Order & FNPRM*, 35 FCC Rcd at 4171-4172.

²⁴⁷ See Kepler Opposition at 13; Viasat Petition at 20. Viasat also argues that SpaceX has not shown that its hall-effect thrusters can withstand the increased resistance caused by atmospheric drag at the proposed lower operational altitude. See Viasat Petition at 47. We observe that at this point SpaceX has deployed and maneuvered a significant number of satellites at lower orbital altitudes.

²⁴⁸ See Astroscale Letter at 2-4; Viasat Petition at 13, 18-19; Viasat Reply at 22-24; Kepler Opposition at 12-13; OneWeb Comments at 5-6; OneWeb Reply at 8-9; see also Kepler April 16 Letter at 2 (requesting the Commission require SpaceX to be responsible for all conjunction avoidance maneuvers with respect to Kepler’s satellites).

several parties note, that spacecraft collision avoidance maneuvers cannot reduce risk to zero. There will be some residual risk. In response to Bureau inquiries about the levels of such risk, SpaceX stated that for each conjunction event, it will take mitigating action to reduce probability of collision (PC) when PC is greater than $1E^{-05}$ (one in one hundred thousand),²⁴⁹ and by that action reduce PC to $1E^{-06}$ (one in a million) or less.²⁵⁰ When analyzing conjunction risk, SpaceX also assumes a ten meter “hard body radius” for its satellites. This hard body radius approach in and of itself substantially increases the assumed area occupied by the spacecraft, since it assumes that an object is the size of a sphere defined by the object’s largest dimension. In addition, the assumed 10-meter radius is substantially larger than the satellites’ actual dimensions. The inherent conservatism in this approach suggests a residual risk from each conjunction lower than $1E^{-06}$, perhaps by one or more orders of magnitude depending on specific details of the conjunction. SpaceX also provides propagated ephemeris data three times a day to the 18th Space control Squadron and screens for potential intra-constellation collisions every hour.²⁵¹ While it might be possible to assess the cumulative total for residual risk not mitigated by maneuvers based on the number of conjunctions, with the number of conjunctions for the Starlink network comparatively higher than for smaller constellations at the same altitude, the range in which this risk level falls appears to be sufficiently low to justify treating it as zero. Furthermore, there is the distinct possibility that this form of residual risk is in some or many cases an artifact of the methods used for assigning probability values, which include some assumptions concerning distribution, rather than a realistic risk. However, given the unprecedented scale of SpaceX’s operations, we believe this is an area that warrants continued monitoring, and will therefore condition this grant on SpaceX reporting, on a semi-annual basis, several indicators for this risk, including the number of collision avoidance maneuvers undertaken by its satellites.

59. With respect to the concerns expressed by some parties about the effectiveness of SpaceX’s collision avoidance process and the information SpaceX has provided about it,²⁵² none of the parties raise specific or particularized concerns that warrant additional inquiry at this time. It appears that the questions raised are primarily ones that could be addressed through good faith coordination among the operators, and we urge resort to such discussions.²⁵³

60. *Collision Risk and Satellite Reliability.* Spacecraft that are not capable of maneuvering generally have little or no capability to avoid collisions, and several parties express concern that, absent very high reliability, at levels above those currently in evidence, the number of SpaceX satellites that fail in a way that makes them un-maneuverable will be high, and with that the consequent collision risk will also be high.²⁵⁴ Viasat also raises a broader concern that SpaceX is employing a deployment strategy focusing more on disposability than reliability.²⁵⁵

²⁴⁹ See SpaceX March 16 Ex Parte at 1.

²⁵⁰ See *id.* SpaceX also identifies $1E^{-04}$ as a more typical industry threshold for action.

²⁵¹ See *id.* at 2.

²⁵² SES/O3b, Kuiper, Viasat, OneWeb, and Astroscale express concern about the lack of information on SpaceX’s autonomous collision avoidance system and the impact of that lack of information on other operators’ ability to physically coordinate operations with SpaceX. See SES/O3B Petition at 17; SES/O3B Reply at 20, 22; SES/October 13 Ex Parte at 4; SES/O3B November 17 Ex Parte, Attachment 1 at 3; Kuiper Petition at 4; Kuiper Reply at 9; Viasat Reply at 25; OneWeb Reply at 9-10; OneWeb February 10 ex Parte at 6; OneWeb February 25 Ex Parte at 6; Astroscale Letter at 4.

²⁵³ See “NASA, SpaceX Sign Joint Spaceflight Safety Agreement” NASA New Release 21-011 (March 18, 2021), available at: <https://www.nasa.gov/press-release/nasa-spacex-sign-joint-spaceflight-safety-agreement>.

²⁵⁴ See Astroscale Letter at 7-8; Viasat Petition at 13-14, 21-22; Kuiper Petition at 2-4; OneWeb Comments at 7.

²⁵⁵ See Viasat Petition at 22-23, 29-32 (citing https://www.reddit.com/r/spacex/comments/gxb7j1/we_are_the_spacex_software_team_ask_us_anything/); Viasat (continued....)

61. SpaceX's satellite failure rate is a matter of significant contention in the record.²⁵⁶ The primary point of contention for the most part does not appear to be the underlying data, but instead the interpretation of its significance. As a manifestation of this, the parties appear to be utilizing different definitions of what constitutes a failure, based on different insights as to the relevance of particular types of satellite failures. For example, and as SpaceX correctly notes, viewed in light of the "25 year rule" limitation on maximum orbital lifetime for satellites in Low Earth Orbit identified in the ODMSP, the Starlink satellites are by definition successful, because even if they fail to operate, they will re-enter the Earth's atmosphere within approximately 5 years.²⁵⁷ Bearing in mind that the ODMSP identifies the need for special, individualized assessments of large constellations, and in particular given that SpaceX has adopted a strategy of accelerating removal of spacecraft from orbit by lowering the spacecraft orbit to speed re-entry, an alternative definition of a satellite failure would be any failure that results in SpaceX being unable to execute this shortened re-entry period. Recognizing that satellite failures typically occur with higher frequency immediately post-launch, SpaceX is also following a strategy of deploying almost all of its spacecraft into a low orbit in the 350 km range or below,²⁵⁸ so that any spacecraft that do not have the capability to maneuver or perform their mission re-enter the atmosphere within a short period of time, essentially as soon as or faster than satellites that complete their mission and are retired. Thus, an alternative definition, and one that several parties support,²⁵⁹ is that a failed satellite is one that loses the capability to maneuver at a higher altitude, as this identifies satellites that present collision risks that are anomalous. For ease of reference, we refer to this type of failure as a "disposal failure." Finally, several parties appear to define satellite failures as any scenario that results in a satellite not performing its mission over a longer-term period.²⁶⁰ This definition for failure rates includes satellites that present very low risk for debris mitigation purposes because disposal, while it may occur sooner than expected, is virtually indistinguishable from a "nominal" disposal. However, the rate at which this scenario occurs can have some relevance in assessing the over-all number of satellites that an operator must launch in order to fill out and maintain its constellation. Moreover, each satellite that does not operate for its full planned mission lifetime must be replaced with another satellite that carries its own failure risk, including for failure of the maneuver capability at the primary mission altitude. For ease of reference, we refer to this scenario as "early mission termination."

62. SpaceX provided data to show that, as of April 2, 2021, and excluding the first 60 prototype Starlink satellites launched (referred to as v0.9), its current system (satellites designated as v1.0), has a disposal failure rate of approximately 1.45% (20 of 1383 satellites) and an early mission termination rate of approximately 3.1% (43 of 1383 satellites, i.e., the 20 disposal failures, plus 7 satellites "screened"

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Reply at 9-15; Viasat September 17 Ex Parte at 1-2; Viasat December 21 Ex Parte at 3; Viasat January 7 Ex Parte at 3; Viasat February 8 Ex Parte at 5, 15; Viasat February 12 Ex Parte at 5, 15.

²⁵⁶ See, e.g., Viasat Petition at 13-15, 21; OneWeb Comments at 5-7; Viasat January 7 Ex Parte; Viasat February 8 Ex Parte; Viasat February 12 Ex Parte at 16-21. See also *McDowell Letter*; Viasat Response to *McDowell Letter*; Viasat October 5 Response to SpaceX.

²⁵⁷ See SpaceX Consolidated Opposition at 3-4, SpaceX September 29 Response to GSO Operators at 3, SpaceX March 2 Response to Viasat at 1, 3-6.

²⁵⁸ SpaceX indicates that the majority of Starlink satellites are deployed by launches dedicated only for SpaceX satellites, with typical deployment orbits "at 265 x 285 km or 208 x 366 km." SpaceX April 2 Ex Parte at 3. One launch to date has involved deployment of ten satellites at an altitude close to the 550 km altitude range for the main Starlink mission as part of a "ride share" launch in which the vast majority of satellites deployed were for other operators.

²⁵⁹ See *McDowell Letter*.

²⁶⁰ Viasat Response to *McDowell Letter*: ViaSat April 12 Ex Parte.

at low altitude immediately post-launch, and 16 additional satellites deorbited early).²⁶¹ Taking into account the 60 v0.9 satellites, and treating the 10 that remain in orbit as of April 9, 2021 as disposal failures,²⁶² the disposal failure rate is 2.16%. All of the v0.9 satellites were prototypes that are being deorbited well before the stated 5-7 year nominal mission lifetime for Starlink satellites,²⁶³ so for purposes of calculating early mission termination rates all would count, which yields an early mission termination rate of 7.4% for the constellation as a whole. SpaceX argues that it has identified and corrected the root cause for satellites in the disposal failure category, improved its manufacturing process and updated the software on on-orbit satellites to address causes of loss of maneuverability.²⁶⁴ Among several data points provided in the record, SpaceX states that as of mid-February 2021, 720 of the last 723 satellites it launched were maneuverable above injection altitude.²⁶⁵

63. Satellites that have a disposal failure will present a collision risk for as long as they remain on orbit. A number of parties submit information based on calculations derived from NASA's Debris Assessment Software, which includes a tool for quantifying a single satellite's risk of collision during its orbital lifetime or 100 years, whichever is shorter. Based on the single satellite risk for a satellite in the disposal failure category, and the rate of disposal failure, a relatively simple calculation can estimate the risk from disposal failure for the constellation as a whole. The information in the record indicates a single satellite risk that can be approximated as .0001,²⁶⁶ and a targeted mission lifetime for each satellite of between 5 and 7 years.²⁶⁷ Over a fifteen year license term, and assuming replenishment on a five year cycle, there would be the initial launch plus two replenishment cycles for the 4,408 satellites, for a total of 13,224 satellites, while a seven year replenishment cycle would yield a number consistent with a SpaceX estimate of fewer than 10,000 satellites launched during the license term.²⁶⁸ These figures do not account for early mission termination, and assuming that rate is 10%, i.e., somewhat higher than the rate to date, yields an upper end estimate for the range of number of satellites to be launched of 15,000 satellites, rounding up from 14,546 (13,224 satellites plus ten percent, 1,322). At the currently observed disposal failure rate of approximately 1.5% for the v1.0 satellites, this implies 150

²⁶¹ SpaceX April 2 Ex Parte at 2. Viasat argues SpaceX's calculated failure rate of 1.45% is misleading because it does not take into account satellites that failed or were screened and deliberately deorbited at injection altitude and also does not include the 60 V0.9 satellites, all of which should be included in a calculation of SpaceX's failure rate. See Viasat April 12 Failure Rate Letter at 2-4, 5-6. Viasat also faults SpaceX for not including information on its lifetime failure rate, which Viasat expects will increase because of manufacturing flaws and aggressive design choices. *Id.* at 4-5. SpaceX did however include data on the number of satellites failed or screened at injection orbit, see SpaceX April 2 Ex Parte at 2, and we have taken these satellites into consideration, along with the 60 v0.9 Starlink satellites in conducting our analysis.

²⁶² This information is based on review of catalog entries for Starlink satellites accessed via the n2yo.com web site, on April 13, 2021.

²⁶³ SpaceX May 15 Response at 5 (spacecraft designed for 5 year mission lifetime); SpaceX April 2 Ex Parte at 1 and Attachment B at 2 (7 year satellite life estimated); SpaceX March 16 Ex Parte (first tranche of satellites fully demised or in the process of de-orbiting).

²⁶⁴ See SpaceX February 22 Ex Parte at 1, SpaceX April 2 Ex Parte at 2.

²⁶⁵ See SpaceX February 22 Ex Parte at 1; SpaceX March 16 Ex Parte at 2; see also SpaceX September 29 Response to GSO Operators at 3 (no satellite failures in the last 233 satellites launched); SpaceX October 5 Ex Parte, at 1, Exhibit 2 (no failures in the last 300 satellites launched).

²⁶⁶ SpaceX July 7 Letter. SpaceX provided several figures for this risk, based on alternative scenarios that might be applicable to its satellites. The .0001 figure assumes a tumbling configuration for the satellite, which would in all circumstances be achievable, and a collision risk figure that at the higher end for the range of altitudes in which Starlink satellites will operate.

²⁶⁷ SpaceX May 15 Response at 5; SpaceX April 2 Ex Parte at 1 (7 years).

²⁶⁸ SpaceX April 2 Ex Parte at 1.

satellites for 10,000 satellites launched, and 225 satellites for 15,000 satellites launched, with a corresponding cumulative collision risk of .015 (one in 66.7) for 10,000 satellites launched and .0225 (one in 44.5) for 15,000 satellites. At a 1% disposal failure rate, there would be 100 satellites failed for 10,000 launched, and 150 for 15,000 launched, with a corresponding cumulative collision risk of .01 (1 in 100) and .015 (1 in 66.7) respectively. At a 0.5% disposal failure rate, there would be 50 satellites failed for 10,000 launched, and 75 for 15,000 launched, with a corresponding cumulative collision risk of .005 (1 in 200) and .0075 (1 in 133.3).

64. While this analysis necessarily involves estimates, it illustrates that it will be important for SpaceX to maintain a high disposal reliability rate for its satellites in order to limit collision risk. Although the trend is at this point promising, the data covers only the early stages of constellation deployment. Typical spacecraft failure curves tend to show high failure rates at the earliest and latest stages of satellite operations. Given that high reliability will be important in maintaining low risk levels, we believe, as suggested by several commenters, that continued monitoring of constellation reliability will be necessary.²⁶⁹ We will require semi-annual reporting concerning the number of satellites launched and disposal reliability. In addition, and as a method of continuing monitoring, we will require on a going forward basis from the information provided in SpaceX's April 2 Ex Parte that if at any time the number of satellites that have experienced a disposal failure reaches three per year, SpaceX will be required to report that fact. The three-satellite reporting threshold corresponds roughly to the expected annual number of satellites that would exhibit a disposal failure, based on the 50 satellites for which disposal failures could be expected from a 0.5% disposal failure rate for 10,000 satellites. In the event disposal failure rates exceed the reporting threshold, the Commission will consider whether additional license conditions or limitations on deployment and operation may be necessary, taking into account any materials submitted by SpaceX to address corrective measures.

65. *Co-Existence of NGSO Systems in LEO.* A number of parties that plan to operate satellites in Low Earth Orbit, particularly in orbits that are in the same altitude range or adjacent to the altitude range in which SpaceX will operate, raise concerns about the operations of more than one constellation in the same orbital region.²⁷⁰ Some of these operators identify constraints and limitations on their own ability to avoid collisions, and one asks that responsibility for conducting collision avoidance maneuvers be assigned to SpaceX.²⁷¹ The information provided in this proceeding establishes that SpaceX is taking necessary actions to avoid collisions through the use of conjunction screening and satellite maneuvers, as well as deployment strategies and management of spacecraft operations. With respect to the request that we include a condition specifying "responsibility" for collision avoidance, we decline to do so, as this might suggest an absence of responsibility for other operators. We expect all operators to engage in and complete good-faith coordination of physical operations, and with respect to SpaceX, its authorization is already conditioned accordingly.

66. Several parties proposing to operate constellations raise concerns about overlapping orbital "shells" based on SpaceX's request to operate within plus or minus 30 km of its specified "nominal" satellite altitudes.²⁷² SpaceX states that the 30 kilometer "tolerance" is considerably larger

²⁶⁹ Viasat Petition at 35; Astroscale Letter at 8; Astroscale Reply at 4.

²⁷⁰ See Spire Comments at 1-2; SES/O3b Petition at 17-18; Kepler Opposition at 12-13; Kuiper Opposition at 4-10; Kuiper May 1 Ex Parte at 2; OneWeb Comments at 3-4; Viasat Petition at 10-11; Viasat December 21 Ex Parte at 7, 10; Viasat February 8 Ex Parte at 12; Viasat February 12 Ex Parte at 12. See also RS Access Letter at 4 (expressing concerns about increased probability of collision).

²⁷¹ See Kepler Reply at 31-32, 28-30; Spire Comments at 2.

²⁷² See SES/O3b Petition at 17-18; Kuiper Opposition at 4-11; Kuiper Reply at 4-8; Kuiper May 1 Ex Parte at 2; Kuiper August 18 Ex Parte at 1-2; Kuiper September 2 Ex Parte at 2; Kuiper September 17 Ex Parte at 1-2; Kuiper September 24 Ex Parte at 3; Kuiper September 30 Ex Parte at 1-2; Kuiper October 6 Ex Parte at 2; Kuiper October 9 Ex Parte at 1, 3; Kuiper October 15 Ex Parte at 2; Kuiper October 16 Ex Parte at 1, 3; see also SpaceX September 3 Response to Kuiper at 2; SpaceX September 14 Ex Parte, Attachment 2; SpaceX October 9 Response to Kuiper at 5;

(continued....)

than what is required for typical operations, but provides leeway for maneuvers involving more than typical station-keeping.²⁷³ Viasat specifically requests the Commission condition any grant of SpaceX's modification on requiring it to maintain an orbital tolerance of 2.5 km or less, to facilitate sharing of the 510-600 km orbital environment with other operators.²⁷⁴ With respect to the upper altitude limits for Starlink operations, we conditioned the Ten-Satellite Partial Grant to require SpaceX to maintain its orbital tolerance such that its satellites will fly below 580 km at all times.²⁷⁵ Kuiper requests we continue to apply that condition to SpaceX's constellation going forward,²⁷⁶ and we will do so. As a practical matter, this will mean that SpaceX satellites in the upper altitude ranges must abide by a smaller orbital tolerance – 10 km or less for the planned operational orbit at 570 km altitude, and 20 km or less for the satellites at 560 km – in order to stay below 580 km at all times. This condition will also limit any risk of Starlink satellites failing at higher altitudes where longer orbital decay times and marginally greater collision risk would be expected. Viasat worries that our approach will effectively split the 510-640 km orbital environment between SpaceX and Kuiper and preclude others from operating in this region,²⁷⁷ but nothing in our grant will prevent physical sharing of low-earth orbit. With respect to Starlink satellites at the lower range of specified nominal altitude ranges, the information provided by the one operator raising a specific concern did not indicate the orbital tolerance of its own operations, but instead indicated a nominal altitude at 507 km, three kilometers below the lowest nominal Starlink altitude.²⁷⁸ We are unable to resolve this issue based on the limited information provided, and in any event the record does not indicate that at this stage there have been any meaningful efforts on the part of the operators to coordinate physical operations. Under the circumstances, we decline to include a specific condition concerning this matter. We also decline to condition this grant to restrict SpaceX's orbital tolerance to the extent Viasat suggests, as it is unclear in the absence of a particular operational scenario whether maintaining the satellites within a smaller or larger operational volume is preferable for purposes of limiting risk.

67. *Accidental Explosions.* The Balance Group and Kepler also express concern that SpaceX has not demonstrated its satellites have no credible failure mode for accidental explosions. SpaceX addressed this issue in its original application for authorization.²⁷⁹ These commenters do not suggest and we find no reason why SpaceX's satellites would be more prone to accidental explosions now than at the time of SpaceX's original authorization. In any event, given the reporting conditions adopted, we anticipate that any unexpected events involving accidental explosions would be identified, as these events can be expected to impact disposal failure rates. If necessary, and as with disposal failures more generally, corrective action can be taken if warranted by the facts.

68. *Other matters.* SpaceX's original authorization and first and second modifications were conditioned on SpaceX submitting, and the Bureau approving, a modification containing an updated orbital debris mitigation plan. SpaceX requests in this application that we find it has satisfied this

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SpaceX November 17 Letter at 2; SpaceX December 4 Ex Parte at 4; SpaceX January 19 Ex Parte, Attachment B at 2.

²⁷³ SpaceX Consolidated Opposition at 10.

²⁷⁴ See Viasat April 12 Conditions Letter, Attachment at 1,2; Viasat April 13 Ex Parte, Attachment at 1, 2; Viasat April 14 Ex Parte, Attachment at 1, 2; Viasat April 12 LEO Letter at 2.

²⁷⁵ See Ten-Satellite Partial Grant at Paras. 12, 19S.

²⁷⁶ See Kuiper February 4 Ex Parte at 1, 3; Kuiper February 4 Letter at 1, 2; Kuiper February 11 Ex Parte at 1, 3; Kuiper February 22 Ex Parte at 1, 3; Kuiper February 25 Ex Parte at 1, 3; Kuiper March 16 Ex Parte at 1, 3.

²⁷⁷ See Viasat April 12 LEO Letter.

²⁷⁸ See SES/O3b Petition at 17-18.

²⁷⁹ See *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, Technical Information at 51-52 (filed Nov. 15, 2016).

condition. For the reasons set forth above, we find SpaceX has satisfied this condition and we will remove it from this authorization.

D. Authority for LEOP and Payload Testing Operations

69. SpaceX requests authority to conduct LEOP operations and payload testing during orbit-raising as well as TT&C operations during deorbit of its satellites. SpaceX has been conducting these operations through a series of 180-day Special Temporary Authority (STA) grants, which allow SpaceX to conduct LEOP operations and payload testing for all satellites previously launched and those to be launched during the six-month period covered by the STA.²⁸⁰ SpaceX argues grant of this request would be in the public interest because it would relieve the Bureau of the burden of processing a continuous stream of STA requests,²⁸¹ and that it has been conducting LEOP operations and testing for over a year without complaint from other operators.²⁸² Viasat expresses concern with the broad authority SpaceX requests in its modification application to conduct testing of its satellites' Ku- and Ka-band payloads,²⁸³ noting SpaceX's statement that it will likely be engaged in orbit-raising and deorbit maneuvers on an ongoing basis.²⁸⁴ Viasat alleges that SpaceX has not defined "harmful interference" in its proposal to conduct these operations on an unprotected, non-harmful interference basis, and Viasat argues that SpaceX has provided insufficient technical analysis to show that its testing operations can be conducted on a non-interference basis with respect to GSO satellites, NGSO systems, and terrestrial fixed services.²⁸⁵

70. We agree with SpaceX that granting it authority for these transition phase operations is in the public interest. SpaceX's practice of testing its satellites at injection altitude, before orbit-raising, allows it to de-orbit any non-functional satellites in a matter of days or weeks, helping to ensure that non-maneuverable satellites do not reach operational orbit. Additionally, given that SpaceX has been conducting these operations on an ongoing basis for over a year pursuant to STA, we conclude that granting SpaceX authority to conduct these operations pursuant to this modification and consistent with

²⁸⁰ See, e.g., Space Exploration Holdings, LLC., Request for Special Temporary Authority, Grant Stamp, IBFS File No. SAT-STA-20190405-00023 (granted May 9, 2019) (granting a 60-day STA to SpaceX for LEOP operations and testing for its first tranche of Starlink satellites) and extensions: IBFS file Nos. SAT-STA-20190717-00063 (granted Jul. 25, 2019), SAT-STA-20190815-00075 (granted Sept. 4, 2019), SAT-STA-20190917-00095 (granted Sept. 25, 2019), SAT-STA-20191018-00118 (granted Oct. 24, 2019), SAT-STA-20191118-00134 (granted Dec. 5, 2019), SAT-STA-20191220-00151 (granted Jan. 2, 2020); Space Exploration Holdings, LLC., Request for Special Temporary Authority, Grant Stamp, IBFS File No. SAT-STA-20190924-00098 (granted Nov. 7, 2019) (granting SpaceX a 60-day STA for LEOP operations and testing for its second tranche of Starlink satellites) and extensions: IBFS file nos. SAT-STA-20200103-00005 (granted Jan. 30, 2020), SAT-STA-20200207-00014 (granted Feb. 10, 2020); Space Exploration Holdings, LLC., Request for Special Temporary Authority, Grant Stamp, IBFS file no. SAT-STA-20191231-00155 (granted-in-part and deferred in part Jan. 2, 2020, granted-in-full Jan 17, 2020); Space Exploration Holdings, LLC., Request for Special Temporary Authority, Grant Stamp, IBFS File No. SAT-STA-20191230-00156 (granted March 19, 2020) (authorizing SpaceX to conduct LEOP operations and testing for all Starlink satellites both previously launched and to be launched during the 180-day period of the STA).

²⁸¹ See SpaceX Consolidated Opposition at 35-36.

²⁸² See *id.* at 36.

²⁸³ See Viasat Petition at 39.

²⁸⁴ See *id.* (quoting SpaceX Third Modification Application, Attachment 1, at 4).

²⁸⁵ See *id.* at 39-40. Viasat states, for example, that SpaceX has not shown that Ku- and Ka-band emissions can be made on a non-interference basis, and has not provided any EPFD analysis or masks to show that testing can be conducted on a non-interference basis with GSOs, or any interference-to-noise (I/N) analysis showing that testing can be conducted without increasing interference to other NGSO systems, or any analysis showing that testing would not cause additional interference to terrestrial fixed services. *Id.* at 40. Viasat alleges that given the size and complexity of the system, the "complete mitigation" of interference is hard to imagine. *Id.*

the rules for GSO satellites, would lessen the burden on Commission resources to process STAs. As to Viasat's concerns regarding the technical aspects of SpaceX's non-interference operations, we have already addressed interference concerns in connection with SpaceX's STA requests. Specifically, we have conditioned SpaceX's STAs on SpaceX providing the input data files for its EPFD analysis to any requesting operator, as well as operating on a non-interference, unprotected basis.²⁸⁶ Given that SpaceX has been conducting these operations since 2019 without issue, we conclude that granting SpaceX authority for these types of operations under this modification, with the same conditions, will sufficiently ensure that other operators do not encounter harmful interference resulting from these operations. Consistent with our grants of STA to date, we limit SpaceX's power levels to those requested in this modification, rather than those requested in its two most recent STA applications.²⁸⁷

71. In connection with orbit raising and de-orbit, Spire requests that SpaceX bear full responsibility for active collision-avoidance during orbit-raising and deorbit operations.²⁸⁸ In connection with orbit-raising and deorbit of its satellites, we expect that SpaceX will undertake the necessary actions to perform collision avoidance. However, this does not remove the responsibility of other operators to assess collision risk upon receipt of a space situational awareness conjunction warning, and mitigate the risk, if necessary.²⁸⁹

E. The National Environmental Policy Act and Other Matters

1. Background and Legal Framework

72. The Commission implements the provisions of the National Environmental Policy Act of 1969 (NEPA)²⁹⁰ in Part 1, Subpart I of the Commission's rules.²⁹¹ The Commission's rules provide that, except for a specifically enumerated list of conditions that expressly require the preparation of an environmental assessment (EA), other Commission actions "are deemed individually and cumulatively to have no significant effect on the quality of the human environment and are categorically excluded[.]"²⁹² Under the Commission's rules, the Commission has delegated to its licensees and applicants both the initial assessment of whether a deployment is categorically excluded from further environmental review and the preparation of an EA when required.²⁹³ Applicants must determine whether a proposed action falls under one of the specified categories in the FCC's rules that would require an EA.²⁹⁴ Given that the categories set forth in section 1.1307(a) and (b) of the FCC's rules largely focus on environmental effects

²⁸⁶ See, e.g., Space Exploration Holdings, LLC, Request for Special Temporary Authority, Grant Stamp, IBFS File No. SAT-STA-20190924-00098, Condition 5, Basis for Grant at 3-4 (granted Nov. 7, 2019)

²⁸⁷ See Space Exploration Holdings, LLC., Request for Special Temporary Authority, IBFS File No. SAT-STA-20200610-00071 (filed Jun. 10, 2020); Space Exploration Holdings, LLC., Request for Special Temporary Authority, IBFS File No. SAT-STA-20201218-00147 (filed Dec. 18, 2020.) Both of these STA requests were for authority for 180 days to continue orbit raising Starlink satellites both those previously launched and those to be launched during the 180-day period and to use a higher power of 21 dBm to assist in Earth station acquisition of the satellites. SpaceX has clarified that it is not requesting this higher power in this modification. See SpaceX April 2 Letter at 4.

²⁸⁸ See Spire Comments at 3.

²⁸⁹ See *Orbital Debris R&O and FNPRM*, 33 FCC Rcd at 4256, Appendix A – Final Rules (adopting an application requirement that space station operators make a certification regarding reviewing conjunction warnings, assessing collision risk, and mitigating the collision risk if necessary).

²⁹⁰ National Environmental Policy Act of 1969, as amended, 42 U.S.C. §§ 4321-4335 (NEPA).

²⁹¹ 47 CFR §1.1301.

²⁹² 47 CFR § 1.1306(a).

²⁹³ See 47 CFR § 1.1301, *et seq.*

²⁹⁴ See 47 CFR §§ 1.1306, 1.1307(a), (b).

at the earth's surface, space stations generally have not triggered these categories and therefore have been categorically excluded from review.

73. The Commission's rules also state that even if an action is otherwise categorically excluded, an interested person who alleges that the action will have a significant environmental impact shall submit "a written petition setting forth in detail the reasons justifying or circumstances necessitating environmental consideration in the decision-making process."²⁹⁵ Under that provision, the Bureau responsible for the particular action "shall review the petition and consider the environmental concerns that have been raised" and if the Bureau "determines that the action may have a significant environmental impact," the Bureau will require the applicant to prepare an EA which will serve as the basis for the determination to proceed with or terminate environmental processing.²⁹⁶ The Commission has not typically received petitions raising environmental concerns regarding the licensing of space stations.

74. In response to SpaceX's Third Modification Application, two parties, The Balance Group and Viasat, have raised objections related to the NEPA.²⁹⁷ In May 2020, The Balance Group submitted an Opposition to the SpaceX modification application alleging, among a number of other issues, that a NEPA analysis was required.²⁹⁸ In December 2020, Viasat filed a "Petition Pursuant to Section 1.1307(c) requesting that the Commission require either an Environmental Assessment (EA) or an Environmental Impact Statement (EIS) before acting on SpaceX's application."²⁹⁹ Viasat explained that it was filing this new Petition as a supplement to a Petition to Deny the modification application it filed in July 2020 as a result of other commenters submitting into the record research, studies, and filings that "raised serious environmental concerns relevant to SpaceX's proposed modification."³⁰⁰

75. Consistent with our NEPA framework, we consider the claims raised by The Balance Group and Viasat under section 1.1307(c) of our rules to determine whether the filings have satisfied the requirement to provide "in detail the reasons justifying or circumstances necessitating environmental consideration in the decision-making process" and if so, whether the action may have a significant environmental impact and require preparation of an EA.³⁰¹ We conclude, based on the record before us, that the issues raised in the filings do not warrant preparation of an EA.

76. Taken together, the parties argue that the SpaceX Third Modification implicates five major categories of impacts related to the environment that should be reviewed under NEPA: the impact of launching and deorbiting large numbers of satellites on the composition of the Earth's atmosphere and global climate change, the risk of SpaceX's satellites surviving reentry and causing damage inside Earth's atmosphere, the increased "light pollution" caused by the modified SpaceX constellation, impact on the safety and sustainability of the orbital environment, and the impact of the satellites' radiofrequency emissions.³⁰² Viasat argues that relying on the Commission's categorical exclusions in this instance would violate the requirements of NEPA; endanger the environmental, aesthetic, health, safety, and economic interests NEPA seeks to protect; and harm the public interest.³⁰³ According to Viasat, there is

²⁹⁵ 47 CFR § 1.1307(c).

²⁹⁶ *Id.* Additionally, if the Bureau responsible for processing a particular action, otherwise categorically excluded, determines that the proposal may have a significant environmental impact, the Bureau, on its own motion, shall require the applicant to submit an EA. 47 CFR § 1.1307(d).

²⁹⁷ *See, e.g.*, Viasat NEPA Petition; The Balance Group Opposition at 13.

²⁹⁸ The Balance Group Opposition at 13.

²⁹⁹ *See generally* Viasat NEPA Petition.

³⁰⁰ *Id.* at i.

³⁰¹ 47 CFR § 1.1307(c).

³⁰² *See* Viasat NEPA Petition at ii, 4; Viasat March 16 Letter at 1-4; The Balance Group Opposition at 13, 16, 24.

³⁰³ *See* Viasat NEPA Petition at 4.

no need to demonstrate “extraordinary circumstances” to justify NEPA review, as SpaceX alleges, because NEPA review is required if an action may have a significant environmental impact, and, even if extraordinary circumstances are required, SpaceX is seeking to launch more satellites than have ever been launched before, which is clearly an extraordinary circumstance.³⁰⁴ SpaceX argues, on the other hand, that because the Commission’s rules categorically exclude from review all actions not enumerated in section 1.1307 of the rules, and because Viasat did not allege that this action falls under an enumerated category for which an EA is required, Viasat must demonstrate that extraordinary circumstances exist to require deviating from established categorical exclusions.³⁰⁵

77. As a threshold matter, we note that it is not clear that all of the issues raised by these parties are within the scope of NEPA or related to our action in approving SpaceX’s Third Modification application.³⁰⁶ We further observe that several of the issues presented to the Commission raise novel questions about the scope of NEPA, including whether NEPA covers sunlight as a source of “light pollution” when reflecting on a surface that is in space. We note that NEPA is a procedural statute intended to ensure that Federal agencies consider the environmental impacts of their actions in the decision-making process.³⁰⁷ We find that we do not need to evaluate and determine whether NEPA applies to the novel issues raised by Viasat and The Balance Group in order to act on SpaceX’s application. Instead, for purposes of our analysis, and out of an abundance of caution, we will assume that NEPA may apply and consider the concerns raised in the record before us under the standard set forth in section 1.1307(c) of our rules. As explained in detail below, based on the record, we do not find that there is a need for SpaceX to prepare an EA on the issues raised in the record.³⁰⁸ In certain instances, we also discuss how the Commission’s responsibilities under the Communications Act, separate from the Commission’s responsibilities under NEPA, address the concerns raised by Viasat and The Balance Group.

78. *Scope of NEPA with respect to “Commission Action.”* In addition to disputes on whether our actions in this proceeding trigger an EA, Viasat and SpaceX disagree on how to determine what Commission action or actions should be subject to any NEPA analysis in this proceeding. The parties disagree on whether all of the satellites that SpaceX has “proposed launching,”³⁰⁹ including every satellite that was a subject to the Commission’s previous authorizations or any satellite application that is new, on file currently, and pending with the Commission, must be taken into consideration in a NEPA analysis.³¹⁰

³⁰⁴ See Viasat NEPA Reply at 13, 17-19; Viasat February 18 Response to SpaceX at 7-8 (quoting CEQ rules at 40 CFR § 1501.4(b)).

³⁰⁵ See SpaceX Opposition to Viasat NEPA Petition at 6-7 (citing 47 C.F.R. §§ 1.1306, 1.1307); SpaceX NEPA Response at 6 (citing 47 CFR §§ 1.1306, 1.1307(a)-(b)).

³⁰⁶ SpaceX, for example, argues that Congress did not intend that NEPA be applied in space. SpaceX March 11 Ex Parte at 1 (citing 42 U.S.C. § 4321; *Metro. Edison Co. v. People Against Nuclear Energy*, 460 U.S. 766 (1983)); see also SpaceX April 2 Ex Parte at 5 (arguing that NEPA does not apply to outer space generally or to SpaceX’s safety upgrade specifically).

³⁰⁷ The Supreme Court has made clear that NEPA is a procedural statute that does not mandate particular results; “[r]ather, NEPA imposes only procedural requirements on [F]ederal agencies with a particular focus on requiring agencies to undertake analyses of the environmental impact of their proposals and actions.” See *Pub. Citizen*, 541 U.S. at 756–57 (citing *Methow Valley*, 490 U.S. at 349–50); *Vt. Yankee*, 435 U.S. at 558 (“NEPA does set forth significant substantive goals for the Nation, but its mandate to the agencies is essentially procedural.”). See also <https://www.govinfo.gov/content/pkg/FR-2020-07-16/pdf/2020-15179.pdf>.

³⁰⁸ 47 CFR § 1.1307(c). We decline to reach the issue, disputed by the parties, of whether there must be “extraordinary circumstances” shown to override the categorical exclusion. Instead, we consider this matter under the framework outlined in Section 1.1307(c) of our rules. *Id.*

³⁰⁹ See Viasat NEPA Petition at 12. We note that although the Commission authorizes deployment and operation of space stations, the FAA is the agency authorized to issue launch licenses.

³¹⁰ See, e.g., Viasat NEPA Petition at 12-13; SpaceX Opposition to Viasat NEPA Petition at 10-11.

Specifically, Viasat argues that the SpaceX Third Modification Application cannot be considered “in isolation” because SpaceX has authorization for about 12,000 satellites already and has also requested authorization for a second generation constellation of 30,000 satellites.³¹¹ Viasat argues that NEPA requires connected actions, actions that are interdependent parts of a larger action and depend on the larger action for their justification, to be examined together.³¹² Viasat claims that the SpaceX constellation is interconnected under the CEQ regulations because “these satellites would be operated by the same party (SpaceX), support the provision of the same broadband services, contribute to the same pool of available capacity to support those services, and utilize common network infrastructure.”³¹³ SpaceX argues, on the other hand, that the Commission need not consider its existing authorization for a separate NGSO satellite system that would operate in the V-band, or its pending application for a new NGSO constellation, in the context of our review of the Third Modification application.³¹⁴ Our action on this modification request will not affect SpaceX’s V-band authorization, which is separately conditioned on the Commission granting a modification of that space station grant to include a final orbital debris mitigation plan.³¹⁵ Moreover, we are not taking action through this modification on the separate request by SpaceX for authorization of a separate NGSO system.³¹⁶ We do not speculate how we may act with respect to those potential future actions, but rather, consistent with section 1.1307(c), consider whether the “particular action” at issue, the instant modification request, should be subject to an EA.³¹⁷

79. SpaceX also argues that its existing authorization for its Ku- and Ka-band system establishes the baseline for considering the potential environmental impact of its third modification.³¹⁸ Viasat argues, on the other hand, that at present SpaceX is not permitted to deploy its 2,814 satellites because of a condition on its authorization requiring approval of a modification with an updated orbital debris showing.³¹⁹ According to Viasat, the question is not whether the SpaceX modification will improve the environmental effects of its constellation from its original authorization, but whether deployment of these satellites, plus replacements, will have a significant environmental impact.³²⁰ We agree with Viasat that, absent Commission action on the instant modification, SpaceX would not be fully authorized to deploy the remainder of the satellites in its Ku-/Ka-band constellation not addressed by previous modification requests.³²¹ We therefore do not use as a baseline the deployment of a sub-set of

³¹¹ Viasat states that the 4,408 satellites addressed in this authorization are just the initial phase of a larger constellation that will contain 42,000 satellites, meaning SpaceX will be launching and deorbiting over 100,000 satellites over the next fifteen years. See Viasat NEPA Petition at 12-13; Viasat NEPA Reply at 5, 10-11, 13-15; Viasat February 18 Response to SpaceX at 8-12.

³¹² See Viasat NEPA Reply at 10 (citing 40 CFR § 1501.9(e)(1)); Viasat February 18 Response to SpaceX at 8-12.

³¹³ See Viasat February 18 Response to SpaceX at 10.

³¹⁴ SpaceX Opposition to Viasat’s NEPA Petition at 10; see *Space Exploration Holdings, LLC, Application for Approval for Orbital Deployment and Operating Authority for the SpaceX V-band NGSO Satellite System*, Memorandum Opinion, Order and Authorization, 33 FCC Rcd 11434 (2018) (*SpaceX V-band Authorization*); Space Exploration Holdings Application for Approval for Orbital Deployment and Operating Authority for the SpaceX Gen2 NGSO Satellite System, IBFS File No. SAT-LOA-20200526-00055 (filed May 26, 2020).

³¹⁵ See *SpaceX V-band Authorization*, 33 FCC Rcd at 11440-41, 11447, paras. 16, 32.o.

³¹⁶ This application, which seeks authorization of a SpaceX “Gen2” NGSO satellite system that would operate in the fixed-satellite service using Ku-, Ka-, and E-band frequencies, has not yet been accepted for filing. See IBFS File No. SAT-LOA-20200526-00055.

³¹⁷ 47 CFR § 1.1307(c).

³¹⁸ See SpaceX Opposition to Viasat’s NEPA Petition at 10; SpaceX March 11 Response to Viasat at 1-2.

³¹⁹ See Viasat NEPA Reply at 5-8; Viasat February 18 Response to SpaceX at 3-4.

³²⁰ See Viasat NEPA Reply at I-I, 5-9; Viasat February 18 Response to SpaceX at 3-5.

³²¹ This includes replacement satellites deployed over the course of the 15-year license term.

SpaceX's satellites at the previously anticipated higher orbital altitude, but instead consider the concerns raised by Viasat and The Balance Group in the context of the deployment of the remainder of the SpaceX satellites addressed in the instant modification, as detailed in the paragraphs below.

2. Potential Effect on Earth's Atmosphere from Satellite Launch and Reentry

80. Viasat raises a number of arguments regarding environmental risks that may be posed by thousands of satellites being launched and then reentering the atmosphere over a short period of time.³²² In particular, Viasat argues that the launch and reentry of so many satellites could release dangerous chemical compounds into the atmosphere that could deplete the ozone layer.³²³ According to Viasat, the number of satellite launches required by the proposed modification will affect the chemical composition of the atmosphere because rockets emit ozone-depleting chemicals.³²⁴ Furthermore, Viasat alleges, when satellites constructed from aluminum, like the Starlink satellites, burn up in the atmosphere, the aluminum becomes alumina, which also contributes to global climate change.³²⁵ Viasat argues that NEPA requires the Commission to conduct further research on the effects of alumina, along with other complex chemical compounds possibly emitted into the atmosphere upon satellite reentry.³²⁶ SpaceX argues generally that its modification request will have no impact on the number of launches or deorbiting satellites planned for its constellation and that its launches as well as its satellites burning up in the atmosphere upon reentry will have no significant effect on the atmospheric environment.³²⁷ With respect to chemical material released from re-entering satellites, SpaceX and Viasat disagree about the amount of alumina that SpaceX's satellites could produce in the atmosphere.³²⁸

81. As to the effect on the atmosphere from satellite launches, SpaceX states that the Federal Aviation Administration (FAA) and NASA found "No Significant Impact" for SpaceX Falcon Launches, including in the FAA's July 2020 Environmental Assessment which undertook an evaluation of SpaceX's proposed increase in launch and reentry rates, including for launches scheduled through 2025.³²⁹ SpaceX

³²² Consistent with some of its arguments raised in the context of orbital debris mitigation, Viasat accuses SpaceX of selecting a strategy of satellite disposability and replaceability over reliability and safety. See Viasat NEPA Petition at II, 4, 8, 9-13, 15-16; Viasat NEPA Reply at 20-21; Viasat February 8 Ex Parte at 6, 21; Viasat February 8 Ex Parte at 32-34; Viasat February 12 Ex Parte at 6, 21, 32-34. Viasat argues this accelerated deorbit will increase the number of satellites being launched and deorbited, so that SpaceX will have to launch a greater number of satellites over the 15-year license period to maintain its constellation. See Viasat NEPA Petition at II, 4, 8, 9-13, 15-16; Viasat NEPA Reply at 20-21; Viasat February 8 Ex Parte at 32-34; Viasat February 12 Ex Parte at 32-34.

³²³ See Viasat NEPA Petition at II, 4, 8, 9-13, 15-16; Viasat NEPA Reply at 20-21; Viasat February 8 Ex Parte at 32-34; Viasat February 12 Ex Parte at 32-34; Viasat April 16 Letter at 6.

³²⁴ See Viasat NEPA Petition at 10-11 (citing Martin Ross et al., Limits on the Space Launch Market Related to Stratospheric Ozone Depletion, 7 *Astropolitics* 50, 52 (2009); Viasat NEPA Reply at 20-22; Viasat February 8 Ex Parte at 32-34; Viasat February 12 Ex Parte at 32-34.

³²⁵ See Viasat NEPA Petition at 11-12 (citing Martin N. Ross & Patti M. Sheaffer, *Radiation Forcing Caused by Rocket Engine Emissions*, 2 *Earth's Future* 177, 193 (2014)); Viasat NEPA Reply at 20-22; Viasat February 8 Ex Parte at 32-34; Viasat February 12 Ex Parte at 32-34.

³²⁶ See Viasat NEPA Petition at 12-13 (citing Martin N. Ross & Leonard David, *An Underappreciated Danger of the New Space Age: Global Air Pollution*, *Sci. Am.* (Nov. 6, 2020), <http://www.scientificamerican.com/article/an-underappreciated-danger-of-the-new-space-age-global-air-pollution/>); Viasat February 8 Ex Parte at 32-34; Viasat February 12 Ex Parte at 32-34.

³²⁷ See SpaceX Opposition to Viasat's NEPA Petition at I, IV-V, 2, 18-20; SpaceX March 11 Response to Viasat at 2; SpaceX April 2 Ex Parte.

³²⁸ SpaceX April 2 Ex Parte at 5; Viasat April 16 Letter at 7.

³²⁹ SpaceX April 2 Ex Parte at 5-6, Attach. at 5 (citing FAA's "Final Environmental Assessment and Finding of No Significant Impact for SpaceX Falcon Launches at Kennedy Space Center and Cape Canaveral Air Force Station", July 2020,

(continued....)

further argues that an assessment of launch operations at Kennedy Space Center indicates that the SpaceX Falcon 9 launch vehicle does not emit any aluminum oxide whatsoever.³³⁰

82. As discussed above, the fact that the SpaceX Third Modification is not equivalent to a request for initial authorization for 2,814 satellites does not preclude an examination of whether the SpaceX deployment may have a significant environmental impact under NEPA. Therefore, we are not persuaded by SpaceX's argument that the modification will not affect the chemicals entering the atmosphere either as part of launch or satellite reentry. We do not, however, find at this time that the record supports requiring SpaceX to prepare an EA. First, with respect to launch activities, the FAA has prepared its own EA on the SpaceX launches, and pursuant to our rules,³³¹ no additional consideration of potential impacts associated with those launches is required.³³² With respect to materials accumulating in the atmosphere as a result of satellite reentry, we find that the allegations Viasat makes in its petition are insufficient for us to determine that additional environmental consideration is necessary under our rules or that granting the SpaceX modification application may have a significant environmental impact on the atmosphere or ozone layer. Additionally, we find that Viasat's arguments regarding "unknowns about other complex chemical compounds" are too vague to warrant further consideration under section 1.1307(c) of our rules.³³³

83. Distinct from the NEPA issues, we also note that, in the context of our orbital debris proceeding, the Commission found that for NGSO satellites, leaving a satellite in orbit as debris at the end of that satellite's lifetime is generally associated with increased risk to future space operations.³³⁴ Where satellites are disposed of by atmospheric re-entry, but some materials do not burn up when reentering the

(Continued from previous page)

https://www.faa.gov/space/environmental/nepa_docs/media/SpaceX_Falcon_Program_Final_EA_and_FONSI.pdf; "Final Environmental Assessment for Space Exploration Technologies Operations Area on Kennedy Space Center", Oct. 2018, https://netpublic.grc.nasa.gov/main/FINAL_%20SpaceX_EA_Roberts%20Rd_10-2-18.pdf; NASA NEPA Finding, Dec. 2018 <https://netpublic.grc.nasa.gov/main/FONSI%20for%20EA%20for%20Space%20Exploration%20Technologies%20Operations%20Area%20KSC--originalsigned.pdf>).

³³⁰ SpaceX April 2 Ex Parte at 6.

³³¹ See 47 CFR § 1.1311(e) ("An EA need not be submitted to the Commission if another agency of the Federal Government has assumed responsibility for determining whether [] the facilities in question will have a significant effect on the quality of the human environment....").

³³² <https://www.faa.gov/space/licenses/>. See also 51 U.S.C. § 50901 et seq. (providing that the Secretary of Transportation is to oversee and coordinate the conduct of commercial launch and reentry operations, issue permits and commercial licenses and transfer commercial licenses authorizing those operations, and protect the public health and safety, safety of property, and national security and foreign policy interests of the United States); 14 CFR § 415.53 (stating that the FAA does not review "payloads" that are subject to regulation by the FCC or the Department of Commerce, National Oceanic and Atmospheric Administration (NOAA); or owned or operated by the U.S. Government)

³³³ While we construe these arguments generously for purposes of NEPA analysis, our rules do require that the petition must set forth "in detail the reasons justifying or circumstances necessitating environmental consideration in the decision-making process." 47 CFR § 1.1307(c).

³³⁴ See *supra* paras. 53-68 (orbital debris discussion); *Orbital Debris R&O and FNPRM*, 35 FCC Red at 4198, para. 87 ("Spacecraft that are unable to complete post-mission disposal, particularly when left at higher altitudes where they may persist indefinitely, will contribute to increased congestion in the space environment over the long-term and increase risks to future space operations").

atmosphere, surviving debris can cause harm to human life and property on Earth.³³⁵ As discussed in greater detail above, SpaceX has demonstrated compliance with the orbital debris rules.³³⁶

3. Satellite Debris Surviving Reentry

84. We next address Viasat's arguments regarding satellite debris that survives atmospheric reentry. Viasat states that "as a general matter" 10 to 40% of a satellite's mass does not burn up on reentry and could reach the Earth's surface.³³⁷ While this statement may be true in discussing satellite design generally, the record establishes it is not accurate for SpaceX's satellites. Viasat alleges that the reentry of the SpaceX Starlink satellites risks surviving debris potentially injuring humans, damaging buildings or aircraft, polluting the landscape, or causing fires in the wilderness.³³⁸ We point out that the Commission already evaluates risk of human casualty from debris surviving re-entry as part of its analysis of an applicant's orbital debris mitigation plans. This analysis typically takes into consideration factors identified using an assessment software developed by NASA and used for evaluating NASA missions. Those factors include the materials composition of the satellite (i.e., what materials are likely to survive reentry), as well as the impacting kinetic energy with which any surviving materials would reach the Earth's surface, among other things.³³⁹ In connection with its orbital debris mitigation demonstration, SpaceX states that its satellites will be fully demisable. In this context, that means that the calculated risk of human casualty from materials reaching the Earth's surface is roughly zero. Viasat argues the Commission cannot take SpaceX's assertion of demisability at face value and must conduct a "hard look" under NEPA.³⁴⁰ SpaceX replies that it has designed its satellites to be fully demisable upon reentry and that this is not merely an assertion, as Viasat claims, since SpaceX has validated its conclusion with a Commission-mandated analysis using software purpose-built by NASA.³⁴¹

85. SpaceX's statement that its satellites are designed to demise upon reentry into Earth's atmosphere is sufficiently supported by the record before us. In its First Modification application, SpaceX submitted technical information concerning the demisability of its satellites, which the Bureau addressed. Because the Bureau previously assessed the casualty risk associated with the SpaceX satellites and there is no material difference between those satellites and the ones under consideration here, we find that Viasat's general assertions do not provide a justification for further environmental review of this issue. We also find that Viasat's general assertions about potential effects to aircraft provide insufficient detail to justify environmental consideration of this issue through an EA.

4. Potential Impact on the Night Sky and Astronomy

86. We address Viasat's arguments that light pollution caused by large satellite constellations

³³⁵ See *infra* paras. 84-85; see also, e.g., https://www.unoosa.org/pdf/publications/st_space_49E.pdf.

³³⁶ See 47 CFR § 25.111(d)(14); Mitigation of Orbital Debris in the New Space Age, Report and Order and Further Notice of Proposed Rulemaking, 35 FCC Rcd 4156 (2020) (*Orbital Debris Order and FNPRM*).

³³⁷ Viasat NEPA Petition at 13.

³³⁸ See *id.* at 13-16; Viasat NEPA Reply at 26-27; Viasat February 8 Ex Parte at 32-34; Viasat February 12 Ex Parte at 32-34.

³³⁹ See, e.g., *Orbital Debris R&O & FNPRM*, 35 FCC Rcd 4156, 4212, para. 117 (adopting the 15 joule metric into the Commission's rules).

³⁴⁰ See Viasat NEPA Petition at 15-16 (citing William M. Wiltshire, Counsel, Space Exploration Holdings, LLC., to Jose P. Albuquerque, Chief, Satellite Division, IBFS File No. SAT-MOD-20181108-00083, at 3 (filed Mar. 13, 2019)); Viasat NEPA Reply at 26-27; Viasat February 8 Ex Parte at 21, 32-34; Viasat February 12 Ex Parte at 21, 32-34.

³⁴¹ See SpaceX Opposition to Viasat's NEPA Petition at V, 20-21; SpaceX January 22 Ex Parte, Attachment A at 4; SpaceX March 11 Response to Viasat at 2.

will have aesthetic, scientific, cultural, social, and health effects.³⁴² The Balance Group also argues that the Commission must perform a review under NEPA to assess the light pollution effects the Starlink system will have on humans, flora, fauna, and animal migration.³⁴³ Viasat notes that light pollution from satellite constellations like Starlink can affect casual stargazers, astrophotographers, and professional astronomers alike,³⁴⁴ that the night sky also has religious and cultural significant meaning for many groups, and that light pollution is also known to cause health problems.³⁴⁵ According to Viasat, the sheer number of satellites in the Starlink constellation, coupled with their operating altitude, will cause those satellites to have a serious impact on astronomy and stargazing.³⁴⁶ SpaceX responds that it has been working with astronomers and that its modification will in fact lessen the effect its constellation will have on the night sky.³⁴⁷ SpaceX argues that lowering the altitude of the SpaceX satellites to below 600 km will significantly reduce the amount of time those satellites reflect sunlight during the night, thereby lessening their impact on astronomy.³⁴⁸ Additionally, SpaceX states that it has been taking measures to darken its satellites, including testing an experimental darkening treatment on one satellite, launching satellites with visors to protect reflective surfaces from the sun's glare, and devising methods to keep satellites oriented to reduce reflectivity.³⁴⁹ According to SpaceX, these methods are making satellites "all but invisible" to the naked eye, thereby mitigating Viasat's concerns about aesthetic effects, for example.³⁵⁰ SpaceX describes this as an iterative process, as a technical challenge, and states that it has been working in close collaboration with the astronomy community.³⁵¹ Finally, SpaceX notes that it makes detailed tracking information available to astronomers so they can avoid its satellites.³⁵² On the

³⁴² See Viasat NEPA Petition at 16; Viasat NEPA Reply at 27-30, 33; Viasat February 8 Ex Parte at 34-35; Viasat February 12 Ex Parte at 34-35.

³⁴³ See The Balance Group Opposition at 10-14.

³⁴⁴ See Viasat NEPA Petition at 16-18; Viasat NEPA Reply at 27-30; Viasat February 8 Ex Parte at 34-35; Viasat February 12 Ex Parte at 34-35.

³⁴⁵ Viasat states that various scientific and astronomy organizations have expressed concerns about light pollution caused by large satellite constellations like Starlink. See, e.g., Viasat NEPA Petition at 18-19 (citing Fabio Falchi et al., *Limiting the Impact of Light Pollution on Human Health, Environment and Stellar Visibility*, 10 J. Env't Mgmt. 2714 (2011); Ron Chepesiuk, *Missing the Dark: Health Effects of Light Pollution*, 117 Env't Health Persps. 20 (2009); Viasat NEPA Reply at 27-30; Viasat February 8 Ex Parte at 34-35; Viasat February 12 Ex Parte at 34-35. Viasat cites to a report warning astronomers to expect significant light pollution interference from satellites in the Starlink constellation orbiting below 614 km. See Viasat NEPA Petition at 19 (citing Constance Walker et al., *Impact of Satellite Constellations on Optical Astronomy and Recommendations Toward Mitigation*, at 3 (2020)); see also Viasat NEPA Reply at 27-30; Viasat February 8 Ex Parte at 34-35; Viasat February 12 Ex Parte at 34-35.

³⁴⁶ See Viasat NEPA Petition at 19-20; Viasat NEPA Reply at 27-30; Viasat February 8 Ex Parte at 34-35; Viasat February 12 Ex Parte at 34-35.

³⁴⁷ See SpaceX Opposition to Viasat's NEPA Petition at I, III, 2, 11-14.

³⁴⁸ See *id.* at I, III, 12-13, 14. SpaceX points out that the very report Viasat cites in support of its claims recommends operators of Large NGSO constellations fly their satellites at altitudes below 600 km for this reason. See *id.* at III, 12-13, 14 (citing Constance Walker et al., *Impact of Satellite Constellations on Optical Astronomy and Recommendations Toward Mitigation*, at 3 (2020)).

³⁴⁹ See *id.* at 11.

³⁵⁰ See *id.* at 11, 14-15.

³⁵¹ See SpaceX April 2 Ex Parte at 4. SpaceX notes that it has established in conjunction with members of the astronomy community – a target of 7th apparent magnitude for an acceptable brightness impact. *Id.*, Attach at 3. SpaceX states that while it has not achieved this ultimate 7th apparent magnitude value goal yet, it has made significant progress toward this goal, diminishing the average brightness of its satellites from 4.99 apparent magnitude to 6.48 apparent magnitude. The higher apparent magnitude values represent objects appearing dimmer.

³⁵² See SpaceX Opposition to Viasat NEPA Petition at 11.

whole, SpaceX argues, its modification will make its satellites less visible both to astronomers and to the general public. In a separate filing, the American Astronomical Society agrees satellites at lower altitudes are preferable to satellites at higher altitudes.³⁵³ According to the American Astronomical Society, by reducing the altitude of its satellites, along with other measures to lower the apparent brightness of its satellites, SpaceX is in fact mitigating the effects of its constellation on visual astronomy.³⁵⁴ Viasat argues that even if light pollution can be mitigated at lower altitudes, the modification would give SpaceX authority to deploy nearly 3,000 satellites into low-earth orbit that it currently does not have authority to deploy, and the increase in the number of satellites will undoubtedly increase the concerns with respect to light pollution, especially because satellites appear brighter at lower altitudes during astronomical twilight.³⁵⁵ Viasat argues that fewer satellites in the sky is a better mitigation technique for light pollution than a lower altitude.³⁵⁶ And, Viasat alleges that SpaceX's attempts to mitigate light pollution, such as its satellite darkening treatment, have been unsuccessful.³⁵⁷

87. After considering the record and claims by Viasat and The Balance Group, we conclude that the issues raised do not justify the need for an EA. With respect to Viasat and The Balance Group's arguments related to possible effects to astronomy, we note that we have a robust record on these issues, including from the American Astronomical Society,³⁵⁸ and find that the record does not support the need to prepare an EA. We take note of SpaceX's representation that it has diminished the average brightness of its satellites from a 4.99 apparent magnitude to a 6.48 apparent magnitude and made commitments to the astronomy community regarding further reduction in the visibility of its satellites. We also take note of SpaceX's representation that its efforts to reduce satellite reflectivity not only would benefit communities of astronomers, but also will, reduce brightness of the Starlink satellites to a naked eye observer.³⁵⁹ We recognize that while SpaceX is still testing some of these solutions, SpaceX must continue its efforts to fulfill its commitments to the astronomy community. Although we do not find that the record before us merits preparation of an EA under NEPA, we conclude that it nonetheless would serve the public interest under the Communications Act for SpaceX to ensure that it does not unduly burden astronomy and other research endeavors.³⁶⁰ Accordingly, we will continue to monitor this situation and SpaceX's efforts to achieve its commitments in this record. With respect to other claims related to potential impact on the night sky, including alleged impacts to human health, flora, fauna, and animal migration, we find that the Viasat and the Balance Group have failed to set forth in detail reasons justifying or circumstances necessitating environmental consideration of these issues.³⁶¹

88. Viasat also argues SpaceX has not addressed the impact its satellites would have on radioastronomy, and thus the constellation will cause environmental impacts by hampering scientific

³⁵³ See American Astronomical Society Reply at 1 (citing Constance Walker et al., *Impact of Satellite Constellations on Optical Astronomy and Recommendations Toward Mitigation*, at 3 (2020)) (stating that satellites orbiting at or below 600 km do appear brighter than satellites at higher altitudes, but they are in sunlight for less of the night, which is "one of the leading benefits to science.")

³⁵⁴ See *id.* at 1.

³⁵⁵ See Viasat NEPA Reply at 27-30; 32-35; Viasat February 8 Ex Parte at 34-35; Viasat February 12 Ex Parte at 34-35.

³⁵⁶ See Viasat NEPA Reply at 27-30; Viasat February 8 Ex Parte at 34-35; Viasat February 12 Ex Parte at 34-35.

³⁵⁷ See Viasat NEPA Reply at 33-34; Viasat February 8 Ex Parte at 32, 34-35; Viasat February 12 Ex Parte at 32, 34-35; Viasat April 16 Letter at 4-5.

³⁵⁸ See generally American Astronomical Society Reply.

³⁵⁹ SpaceX April 2 Ex Parte at 4.

³⁶⁰ See, e.g., 42 U.S.C. § 4332 (directing federal agencies to "interpret[] and administer[]" their organic statutes "in accordance" with NEPA's environmental protection policies).

³⁶¹ See 47 CFR § 1.1307(c).

advancements.³⁶² The Balance Group notes that SpaceX has not provided peer-reviewed studies and written declarations from impacted federal, state, international, and independent astronomy facilities to show there will not be damage to those facilities caused by the SpaceX constellation as currently authorized and as modified.³⁶³ SpaceX notes in its reply to The Balance Group that the Commission has adopted several footnotes to the United States Table of Frequency Allocations to protect the radio astronomy service, many of these footnotes developed by the ITU.³⁶⁴ Compliance with the requirement to protect the radio astronomy service is a condition for all space station authorizations utilizing the relevant spectrum bands.³⁶⁵ SpaceX states that it completed coordination over a year ago to ensure protection of the radio astronomy service.³⁶⁶ As to the Radio Astronomy Service, SpaceX is correct that its authorization is conditioned to require it to protect the Radio Astronomy Service, and SpaceX did complete coordination to ensure that protection. Neither Viasat nor The Balance Group have provided a basis to call into question the validity of that coordination or SpaceX's ability to protect the Radio Astronomy Service, and have not raised environmental concerns with respect to this issue that would warrant requiring preparation of an EA.

5. Satellite Collisions in Space

89. We next address Viasat's argument that increasing the density of satellites in the 540-570 km orbital shell will increase the risk of collisions and thus increase the amount of orbital debris, potentially making this area of space unviable, as discussed above.³⁶⁷ Viasat argues that orbital debris considerations fall under the ambit of NEPA because it affects the human environment by (1) causing severe ecological harm to the near-Earth orbital environment, the ecosystem in question, because orbital debris interferes with humanity's ability to explore and develop space and (2) orbital debris may cause severe economic harm by increasing the probability of damage to existing satellites and other space vehicles.³⁶⁸ SpaceX argues in response, that among other things, the Commission already has an orbital debris mitigation regime to review satellite applications, and environmental review of orbital debris under NEPA would be unnecessary and redundant.³⁶⁹ Viasat alleges that reviewing an applicant's orbital debris mitigation plan does not discharge its duties under NEPA.³⁷⁰ Without deciding whether such alleged impacts in space are even within the scope of NEPA (which applies to effects on the quality of the human environment), we find that Viasat's arguments about these issues have failed to set forth in detail reasons justifying or circumstances necessitating environmental consideration of these issues under section 1.1307(c) of our rules.³⁷¹ Separate from the NEPA issues, we note, as discussed above, that we have reviewed SpaceX's orbital debris mitigation plan, and conclude that, as conditioned, SpaceX's debris

³⁶² See Viasat NEPA Reply at 30-32 (citing Constance Walker et al., *Dark and Quiet Skies for Science and Society: Report and Recommendations* 160-81 (2020)); Viasat February 8 Ex Parte at 34-35; Viasat February 12 Ex Parte at 34-35; Viasat April 16 Letter at 5-6.

³⁶³ See The Balance Group Opposition at 20.

³⁶⁴ See SpaceX Reply to The Balance Group at 4.

³⁶⁵ See *id.*

³⁶⁶ See *id.* (citing Press Statement 19-005, "Statement on NSF and SpaceX Radio Spectrum Coordination Agreement," NATIONAL SCIENCE FOUNDATION (June 4, 2019), https://www.nsf.gov/news/news_sum.jsp?cntn_id=298678).

³⁶⁷ See Viasat NEPA Petition at III, 4, 9, 21-26; Viasat NEPA Reply at 35-39; Viasat February 8 Ex Parte at 6, 21, 36-37; Viasat February 12 Ex Parte at 6, 21, 36-37.

³⁶⁸ See Viasat NEPA Petition at 21-24; Viasat February 8 Ex Parte at 36-37; Viasat February 12 Ex Parte at 36-37.

³⁶⁹ See SpaceX Opposition to Viasat's NEPA Petition at 17-18.

³⁷⁰ See Viasat NEPA Reply at 38-39; Viasat February 8 Ex Parte at 36-37; Viasat February 12 Ex Parte at 36-37.

³⁷¹ See 47 CFR § 1.1307(c); 42 U.S.C. § 4332(C).

mitigation plan is consistent with the public interest.

6. Radiofrequency Emissions

90. Finally, The Balance Group argues that the SpaceX Third Modification application is missing information on peer-reviewed studies assessing radiofrequency exposure caused by the SpaceX constellation,³⁷² and asks what impact the radiofrequency exposure caused by SpaceX's constellation will have on humans, flora, and fauna as assessed by expert agencies.³⁷³ The Balance Group asks whether SpaceX has accounted for the differences in people, both in varying desire for additional connectivity and varying tolerances for light pollution and radiofrequency exposure.³⁷⁴ In response to these concerns, SpaceX points out that the Commission completed a review of its radiofrequency exposure rules in November 2019.³⁷⁵ SpaceX also states that it complies with the Commission's radiofrequency exposure rules.³⁷⁶ In its reply, The Balance Group suggests that the November 2019 radiofrequency exposure rules are under review and may not survive as they are currently structured,³⁷⁷ and states that SpaceX has failed to provide a radiation hazard report for its modification application or authorizations.³⁷⁸

91. A proposed project would require preparation of an EA if it "would cause human exposure to levels of radiofrequency radiation in excess of the limits" in the Commission's radiofrequency rules.³⁷⁹ The record in this matter fails to allege that the SpaceX modification would result in human exposure to radiofrequency emissions that would exceed the limits in the Commission's rules. SpaceX further confirms its compliance with our radiofrequency exposure rules. Therefore, no additional environmental consideration of radiofrequency exposure issues is required.

92. In sum, with respect to NEPA, we conclude that the record before us does not support a need for further environmental review. Accordingly, Viasat's Petition Pursuant to Section 1.1307 and the Opposition and Motions of the Balance Group are denied to the extent that they raise any NEPA related issues.

F. Other Matters

93. In addition to those matters addressed above, The Balance Group raises a number of additional concerns with respect to both the SpaceX Third Modification Application and the SpaceX system as a whole.³⁸⁰ These concerns are either already addressed in analysis of the application, are more appropriately addressed as part of rulemaking proceedings, or are otherwise beyond the scope of this modification proceeding. For example, a number of The Balance Group arguments, to the extent that they do not overlap with issues addressed above, appear to raise general concerns about the Commission's process for evaluation of satellite applications, beyond the specific license modification request we address here.³⁸¹ We note that the Regulatory Flexibility Act, cited by The Balance Group, does not apply

³⁷² See The Balance Group Opposition at 18.

³⁷³ See *id.* at 18-19. The Balance Group also expresses concerns about the lack of peer-reviewed studies from federal agencies assessing the effects of the radiofrequency exposure on food production. *Id.*

³⁷⁴ See *id.* at 21.

³⁷⁵ See SpaceX Reply to The Balance Group at 4 (citing *Proposed Changes in the Commission's Rules Regarding Human Exposure to Radiofrequency Electromagnetic Fields*, 34 FCC Rcd 11687 (2019)).

³⁷⁶ See *id.*

³⁷⁷ See The Balance Group June 16 Reply to SpaceX at 20.

³⁷⁸ See *id.*

³⁷⁹ 47 CFR § 1.1307(b).

³⁸⁰ See generally The Balance Group Opposition.

³⁸¹ See The Balance Group Opposition at 13 (stating that "[t]he FCC holds requirements under the [APA], [NEPA], Radiation Hazard Report (RHR) obligations, Regulatory Flexibility Act (RFA), Secure 5G and Beyond Act, the (continued....)

to this proceeding as we are not adopting regulations.³⁸² Other issues raised by the Balance Group, for example, such as those regarding insurance and indemnification, are addressed as part of our ongoing proceeding on orbital debris mitigation.³⁸³ All of SpaceX's authorizations, including this grant of the SpaceX Third Modification Application, are conditioned on SpaceX complying with the outcome of future Commission rulemakings.

G. Petition for Reconsideration of Partial Grant

94. On February 8, 2021, Viasat filed a petition for reconsideration of the Bureau Order authorizing SpaceX to deploy and operate ten additional satellites at a nominal altitude of 560 km, while otherwise deferring consideration of SpaceX's broader application.³⁸⁴ The Bureau has referred this Petition to the Commission for consideration.³⁸⁵ Despite these ten satellites having already been launched, Viasat reiterates four of its arguments regarding SpaceX's constellation as modified: the reliability of SpaceX's satellites; the medium and long-term effects of SpaceX's alleged space safety failures; the Bureau Order's improper assessment of the relationship between satellite altitude and safety; and failure of the Bureau Order to evaluate the effects of SpaceX's system on systems other than Kuiper's, either above or below 580 km.³⁸⁶ Viasat suggests the Bureau acknowledge these errors and ensure that they are rectified going forward.³⁸⁷ Viasat recognizes that the ten satellites covered by the partial grant have already been launched, but observes that the reasoning expressed in the Order, if not addressed, may become improperly invoked as Commission policy in the future.³⁸⁸ Viasat argues that the Order not only grants authority for SpaceX to deploy ten satellites, but in fact grants SpaceX authority to deploy and operate its entire constellation consisting of 1,594 satellites at approximately 520-580 km, taking into account orbital tolerances, and an unlimited number of identical replacement satellites, and that the Order should have evaluated whether allowing all of those satellites to collectively operate in overlapping orbits will be in the public interest, taking into account SpaceX's experiential failure rate. Viasat further argues that this grant will encourage other operators to artificially segment their systems for purposes of application processing, and encourage them to seek "partial" grants of those segments without having the Commission ask the broader question of whether an authorized system as a whole creates significant risk that endangers the public interest.³⁸⁹

95. As discussed above, SpaceX's operations at lower altitudes and significant maneuverability should result in lower collision risk and an improved orbital debris environment. The Bureau also considered other systems besides Kuiper in making its determination in the Ten-Satellite Partial Grant. The Bureau specifically addressed Kepler's concerns regarding overlap with its system,³⁹⁰

(Continued from previous page) _____
Constitution and Convention of the [ITU], and other similarly situated cross-agency and cross-government obligations, to conduct a detailed review of a modification request that is this massive in scope."'). In a letter filed on April 21, 2021, Professor Andrew Lawrence also raised some additional generalized concerns, including some regarding broader international space law and infrastructure policy. *See generally* Andrew Lawrence Letter. These concerns are similarly beyond the scope of this proceeding.

³⁸² See Regulatory Flexibility Act of 1980, as amended, 5 U.S.C. § 601 *et seq.*

³⁸³ See *Orbital Debris R&O and FNPRM*, 35 FCC Red at 4237-4245, paras. 176 -192.

³⁸⁴ Viasat Recon Petition.

³⁸⁵ 47 CFR § 1.106(a)(1).

³⁸⁶ See Viasat Recon Petition at 2-16; Viasat Recon Reply at 7-8, 10.

³⁸⁷ See Viasat Recon Petition at 2.

³⁸⁸ Viasat Recon Reply at 1-2.

³⁸⁹ *Id.* at 3.

³⁹⁰ See *Ten-Satellite Partial Grant* at para. 12.

and took all comments filed to date into consideration when analyzing orbital debris. Furthermore, even if Viasat is correct that the Bureau should have considered the ten satellites in conjunction with the 1,584 satellites already authorized, the safety and orbital debris characteristics of these satellites have already been thoroughly examined in SpaceX's original authorization, two modifications, and one order on reconsideration. As discussed above, we are not at this time concerned by the failure rates, given SpaceX's vast improvements and the lower altitude. We therefore find that the Bureau extensively considered the issues Viasat raises in its reconsideration petition above, and we deny Viasat's petition for reconsideration.

IV. CONCLUSION AND ORDERING CLAUSES

96. Accordingly, IT IS ORDERED, that the Third Modification Application filed by Space Exploration Holdings, LLC (SpaceX), IS GRANTED, pursuant to section 309(a) of the Communications Act of 1934, as amended, 47 U.S.C. § 309(a).

97. IT IS FURTHER ORDERED that this authorization is subject to the following requirements and conditions:³⁹¹

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).

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, and are subject to the condition that SpaceX not use more than one satellite beam from any of its satellites in the same frequency in the same or overlapping areas at a time.

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-

³⁹¹ The conditions here replicate the full set of conditions applicable to SpaceX operations as specified in prior orders, except that conditions in paragraphs e and w have been modified, and new conditions have been specified at paragraphs j, o, r, s, t, and u. We also note that SpaceX has previously satisfied some of these conditions.

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, 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 19.7-20.2 GHz frequency band are subject to the condition that SpaceX may not use more than one satellite beam for satellite transmissions on the same frequency to the same or overlapping areas at a time.

k. 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.

l. 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.

m. 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).

n. 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.

o. For downlink operations in the Ku-band, SpaceX must ensure that the PFD, as measured on the surface of the Earth, satisfies the applicable limits set forth in the Commission's rules, 47 CFR § 25.208(o), and the ITU Radio Regulations, including for the lower satellite altitude and elevation angles authorized in this modification. SpaceX must reduce the PFD for its Ka-band downlinks by 7 dB as compared to its current authorization.

p. Under 47 CFR § 25.146(a), 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. In case of an unfavorable finding, SpaceX must adjust its operation to satisfy the ITU requirements. 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 contained in Article 22 of the ITU Radio Regulations, as well as Resolution 76 (WRC-03) of the ITU Radio Regulations.

q. SpaceX must make available to any requesting party the data used as input to the ITU-approved validation software to demonstrate compliance with applicable Equivalent Power Flux Density (EPFD) limits.

r. SpaceX must accept any additional interference resulting from this modification compared to its current authorization, from licensees or market access grantees authorized in the Commission's NGSO 2016 Processing Round. SpaceX must also accept any additional interference into its Ka-band uplink resulting from this modification compared to its current authorization, from the Kuiper Systems, LLC NGSO system as authorized in July 2020. For this purpose, the allowable level of uplink interference from Kuiper into SpaceX shall be established by a showing submitted by Kuiper and accepted by the Commission that its operations would not have caused harmful interference to SpaceX's NGSO system at the altitudes where SpaceX would have operated prior to this modification.

s. SpaceX must operate consistent with the technical specifications provided to the Commission, including any supplemental specifications, in connection with this Third Modification Application, including antenna beam patterns and other technical information.

t. During launch and early orbit phase operations, payload testing, and deorbit of its satellites, SpaceX must operate on a non-harmful interference basis, *i.e.* SpaceX must not cause harmful interference and must accept any interference received. In the event of any harmful interference under this grant, SpaceX must immediately cease operations upon notification of such interference and inform the Commission, in writing, of such an event.

u. SpaceX must provide a semi-annual report, by January 1 and July 1 each year, covering the preceding six month period, respectively, from June 1 to November 30 and December 1 to May 31. The report should include the following information:

- i. The number of conjunction events identified for Starlink satellites during the reporting period, and the number of events that resulted in an action (maneuver or coordination with another operator), as well as any difficulties encountered in connection with the collision avoidance process and any measures taken to address those difficulties.
 - ii. Satellites that, for purposes of disposal, were removed from operation or screened from further deployment at any time following initial deployment, and identifying whether this occurred less than five years after the satellite began regular operations or were available for use as an on-orbit replacement satellite,
 - iii. Satellites that re-entered the atmosphere,
 - iv. Satellites for which there was a disposal failure, as that term is defined in this Order, including a discussion of any assessed cause of the failure and remedial actions.

SpaceX must also provide a report if during any continuous one-year period that begins after April 2, 2021, there are three or more satellite disposal failures. Such report shall be filed not later than 10 days following the third disposal failure and must either state the assessed cause of the failure and remedial actions for each of the disposal failures during the period, if available, or provide a schedule for completion of a process for doing so.

Based on the information reported, the license may be subject to additional terms and conditions, including additional reporting obligations, limitations on additional deployments, requirements for early removal of satellites from orbit, or any other appropriate conditions to limit collision risk.

v. SpaceX must maintain satellite orbits so as to operate all of its satellites at or below 580 km.

w. 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. This includes, but is not limited to, any conditions or requirements resulting from any action in the proceedings associated with IB Docket 18-818³⁹² and WTB Docket 20-443³⁹³.

x. IT IS FURTHER ORDERED that SpaceX is 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).

98. 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**,³⁹⁴ 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% 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 of them in accordance with the authorization no later than **March 29, 2027**. 47 CFR § 25.164(b).³⁹⁵

99. 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).

100. 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.

101. IT IS FURTHER ORDERED that Viasat's Petition to Deny or Defer is DENIED.

102. IT IS FURTHER ORDERED that SES/O3B's Petition to Deny or Defer is DENIED.

103. IT IS FURTHER ORDERED that Kepler's Objection is DENIED.

104. IT IS FURTHER ORDERED that Kuiper's Objection is DENIED.

³⁹² See generally *Orbital Debris R&O & FNPRM*.

³⁹³ See generally *12 GHz NPRM*.

³⁹⁴ We note that SpaceX filed the required bond on April 23, 2018 and filed a rider to that bond on March 25, 2019 that increases the maximum penal sum of the original surety bond in compliance with the Commission's rules and the terms of SpaceX's authorization.

³⁹⁵ We note that the *NGSO FSS Order* modified section 25.164(b) to offer additional flexibility and requires launch and operation of 50% of an authorized system within six years of grant and the remaining satellites within nine years of grant.

105. IT IS FURTHER ORDERED that The Balance Group's Opposition and Motions for Consultation with Affected Agencies, for Disclosure, for Certification of Suitably Comprehensive Insurance Coverage, for Certification of Indemnity, and to Suspend or Revoke Licenses is DENIED.

106. IT IS FURTHER ORDERED that Viasat's Petition Pursuant to Section 1.1307 is DENIED.

107. IT IS FURTHER ORDERED that DISH's Request for Production of Evidence is DISMISSED as moot.

108. IT IS FURTHER ORDERED that DISH's Request for a Protective Order is DENIED IN PART and otherwise DEFERRED as set forth in para. 51.

109. IT IS FURTHER ORDERED THAT Viasat's Petition for Reconsideration of the Ten-Satellite Partial Grant, DA 21-34, is DENIED.

FEDERAL COMMUNICATIONS COMMISSION

Marlene H. Dortch
Secretary