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

In the Matter of	)	
	)	
Space Exploration Holdings, LLC	)	IBFS File Nos.
	)	SAT-LOA-20200526-00055 and
Request for Orbital Deployment and Operating	)	SAT-AMD-20210818-00105
Authority for the SpaceX Gen2 NGSO	)	
Satellite System	)	Call Sign S3069

ORDER AND AUTHORIZATION

Adopted: November 29, 2022 **Released: December 1, 2022**

By the Commission:

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I. INTRODUCTION

1. In this Order and Authorization (Order), we grant in part and defer in part, with conditions, the application of Space Exploration Holdings, LLC. (SpaceX) to construct, deploy, and operate a constellation of 29,988 non-geostationary orbit (NGSO) satellites, to be known as its "second-generation" Starlink constellation (Gen2 Starlink), using Ku-, Ka-, and E-band frequencies to provide fixed-satellite service (FSS).[1] Specifically, we grant SpaceX authority to construct, deploy, and operate up to 7,500 satellites operating at altitudes of 525, 530, and 535 km and inclinations of 53, 43, and 33 degrees, respectively, using frequencies in the Ku- and Ka-band. We defer consideration of SpaceX's proposed use of E-band frequencies and tracking beacons. We also grant SpaceX's request for authority to conduct launch and early orbit phase (LEOP) operations and testing during orbit-raising, as well as tracking, telemetry and command (TT&C) during the process of removing its satellites from orbit, consistent with the parameters described in the application and related materials. Finally, we grant in part and dismiss in part SpaceX's request for various waivers. Our action will allow SpaceX to begin deployment of Gen2 Starlink, which will bring next generation satellite broadband to Americans nationwide, including those living and working in areas traditionally unserved or underserved by terrestrial systems. Our action also will enable worldwide satellite broadband service, helping to close the digital divide on a global scale. At the same time, this limited grant and associated conditions will protect other satellite and terrestrial operators from harmful interference and maintain a safe space environment, promoting competition and protecting spectrum and orbital resources for future use. We defer action on the remainder of SpaceX's application at this time.

2. Interested parties raised a number of significant issues in the record regarding this application, and we have carefully considered these issues in arriving at our decision today. These issues include, but are not limited to, orbital debris mitigation and space safety, protection of systems licensed in previous NGSO FSS processing rounds and sharing of information with other operators, compliance with equivalent power-flux density (EPFD) limits and other issues involving protection of geostationary satellite orbit (GSO) space stations from harmful interference, protection of science missions using electromagnetic spectrum, as well as various concerns that parties deem to be environmental, such as potential atmospheric effects from launches and satellite reentries and potential effects on astronomy and night sky observation. To address these and other issues, we require that SpaceX comply with a series of conditions that are outlined below. To address concerns about orbital debris and space safety, we limit this grant to 7,500 satellites only, operating at certain altitudes, and note that SpaceX has committed to requesting modification of its previously-granted license for operations in the V-band so that it will incorporate those V-band operations into its Starlink Gen2 system, rather than operating a separate system in the V-band. This means our action today does not increase the total number of satellites SpaceX is authorized to deploy, and in fact slightly reduces it, as compared to the total number of satellites SpaceX would potentially have deployed otherwise. We also adopt requirements that require SpaceX to report

[1] *See Space Exploration Holdings, LLC,* Application for Orbital Deployment and Operating Authority for the SpaceX Gen2 NGSO Satellite System, IBFS File No. SAT-LOA-20200526-00055 (filed May 26, 2020) (SpaceX Gen2 Application); *Space Exploration Holdings, LLC*, Amendment to Pending Application for the SpaceX Gen2 NGSO Satellite System, IBFS File No. SAT-AMD-20210818-00105 (dated Aug. 18, 2021) (SpaceX Gen2 Amendment).

mitigation actions taken to avoid collisions in space, coordinate and collaborate with NASA to ensure continued availability of launch windows and on other matters, and pause deployment of new satellites if satellite failures exceed a certain threshold. To address issues related to spectrum rights, interference concerns, and competition in low-Earth orbit (LEO), we condition today's action on SpaceX coordinating with NGSO FSS systems licensed in certain prior processing rounds; reporting whether the International Telecommunication Union's finding on compliance with EPFD limits takes into account all of the relevant ITU filings for its Gen2 Starlink system combined; and for operations in certain frequency bands, using no more than one satellite beam from any of its authorized Gen2 Starlink satellites in the same frequency in the same or overlapping areas at a time. Finally, to address concerns about protection of science missions, we adopt conditions and reporting requirements that will help to limit any impact on astronomy, including limiting SpaceX's operations to below 580 km, requiring SpaceX to continue to coordinate and collaborate with NASA to minimize impacts to NASA's science missions, requiring SpaceX to coordinate with the National Science Foundation, and requiring SpaceX to coordinate with specific observatories to protect radioastronomy operations. With these and other conditions and limitations in place, we conclude that our action today would be in the public interest.

3. Accordingly, we grant-in-part and deny-in-part the Petition to Defer and Condition of SES Americom and O3b Limited (SES/O3b),[2] the Petition to Deny or Defer in Part of RS Access, LLC (RS Access),[3] and the Petition to Deny or Hold in Abeyance of Viasat Inc. (Viasat).[4] In response to these petitions, comments from the NASA and National Science Foundation (NSF),[5] and comments from Kuiper Systems, LLC (Kuiper)[6] we adopt a number of conditions. We deny the Petition to Dismiss or Deny in Part of DISH Network Corporation (DISH).[7] We dismiss the Opposition and Motion to Await Conclusion of Pending Directly Intertwined Litigation, Motion for Consultation with Affected Agencies, Motion for Disclosure, Motion for Certification of Suitably Comprehensive Insurance Coverage, Motion for Certification of Indemnity, and Motion to Suspend or Revoke Licenses of The Balance Group,[8] and we dismiss the "Motion for Abeyance" filed by DISH.[9]

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[2] *See* Petition to Defer and Condition of SES Americom and O3b Limited, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (filed Feb. 8, 2022) (SES/O3b Petition).

[3] *See* Petition to Deny or Defer in Part of RS Access, LLC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (filed Feb. 8, 2022) (RS Access Petition).

[4] *See* Petition of Viasat, Inc., IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (filed Feb. 8, 2022) (Viasat Petition).

[5] *See* Letter from Kathy Smith, Chief Counsel, National Telecommunications and Information Administration, to Marlene H. Dortch, Secretary, FCC, IBFS File No. SAT-AMD-20210818-00105 (dated Feb. 8, 2022) (NTIA Letter); Letter from Kathy Smith, Chief Counsel, National Telecommunications and Information Administration, to Marlene H. Dortch, Secretary, FCC, IBFS File No. SAT-AMD-20210818-00105 (dated Mar. 10, 2022) (NTIA March 10, 2022 Letter).

[6] *See* Comments of Kuiper Systems, LLC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (filed Feb. 8, 2022) (Kuiper Comments).

[7] *See* Petition to Dismiss or Deny in Part of DISH Network Corporation, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (filed Feb. 8, 2022) (DISH Petition).

[8] *See* Opposition and Motion to Await Conclusion of Pending Directly Intertwined Litigation; Motion for Consultation with Affected Agencies; Motion for Disclosure; Motion for Certification of Suitably Comprehensive Insurance Coverage; Motion for Certification of Indemnity; and Motion to Suspend or Revoke Licenses of The Balance Group, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (filed Feb. 8, 2022) (The Balance Group Opposition).

[9] *See* Motion for Abeyance of DISH Network Corporation, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (filed Jan. 27, 2022) (DISH Motion for Abeyance).

II. BACKGROUND

4. *SpaceX First Generation Starlink System.* On March 28, 2018, the Commission granted SpaceX authority to deploy and operate its first-generation NGSO satellite system comprising 4,425 satellites operating in the Ku- and Ka-bands for provision of FSS (Gen1 Starlink).[10] The Commission has since granted three license modifications for the Gen1 Starlink system,[11] and a number of requests for Special Temporary Authority (STA) for LEOP and payload testing operations and to adjust earth station elevation angles.[12] Petitions for reconsideration are pending against the *SpaceX Third Modification Order*.[13] On August 26, 2022, the Court of Appeals for the D.C. Circuit upheld the *SpaceX Third Modification Order*.[14] SpaceX has also applied for fourth and fifth modifications of its Gen1 Starlink constellation, which are currently pending.[15] As of October 2022, SpaceX has launched more than 3,500

[10] *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 Gen1 Authorization).

[11] *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)*; *Space Exploration Holdings, LLC, Request for Modification of the Authorization for the SpaceX NGSO Satellite System*, Order and Authorization, 34 FCC Rcd 12307 (IB 2019) (*SpaceX Second Modification Order*); Space Exploration Holdings, LLC, Request for modification of the Authorization for the SpaceX NGSO Satellite System, 36 FCC Rcd 122 (IB 2021) (SpaceX Third Modification Partial Grant); *Space Exploration Holdings, LLC, Request for Modification of the Authorization for the SpaceX NGSO Satellite System*, Order and Authorization and Order on Reconsideration, 36 FCC Rcd 7995 (2021) (*SpaceX Third Modification Order*).

[12] *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); *See also* Space Exploration Holdings, LLC, Request for Special Temporary Authority, Grant Stamp, IBFS File No. SAT-STA-20220516-00051 (granted Aug. 3, 2022) (authorizing SpaceX to reduce its earth station elevation angles to a minimum of 5 degrees in regions above 53 degrees latitude to maximize service while SpaceX builds out the polar regions of its Gen1 Starlink Constellation). We note that the Commission granted SpaceX authority to conduct LEOP and payload testing operations on an ongoing basis for its Gen1 Starlink system in the *SpaceX Third Modification Order*. *See SpaceX Third Modification Order*, 36 FCC Rcd at 8034-35, 8049, paras. 69-71, 97t.

[13] *See* Petition for Reconsideration of SES Americom and O3b Limited, IBFS File No. SAT-MOD-20200417-00037 (filed May 27, 2021); Petition for Reconsideration of Hughes Network Systems LLC, IBFS File No. SAT-MOD-20200417-00037 (filed May 27, 2021).

[14] *See Viasat, Inc. v. FCC*, 47 F.4th 769 (D.C. Cir. 2022).

[15] *See* Space Exploration Holdings, LLC, Request for Modification of the Authorization for the SpaceX NGSO Satellite System, IBFS File No. SAT-MOD-20220725-00074 (filed Jul. 25, 2022); Space Exploration Holdings, LLC, Request for Modification of the Authorization for the SpaceX NGSO Satellite System, IBFS File No. SAT-MOD-20220906-00100 (filed Sept. 6, 2022).

of its Gen1 Starlink satellites.[16] We also note that SpaceX holds an authorization for an additional constellation of 7,518 very-low-Earth orbit (VLEO) Starlink satellites using V-band frequencies (V-band Starlink).[17]

5. *Processing Round.* In response to several applications filed with the Commission for operations in the Ku- and Ka- frequency bands,[18] the Satellite Division initiated a processing round for 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 frequency bands by NGSO FSS systems (the 2020 Ku/Ka-band Processing Round),[19] pursuant to section 25.157 of the Commission's rules.[20] These frequency bands were the subject of prior processing round public notices and filing deadlines.[21] The Satellite Division also included in this new processing round applications and petitions to operate in the 13.8-13.85 GHz band.[22] In addition to requests from New Spectrum Satellite (New Spectrum),[23] WorldVu Satellites Limited (OneWeb),[24] and Kuiper,[25] that were pending prior to and listed in the public notice announcing the processing round, other companies

[16] *See* Alejandro Alcantarilla Romera, SpaceX Launches the 3,500th Starlink Satellite, NASASpaceFlight.com (October 20, 2022), https://www.nasaspaceflight.com/2022/10/spacex-3500-starlink/.

[17] *See Space Exploration Holdings LLC*, *Application for Approval for Orbital Deployment and Operating Authority for the SpaceX V-Band NGSO System*, Memorandum Opinion, Order and Authorization, 33 FCC Rcd 11434 (2018) (*SpaceX V-band Authorization*). In addition to the 7,518 new satellites using V-band frequencies, the *SpaceX V-band Authorization* also granted SpaceX authority to add V-band communications to its 4,408 Ku- and Ka-band Gen1 Starlink satellites. SpaceX has not yet begun operations using V-band frequencies with its Gen1 Starlink satellites and has not launched any of the 7,518 V-band Starlink satellites. SpaceX recently indicated its intent to modify this license to combine the 7,518 satellites with its Gen2 Starlink license. *See* Letter from David Goldman, Director, Satellite Policy, Space Exploration Technologies Corp., to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Oct. 27, 2022) (SpaceX October 27, 2022 Letter).

[18] New Spectrum Satellite (New Spectrum), IBFS File No. SAT-PDR-20170726-00111 (Call Sign S3019), WorldVu Satellites Limited (OneWeb), IBFS File No. SAT-MOD-20180319-00022 (Call Sign S2963), and Kuiper Systems LLC (Kuiper), IBFS File No. SAT-LOA-20190704-00057 (Call Sign S3051).

[19] *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, 13.8-14.5 GHz, 17.7-18.6 GHz, 18.8-20.2 GHz, And 27.5-30 GHz Bands*, *Satellite Policy Branch Information*, Report No. SPB-279, DA 20-325 (rel. March 24, 2020) (2020 Ku/Ka-band Processing Round Public Notice).

[20] 47 CFR § 25.157.

[21] *See OneWeb Petition Accepted for Filing; Cut-Off Established for Additional NGSO-Like Satellite Applications or Petitions 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 (rel. Jul. 15, 2016) (establishing a cut off deadline of Nov. 15, 2016 for additional applications and petitions in these bands); *Satellite Policy Branch Information: 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, 32 FCC Rcd 4180 (rel. May 26, 2017) (establishing a cut off deadline of July 26, 2017 for additional applications and petitions in these bands).

[22] The Satellite Division previously accepted New Spectrum Satellite's petition for market access in the 13.8-13.85 GHz band, but it made no determination as to whether a processing round would be initiated for these frequencies and did not invite additional applications in these frequencies at that time. *Satellite Policy Branch Information: Space Station Applications Accepted for Filing*, Public Notice, Report No. SAT-01251 (rel. Oct. 12, 2018). New Spectrum's request to use the 3700-4200 MHz (space-to-Earth) and 5925-6725 MHz (Earth-to-space) frequency bands was not accepted for filing at that time.

[23] IBFS File No. SAT-PDR-20170726-00111 (Call Sign S3019).

[24] IBFS File No. SAT-MOD-20180319-00022 (Call Sign S2963).

[25] IBFS File No. SAT-LOA-20190704-00057 (Call Sign S3051).

including Kepler,[26] Mangata Networks LLC,[27] Viasat,[28] and EOS[29] filed applications in response to the initiation of the processing round.

6. *SpaceX Gen2 Starlink Application.* On May 26, 2020, SpaceX filed the instant application as part of the 2020 Ku/Ka-band processing round.[30] SpaceX requested authority to construct, deploy, and operate 30,000 satellites at altitudes ranging from 328 km to 614 km.[31] On August 18, 2021, SpaceX amended its application to modify the configuration of Gen2 Starlink.[32] In its amendment, SpaceX specifically requested authority for one of two mutually exclusive configurations for its satellites.[33] SpaceX stated it would ultimately choose a configuration based on the readiness of its Starship launch vehicle.[34] Before the amended Gen2 Starlink application was accepted for filing, several parties submitted letters, *ex parte* presentations, and comments on the record, many objecting to SpaceX's applying for two mutually exclusive configurations.[35]

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[26] IBFS File No. SAT-PDR-20200526-00059 (Call Sign S3070).

[27] IBFS File No. SAT-PDR-20200526-00054 (Call Sign S3068).

[28] IBFS File No. SAT-MPL-20200526-00056 (Call Sign S2986).

[29] IBFS File No. SAT-MOD-20200526-00057, Call Sign S2982. This application was subsequently withdrawn.

[30] *See Generally* SpaceX Gen2 Application.

[31] *Id. Technical Attachment* at 1.

[32] *See generally* SpaceX Gen2 Amendment.

[33] *Id. Narrative* at 3-6.

[34] *Id.* Narrative at 3, 5. SpaceX's preferred configuration would consist of 29,988 satellites at altitudes ranging from 340 km to 614 km and would rely on SpaceX's Starship for launches. SpaceX's alternative configuration would consist of 29,996 satellites operating at altitudes ranging from 328 km to 614 km and would primarily rely on SpaceX's Falcon 9 rocket for deployment. *Id. Narrative* at 3-6. SpaceX notified the Commission on January 7, 2022, that it had chosen the first, preferred, configuration. *See* Letter from William M. Wiltshire, Counsel, Space Exploration Holdings, LLC, to Karl A. Kensinger, Chief, Satellite Division, International Bureau, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105, at 2 (dated Jan. 7, 2022) (SpaceX January 7, 2022 Response to Satellite Division Information Request).

[35] *See Ex Parte* Presentation of Space Exploration Holdings, LLC, IBFS File No. SAT-LOA-20200526-00055 (filed August 2, 2021) (SpaceX August 2, 2021 *Ex Parte*); *Ex Parte* Presentation of Kuiper Systems, LLC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (filed Aug. 25, 2021) (Kuiper August 25, 2021 *Ex Parte*); Letter from David Goldman, Director, Satellite Policy, Space Exploration Technologies Corp., to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Aug. 31, 2021) (SpaceX August 31, 2021 Letter); Letter from C. Andrew Keisner, Counsel, Kuiper Systems LLC, to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Sept. 8, 2021) (Kuiper September 8, 2021 Letter); Letter from David Goldman, Director, Satellite Policy, Space Exploration Technologies Corp., to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Sept. 9, 2021) (SpaceX September 9, 2021 Letter); Letter from Amy R. Mehlman, Vice President, U.S. Government Affairs and Policy, Viasat, Inc., to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Sept. 10, 2021) (Viasat September 10, 2021 Letter); Letter from David Goldman, Director, Satellite Policy, Space Exploration Technologies Corp., to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Sept. 14, 2021) (SpaceX September 14, 2021 Letter); Letter from Amy R. Mehlman, Vice President, U.S. Government Affairs and Policy, Viasat, Inc., to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Sept. 21, 2021) (Viasat September 21, 2021 Letter); *Ex Parte* Presentation of Space Exploration Holdings, LLC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (filed Sept. 22, 2021) (SpaceX September 22, 2021 *Ex Parte*); Letter from Jennifer A. Manner, Senior Vice President, Regulatory Affairs, EchoStar Satellite Services LLC, to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Sept. 23, 2021) (Echostar/Hughes September 23, 2021 Letter); *Ex Parte* Presentation of Kuiper Systems LLC, IBFS File

(continued….)

7. On December 23, 2021, the Satellite Division found the SpaceX Gen2 Starlink application, as amended, acceptable for filing and placed the application and amendment on public notice.[36] At the same time, the Satellite Division sent a letter requesting additional information from SpaceX.[37] SpaceX responded on January 7, 2022, and at that time notified the Commission it would be pursuing only one of the two specified configurations for Gen2 Starlink.[38] Specifically, SpaceX now proposes to operate 29,988 satellites at altitudes ranging from 340 km to 614 km.[39] Approximately two thirds of the satellites (19,440) would be deployed in shells centered at altitudes from 340 km to 360 km (below the International Space Station (ISS)), approximately one third (10,080) would be deployed in shells centered at altitudes from 525 km to 535 km (above ISS and below SpaceX's Gen1 Starlink constellation), and 468 satellites would be deployed into retrograde inclinations in shells centered at altitudes of 604 km and 614 km (above Gen1).[40] SpaceX's specific proposed arrangement of satellites is set forth in the following table:

Altitude (km)	Inclination (degrees)	Orbital Planes	Satellites Per Plane	Total Satellites
340	53	48	110	5280
345	46	48	110	5280
350	38	48	110	5280

(Continued from previous page)
Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (filed Sept. 23, 2021) (Kuiper September 23, 2021 *Ex Parte*); Letter from David Goldman, Director, Satellite Policy, Space Exploration Technologies Corp., to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Sept. 21, 2021)(SpaceX September 29, 2021 Letter); Letter from Jennifer A. Manner, Senior Vice President, Regulatory Affairs, EchoStar Satellite Services LLC, to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Oct. 8, 2021) (Echostar/Hughes October 8, 2021 Letter); Letter from C. Andrew Keisner, Counsel, Kuiper Systems LLC, to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Oct. 12, 2021) (Kuiper October 12, 2021 Letter); Letter from David Goldman, Director, Satellite Policy, Space Exploration Technologies Corp., to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Oct. 15, 2021) (SpaceX October 15, 2021 Letter); Letter from Carlos M. Nalda, Counsel, Eutelsat S.A., to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Oct. 22, 2021) (Eutelsat October 22, 2021 Letter); *Ex Parte* Presentation of Space Exploration Holdings, LLC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (filed Nov. 10, 2021) (SpaceX November 10, 2021 *Ex Parte*); Letter from Suzanne Malloy, Vice President, Regulatory Affairs, O3b Limited, to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Dec. 1, 2021) (SES/O3b December 1, 2021 Letter); *Ex Parte* Presentation of Space Exploration Holdings, LLC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (filed Dec. 6, 2021) (SpaceX December 6, 2021 *Ex Parte*); *Ex Parte* Presentation of Hughes Network Systems, LLC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (filed Dec. 9, 2021) (Hughes December 9, 2021 *Ex Parte*); *Ex Parte* Presentation of Space Exploration Holdings, LLC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (filed Dec. 20, 2021) (SpaceX December 20, 2021 *Ex Parte*).

[36] *Satellite Policy Branch Information, Space Station Applications Accepted for Filing*, Report No. SAT-01598 (Dec. 23, 2021).

[37] *See* Letter from Karl A. Kensinger, Chief, Satellite Division, International Bureau, FCC, to William M. Wiltshire, Counsel, Space Exploration Holdings, LLC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Dec. 23, 2021) (Satellite Division December 23, 2021 Information Request).

[38] *See* SpaceX January 7, 2022 Response to Commission Information Request at 1.

[39] *See* SpaceX Gen2 Amendment, Narrative at 5.

[40] *Id.*

360	96.9	30	120	3600
525	53	28	120	3360
530	43	28	120	3360
535	33	28	120	3360
604	148	12	12	144
614	115.7	18	18	324

SpaceX recently informed us that it now intends to deploy Gen2 Starlink satellites using both the Starship and Falcon 9 launch vehicles, beginning with the three shells in the lower 500 km altitude range, followed by the shells at lower altitudes, and finally the 604 and 614 km altitude shells.[41]

8. SpaceX proposes operations in the 10.7-12.75 GHz, 17.8-18.6 GHz, 18.8-19.3 GHz, 19.7-20.2 GHz, and 71.0-76.0 GHz (space-to-Earth) and 12.75-13.25 GHz, 14.0-14.5 GHz, 27.5-29.1 GHz, 29.5-30.0 GHz, and 81.0-86.0 GHz (Earth-to-space) frequency bands.[42] SpaceX also proposes telemetry, tracking, and command (TT&C) operations in the 12.15-12.25 GHz (space-to-Earth), 18.55-18.60 GHz (space-to-Earth), and 13.85-14.0 GHz (Earth-to-space) frequency bands.[43] SpaceX also intends to operate tracking beacons on some of its satellites, which would communicate in the 137.00-138.00 MHz (Earth-to-space) and 148.00-150.05 MHz (space-to-Earth) frequency bands.[44] SpaceX describes Gen2 Starlink as complementing and augmenting Gen1 Starlink.[45] SpaceX intends to fully deploy and maintain both systems, including launching replacement satellites, and Starlink user terminals will be able to communicate with both Gen1 Starlink and Gen2 Starlink satellites.[46] Additionally, SpaceX requests various waivers of our rules, including ITU and Commission PFD limits in the Ka-band,[47] the requirement to obtain a favorable or qualified-favorable finding from the International Telecommunication Union (ITU) prior to commencing operations,[48] the requirement to conduct TT&C operations within authorized frequency bands, preferably at the band edges,[49] and to the extent necessary, various limitations in the Commission's Schedule S software.[50]

9. After SpaceX clarified which configuration it would pursue, Kuiper requested an extension of the deadline for filing petitions to deny,[51] which was supported by Viasat,[52] and which the

[41] *See* Letter from David Goldman, Director, Space Exploration Technologies Corp., to Marlene H. Dortch, Secretary, FCC, IBFS file Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105, at 4 (dated Aug. 19, 2022) (SpaceX August 19, 2022 Letter); Letter from David Goldman, Senior Director, Satellite Policy, Space Exploration Technologies Corp., to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105, at 4 (dated Oct. 4, 2022) (SpaceX October 4, 2022 Letter).

[42] *See* SpaceX Gen2 Amendment, Frequencies Requested. SpaceX states it will conduct operations in the 12.7-12.75 GHz band outside of the United States only. *See* SpaceX Gen2 Application, Technical Attachment at 4.

[43] *See* SpaceX Gen2 Application, Technical Attachment at 4.

[44] *See* SpaceX August 19, 2022 Letter at 6, n.17; SpaceX October 4, 2022 Letter at 2, Exhibit A.

[45] *See* SpaceX January 7, 2022 Response to Satellite Division Information Request at 3.

[46] *Id.* As a separate system, the Gen2 system will need to be added as an authorized point of communication to existing Starlink earth station licenses, through the filing of applications to modify those licenses.

[47] *See* 47 CFR § 25.146(a)(1) SpaceX originally requested a waiver of the PFD limits in the Ka-band included in section 25.208(e), but those limits have been incorporated into section 25.146(a)(1) of the Commission's rules.

[48] *See* 47 CFR § 25.146(c).

[49] *See* 47 CFR § 25.202(g)(1).

[50] *See* SpaceX Gen2 Amendment, Waiver Requests.

[51] *See* Request of Kuiper Systems, LLC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (filed Jan. 10, 2022) (Kuiper January 10, 2022 Request for Extension).

Satellite Division granted on January 13, 2022,[53] extending the deadline to February 8, 2022. In the midst of the initial comment filing period, DISH also filed a motion seeking that the proceeding be held in abeyance pending the production of additional evidence concerning the basis for SpaceX's certification of compliance with Commission and ITU equivalent power flux density (EPFD) limits,[54] which numerous parties supported or opposed.[55] This informal request was not acted on prior to the deadline for filing petitions to deny, and on that deadline RS Access, DISH, SES/O3b, and Viasat filed petitions to deny or defer.[56] Kepler Communications, Inc. (Kepler); Kuiper; Broadband International Legal Action Network (BBILAN); the Balance Group; Echostar Satellite Services, LLC and Hughes Network Systems, LLC (Echostar/Hughes); and WorldVu Satellites LTD (OneWeb) filed comments.[57] The National Telecommunications and Information Administration (NTIA) also submitted letters on behalf of NASA

(Continued from previous page)

[52] *See* Letter from Jarrett S. Taubman, Vice President and Deputy Chief Government Affairs and Regulatory Officer, Viasat, Inc., to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Jan. 13, 2022) (Viasat January 13, 2022 Letter). SpaceX objected to an extension of the filing window, given that interested parties had already had months to review SpaceX's application. *See* SpaceX January 7, 2022 Response to Satellite Division Information Request, at 2-3; Opposition of Space Exploration Holdings, LLC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (filed Jan. 11, 2022) (SpaceX January 11, 2022 Opposition to Extension Request).

[53] *See Satellite Policy Branch Information, Actions Taken*, Report No. SAT-01601 (Jan. 13, 2021). Kuiper's request was for a 30-day extension of the filing window. The Satellite Division extended the comment filing window by 15 days, meaning interested parties had a full 30 days after SpaceX confirmed its chosen configuration to review and comment on SpaceX's Gen2 Starlink application, as amended.

[54] *See* DISH Motion for Abeyance.

[55] *See* Letter from Jarrett S. Taubman, Vice President and Deputy Chief Government Affairs and Regulatory Officer, Viasat, Inc., to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Jan. 31, 2022) (Viasat January 31, 2022 Letter); Letter from Suzanne Malloy, Vice President, Regulatory Affairs, O3b Limited, to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Feb. 1, 2022) (SES/O3b February 1, 2022 Letter); Letter from David Goldman, Director, Satellite Policy, Space Exploration Technologies Corp., to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Feb. 2, 2022) (SpaceX February 2, 2022 Letter); Letter from Pantelis Michalopoulos, Counsel, DISH Network Corporation, to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Feb. 4, 2022) (DISH February 4, 2022 Letter); Echostar/Hughes Comments; Letter from David Goldman, Director, Satellite Policy, Space Exploration Technologies Corp., to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Feb. 4, 2022) (SpaceX February 4, 2022 Letter).

[56] *See* RS Access Petition; DISH Petition; SES/O3b Petition; Viasat Petition.

[57] *See* Kuiper Comments; The Balance Group Opposition; Comments of Kepler Communications, Inc., IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (filed Jan. 24, 2021) (Kepler Comments); Comments of EchoStar Satellite Services LLC. And Hughes Network Services LLC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (filed Feb. 4, 2022) (EchoStar/Hughes Comments); Comments of Broadband International Legal Action Network, IBFS File No. SAT-LOA-20200526-00055 (filed Feb. 8, 2022) (BBILAN Comments); Comments of WorldVu Satellites Limited, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (filed Feb. 8, 2022) (OneWeb Comments). OneWeb and SpaceX subsequently reached a coordination agreement, and OneWeb withdrew its comments. *See* Letter from David Goldman, Director, Satellite Policy, Space Exploration Technologies Corp., to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Jun. 13, 2022) (SpaceX June 13, 2022 Letter); Letter from David Goldman, Director, Satellite Policy, Space Exploration Technologies Corp., and Kimberly M. Baum, VP, Spectrum Engineering and Policy, WorldVu Satellites Limited, to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105, SAT-MPL-20200526-00062, SAT-APL-20210112-00007 (dated Jul. 21, 2022) (SpaceX and OneWeb July 21, 2022 Joint Letter).

and NSF.[58] SpaceX filed a consolidated opposition.[59] Echostar/Hughes, RS Access, Kepler, Viasat, SES/O3b, DISH, and OneWeb filed replies.[60] The record has remained active, and several interested parties have continued to file comments, letters, and *ex parte* presentations.[61]

[58] *See* NTIA Letter; NTIA March 10, 2022 Letter.

[59] *See* Opposition of Space Exploration Holdings, LLC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (filed Feb. 24, 2022) (SpaceX Consolidated Opposition).

[60] *See* Reply of EchoStar Satellite Services LLC. And Hughes Network Services LLC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (filed Feb. 18, 2022) (EchoStar/Hughes Reply); Reply of RS Access LLC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20200818-00105 (filed Mar. 8, 2022) (RS Access Reply); Reply of Kepler Communications, Inc., IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (filed Mar. 8, 2022) (Kepler Reply); Reply of Kuiper Systems LLC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (filed Mar. 3, 2022) (Kuiper Reply); Reply of Viasat, Inc., IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (filed Mar. 8, 2022) (Viasat Reply); Reply of SES Americom and O3b Limited, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (filed Mar. 8, 2022) (SES/O3b Reply); Reply of DISH Network Corporation, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (filed Mar. 8, 2022) (DISH Reply); Reply of Viasat, Inc., IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (filed Mar. 8, 2022) (Viasat Reply); *see also* Reply of WorldVu Satellites Limited, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (filed Mar. 8, 2022) (OneWeb Reply). We note that OneWeb withdrew its reply along with its initial comments after reaching a coordination agreement with SpaceX. *See* SpaceX June 13, 2022 Letter; SpaceX and OneWeb July 21, 2022 Joint Letter.

[61] *See Ex Parte* Presentation of DISH Network Corporation, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (filed March 18, 2022) (DISH March 18, 2022 *Ex Parte*); Letter from Darren McKnight, LeoLabs, to Karl A. Kensinger, Chief, Satellite Division, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105, IB Docket No. 18-313 (dated March 29, 2022) (LeoLabs March 29, 2022 Letter); Letter from David Goldman, Director, Satellite Policy, Space Exploration Technologies Corp., to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated March 30, 2022) (SpaceX March 30, 2022 Letter); Letter from David Goldman, Director, Satellite Policy, Space Exploration Technologies Corp., to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Apr. 7, 2022) (SpaceX April 7, 2022 Letter); Letter from David Goldman, Director, Satellite Policy, Space Exploration Technologies Corp., to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Apr. 8, 2022) (SpaceX April 8, 2022 Letter); Letter from Jarrett S. Taubman, Vice President and Deputy Chief, Government Affairs, Viasat, Inc., to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Apr. 25, 2022) (Viasat April 25, 2022 Letter); Letter from Jarrett S. Taubman, Vice President and Deputy Chief, Government Affairs, Viasat, Inc., to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated May 2, 2022) (Viasat May 2, 2022 Letter); Letter from David Goldman, Director, Satellite Policy, Space Exploration Technologies Corp., to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated May 10, 2022) (SpaceX May 10, 2022 Letter); Letter from Jarrett S. Taubman, Vice President and Deputy Chief, Government Affairs, Viasat, Inc., to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated May 16, 2022) (Viasat May 16, 2022 Letter); *Ex Parte* Presentation of Space Exploration Holdings, LLC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (filed May 18, 2022) (SpaceX May 18, 2022 *Ex Parte*); Letter from Jarrett S. Taubman, Vice President and Deputy Chief, Government Affairs, Viasat, Inc., to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated May 18, 2022) (Viasat May 18, 2022 Letter); *Ex Parte* Presentation of Kuiper Systems LLC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (filed May 24, 2022) (Kuiper May 24, 2022 *Ex Parte*); Letter from Pantelis Michalopoulos, Counsel, DISH Network Corporation, to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated June 6, 2022) (DISH June 6, 2022 Letter); Letter from Jarrett S. Taubman, Vice President and Deputy Chief, Government Affairs, Viasat, Inc., to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055, SAT-AMD-20210818-00105, and SAT-MOD-20200417-00037 (dated Jun. 7, 2022) (Viasat June 7, 2022 Letter); *Ex Parte* Presentation of Kuiper Systems LLC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-

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AMD-20210818-00105 (filed Jun. 24, 2022) (Kuiper June 24, 2022 *Ex Parte*); Letter from David Goldman, Director, Satellite Policy, Space Exploration Technologies Corp., to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Jun. 30, 2022) (SpaceX June 30, 2022 Letter); Letter from Jameson Dempsey, Principal, Satellite Policy, Space Exploration Technologies Corp., to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Jul. 6, 2022) (SpaceX July 6, 2022 Letter); Letter from Jameson Dempsey, Principal, Satellite Policy, SpaceX Technologies Corp., to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Jul. 13, 2022) (SpaceX July 13, 2022 Letter); Letter from Jarrett S. Taubman, Vice President and Deputy Chief, Government Affairs, Viasat, Inc., to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Jul. 18, 2022) (Viasat July 18, 2022 Letter); *Ex Parte* Presentation of Space Exploration Holdings, LLC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (filed Jul. 25, 2022) (SpaceX July 25, 2022 *Ex Parte*); Letter from Jameson Dempsey, Principal, Satellite Policy, Space Exploration Technologies Corp., to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Jul. 28, 2022) (SpaceX July 28, 2022 Letter); *Ex Parte* Presentation of Space Exploration Holdings, LLC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (filed Aug. 1, 2022) (SpaceX August 1, 2022 *Ex Parte*); *Ex Parte* Presentation of Kuiper Systems, LLC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (filed Aug. 4, 2022) (Kuiper August 4, 2022 *Ex Parte*); Letter from Jarrett S. Taubman, Vice President and Deputy Chief, Government Affairs, Viasat, Inc., to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Aug. 24, 2022) (Viasat August 24, 2022 Letter); Letter from David Goldman, Senior Director, Satellite Policy, Space Exploration Technologies Corp., to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Aug. 29, 2022) (SpaceX August 29, 2022 Letter); *Ex Parte* Presentation of Viasat, Inc., IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (filed Aug. 29, 2022) (Viasat August 29, 2022 *Ex Parte*); *Ex Parte* Presentation of Kuiper Systems, LLC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (filed Sept. 6, 2022) (Kuiper September 6, 2022 *Ex Parte*); Comments of the Natural Resources Defense Counsel and International Dark Sky Association, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (filed Sept. 7, 2022) (NRDC/IDA Comments); Letter from Professor Andy Lawrence, Institute for Astronomy, University of Edinburgh, to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Sept. 18, 2022) (Andy Lawrence September 18, 2022 Letter); Letter from Jarrett S. Taubman, Vice President and Deputy Chief, Government Affairs, Viasat, Inc., to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Sept. 19, 2022) (Viasat September 19, 2022 Letter); Letter from Jameson Dempsey, Principal, Satellite Policy, Space Exploration Technologies Corp., to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Sept. 21, 2022) (SpaceX September 21, 2022 Letter); Letter from Mark Phillips, President, the Astronomical Society of Edinburgh, to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Sept. 23, 2022) (The Astronomical Society of Edinburgh September 23, 2022 Letter); Letter from Sierra Solter Hunt, PhD Candidate in Plasma Physics, University of Iceland, to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Sept. 23, 2022) (Sierra Solter Hunt September 23, 2022 Letter); Letter from Pantelis Michalopoulos, Counsel, DISH Network Corporation, to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Sept. 23, 2022) (DISH September 23, 2022 Letter); Letter from Tyler Kokjohn, to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Sept. 26, 2022) (Tyler Kokjohn September 26, 2022 Letter); Letter from Samantha Lawler, Assistant Professor for Astronomy, University of Regina, to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Sept. 30, 2022) (Samantha Lawler September 30, 2022 Letter); Letter from Carrie Nugent, Associate Professor of Computational Physics and Planetary Science, Olin College of Engineering, to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Sept. 30, 2022) (Carrie Nugent September 30, 2022 Letter); Letter from Jarrett S. Taubman, Vice President and Deputy Chief, Government Affairs, Viasat, Inc., to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Oct. 4, 2022) (Viasat October 4, 2022 Letter); Letter from Meredith Rawls, University of Washington Department of Astronomy, to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Oct. 5, 2022) (Meredith Rawls October 5, 2022 Letter); Letter from Roberto Trotta, Imperial College London and International School for aDvanced Study, Trieste, Italy, to

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III. DISCUSSION

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Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00055 (dated Oct. 6, 2022) (Roberto Trotta October 6, 2022 Letter); Letter from David Goldman, Senior Director, Satellite Policy, Space Exploration Technologies Corp., to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Oct. 6, 2022) (SpaceX October 6, 2022 Letter); Letter from Cameron Nelson, Tenzing Startup Consultants, to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Oct. 10, 2022) (Cameron Nelson October 10, 2022 Letter); Letter from Graeme Cuffy to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Oct. 11, 2022) (Graeme Cuffy October 11, 2022 Letter); Letter from Jarrett S. Taubman, Vice President and Deputy Chief, Government Affairs, Viasat, Inc., to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Oct. 13, 2022) (Viasat October 13, 2022 Letter); letter from Jennifer A. Manner, Senior Vice President, Regulatory Affairs, Echostar Satellite Services LLC. and Hughes Network Systems LLC, Jeff Blum, Executive Vice President, Legislative and Regulatory Affairs, DISH Network Corporation, Stacy Fuller, Senior Vice President, External Affairs, DIRECTV LLC, Jarrett S. Taubman, VP and Deputy Chief Government Affairs, Viasat, Inc., Donna Bethea-Murthy, Senior Vice President, Global Regulatory Affairs, Inmarsat, Inc., to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Oct. 14, 2022) (GSO Operators October 14, 2022 Letter); Letter from David Goldman, Senior Director, Satellite Policy, Space Exploration Technologies Corp., to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Oct. 17, 2022) (SpaceX October 17, 2022 Letter); Letter from Jameson Dempsey, Principal, Satellite Policy, to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Oct. 20, 2022) (SpaceX October 20, 2022 Letter); Letter from Jameson Dempsey, Principal, Satellite Policy, to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Oct. 24, 2022) (SpaceX October 24, 2022 Letter); Letter from Melissa Shipp, to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Oct. 26, 2022) (Melissa Shipp October 26, 2022 Letter); SpaceX October 27, 2022 Letter; Letter from Pantelis Michalopoulos, Counsel, DISH Network Corporation, to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Oct. 27, 2022) (DISH October 27, 2022 Letter); Letter from David Goldman, Senior Director, Satellite Policy, Space Exploration Technologies Corp., to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Oct. 27, 2022) (SpaceX October 27, 2022 Letter); Letter from Pantelis Michalopoulos, Counsel, DISH Network Corporation, to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Nov. 4, 2022) (DISH November 4, 2022 Letter); Letter from Jarrett S. Taubman, VP and Deputy Chief Government Affairs, Viasat, Inc., to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Nov. 7, 2022) (Viasat November 7, 2022 Letter); Letter from David Goldman, Senior Director, Satellite Policy, Space Exploration Technologies Corp., to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Nov. 10, 2022) (SpaceX November 10, 2022 Letter); Letter from Professor Mike Edmunds, President, Royal Astronomical Society, to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Nov. 10, 2022) (RAS November 10, 2022 Letter); Letter from Pantelis Michalopoulos, Counsel, DISH Network Corporation, to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (dated Nov. 16, 2022) (DISH November 16, 2022 Letter); *Ex Parte* Presentation of Echostar Satellite Services LLC. and Hughes Network Systems LLC, DISH Network Corporation, DIRECTV LLC, Viasat, Inc., Inmarsat, Inc., IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (filed Nov. 17, 2022) (GSO Operators November 17, 2022 *Ex Parte*); Letter from Michael J. Carlson, Corporate Counsel, Kuiper Systems LLC., to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20200526-00055, SAT-AMD-20210818-00105, and SAT-LOA-20170301-00027 (dated Nov. 17, 2022) (Kuiper November 17, 2022 Letter); *Ex Parte* Presentation of Space Exploration Holdings, LLC, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (filed Nov. 17, 2022) (SpaceX November 17, 2022 *Ex Parte*); Letter from David Goldman, Director, Satellite Policy, Space Exploration Technologies Corp. to Marlene H. Dortch, Secretary, FCC (dated Nov. 24, 2021); Letter from Pantelis Michalopoulos, Counsel to DISH Network Corporation to Marlene H. Dortch, Secretary, FCC (dated Nov. 28, 2022) (DISH November 28, 2022 Letter).

10. After our review of the record, we conclude that granting in part the SpaceX Gen2 Starlink application, as amended, subject to the requirements and conditions specified herein, will serve the public interest. Below, we address the various outstanding issues raised by commenters on SpaceX's application. Where appropriate we defer matters of general applicability to ongoing or potential future rulemakings.

A. Procedural Matters

11. *Status of amendment.* Our satellite licensing rules require that a major amendment to an existing application be treated as a newly filed application, which would necessitate the opening of or consideration in a new processing round.[62] An amendment is considered major if it would increase the potential for interference, change the frequencies to be used or the orbital location of the satellites, require the application to be reviewed under the National Environmental Policy Act (NEPA), or if it is deemed by the Bureau to be substantial under section 309 of the Communications Act.[63] SpaceX states that its amendment, filed after the deadline for the 2020 Ku/Ka-band processing round, will not cause any additional interference as compared to its original application and is therefore a minor amendment.[64] SpaceX also argues that in the event of an in-line interference event, the large number of Gen2 Starlink satellites will provide flexibility to avoid interference while continuing service to customers, by utilizing other non-interfering or interference-free Starlink satellites.[65] Several operators, however, argue that SpaceX's amendment may be major under our rules because it could cause additional interference to satellite and terrestrial operators due to its increased power levels, its proposed decrease in elevation angles in the Ku-band, and its proposed effective number of co-frequency, co-polarization satellite beams communicating with any given location on the Earth's surface across Gen1 Starlink and Gen2 Starlink combined.[66] With the conditions we impose herein, we find SpaceX's amendment to be minor, as their operations will not cause increased interference to other operators.[67]

12. *Unbuilt system rule.* Our rules state that applicants holding an authorization for one licensed-but-unbuilt NGSO-like satellite system in a particular frequency band will not be permitted to apply for another NGSO-like satellite system in that frequency band.[68] In its December 23, 2021 letter, the Satellite Division requested SpaceX address the applicability of this rule to Gen2 Starlink, noting that it would use the same frequencies as Gen1 Starlink and that at the time of the Satellite Division's information request SpaceX had neither completed deployment of Gen1 Starlink nor deployed half of its satellites in accordance with Commission milestone requirements.[69] In response, SpaceX quotes the Commission's reasoning in adopting the Unbuilt System Rule, arguing that the Commission clarified that it would not accept "applications from entities with more than one pending application for an NGSO-like system, or more than one NGSO system where no satellites have been launched, in any frequency band," and so as long as an operator had launched one satellite in its constellation, the system is considered

[62] *See* 47 CFR § 25.116(c).

[63] *See* 47 CFR § 25.116(b).

[64] *See* SpaceX Amendment, Narrative at 6-7, Technical Attachment, Annex 2A, at Figures A2A-I.1 and A2A-V.2; SpaceX Consolidated Opposition, at 35.

[65] *See* SpaceX Amendment, Narrative at 6-7.

[66] *See* Kuiper Reply at 20; RS Access Reply at 6; DISH September 23, 2022 Letter at 10. We also note that, before SpaceX filed its Consolidated Opposition, which included its EPFD analysis, DISH, Viasat, and Echostar/Hughes argued that with no EPFD analysis from SpaceX, it was impossible to evaluate whether the amendment was major or minor—not even SpaceX could be certain it is a minor amendment. *See* DISH Petition at 11; Viasat Petition at 18-19; Echostar/Hughes Reply at 2.

[67] We consider the application of NEPA to this application below.

[68] *See* 47 CFR § 25.159(b).

[69] *See* Satellite Division December 23, 2021 Information Request at 1-2.

built.[70] SpaceX argues that because it had launched more than 1,900 satellites in its Gen1 system as of January 2022, its system is not "unbuilt."[71]

13. Several commenters argue that the unbuilt system rule should be interpreted consistent with milestone requirements, so that a licensee must deploy at least half of a system before its application for a second system in the same frequency bands can be submitted.[72] We agree that the purpose of the Unbuilt System Rule is to discourage speculative applications, but find that even when examining SpaceX's deployment beyond the first Gen1 Starlink satellite, there would be no reasonable basis for a concern with speculation. When SpaceX filed its Gen2 Starlink application in May 2020, it had launched roughly 420 Gen1 Starlink satellites, nearly one tenth of the 4,408 satellites in its modified authorization. At that time, SpaceX was launching satellites on a monthly basis with plans for that cadence to become more frequent. Moreover, at the time that the application was accepted for filing, SpaceX had launched more than 1900 satellites and was by then launching on average every week to two weeks. In any event, we find that it is not necessary to waive the unbuilt system rule, as SpaceX has demonstrated that its Gen1 Starlink constellation can be considered "built" for purposes of that provision and is not speculative.

14. With respect to objections that SpaceX should have submitted the instant request as an application for modification of its Gen1 Starlink system,[73] we see no basis for requiring filing in this format. SpaceX seeks to launch nearly 30,000 additional satellites with a significantly different design from its Gen1 Starlink satellites, and therefore submitting the application so as to treat it as a separate request is consistent with the underlying facts of the planned deployment.

15. *Technically-identical replacements.* Viasat argues that SpaceX has not provided enough information about the physical and technical characteristics of its Gen2 Starlink satellites to give the Commission a baseline on which to evaluate if replacements are technically identical for purposes of a Commission rule that permits launch of such satellites.[74] Viasat argues that SpaceX must provide the number of beams on each satellite, number of channels per beam, number of co-frequency reuses per satellite, and satellite and earth station antenna masks, especially regarding sidelobes, along with satellite mass and cross-sectional area.[75] Viasat stresses that this information is crucial for the Commission to have and review prior to any grant of authority for the Gen2 Starlink system.[76]

16. SpaceX subsequently provided the physical characteristics and associated factual material such as sample logs from NASA's Debris Assessment Software (DAS) for the current designs of its Gen2

[70] *See* SpaceX January 7, 2022 Response to Satellite Division Information Request at 3, 4 (quoting *Amendment of the Commission's Space Station Licensing Rules and Policies,* 18 FCC Rcd 10760, para. 233 (2003)); SpaceX Consolidated Opposition at 58-65. SpaceX argues that for NGSO systems deployed over a series of launches, it cannot be considered unbuilt if it has begun launches. SpaceX also notes that it is providing service to paying customers, so its system cannot be unbuilt. *See* SpaceX Consolidated Opposition at 62-63.

[71] *See* SpaceX January 7, 2022 Response to Satellite Division Information Request at 3, 4 (quoting *Amendment of the Commission's Space Station Licensing Rules and Policies,* 18 FCC Rcd 10760, para. 233 (2003)); SpaceX Consolidated Opposition at 58-65.

[72] *See* RS Access Petition at 1, 3-6; Echostar/Hughes Reply at 2 (citing 47 CFR § 25.164(b)); RS Access Reply at 7-10. RS Access argues that since both the Unbuilt System Rule and the milestone requirements are meant to discourage speculative applications and prevent spectrum warehousing, the two rules should be interpreted in tandem.

[73] *See* Viasat Petition at 70-71; Viasat Reply at 59-62; RS Access Reply at 9-10.

[74] *See* Viasat Petition at 19 (citing 47 CFR § 25.113(i)).

[75] *Id.*; Viasat Reply at V, 23.

[76] *See* Viasat Petition at 19. Viasat argues this is particularly true because, according to Viasat, SpaceX has modified its satellite design in the past without informing the Commission.

Starlink satellites.[77] This information was sufficient for us to complete our review of the application and forms the basis for our grant of authority for SpaceX to construct, deploy, and operate satellites, including technically identical replacement satellites for the Gen2 Starlink system.[78] We remind SpaceX that should it wish to change these characteristics on its satellites, it will need to apply for a license modification, and we condition this authorization as we conditioned the *SpaceX Third Modification Order*: SpaceX must operate consistent with the technical specifications provided to the Commission as part of its application, including any supplemental specifications. The relevant technical information includes antenna beam patterns; GSO avoidance angle; physical characteristics; frequencies used for satellite communications, including outside the United States; and other technical information. Should SpaceX wish to alter these technical specifications, it must apply for a license modification from the Commission.

17. *Ongoing litigation.* As part of its opposition and motions, The Balance Group filed a motion "to await conclusion of pending directly intertwined litigation."[79] The Balance Group argues the record for SpaceX's third modification of its Gen1 Starlink system is still open, and this record has made clear SpaceX's Gen1 Starlink constellation will "brighten and alter the night sky" from sunlight reflected from satellites, which will have major impacts to the environment, animal migration, human health, and astronomical observation.[80] On August 26, 2022, the D.C. Circuit upheld the Commission's decision in the *SpaceX Third Modification Order*, resolving the ongoing litigation.[81] We therefore dismiss The Balance Group's motion as moot.

18. *Partial grant.* On June 24, 2022, Kuiper filed an *ex parte* presentation in which it noted both complicated issues raised in the record and SpaceX's goal to help close the digital divide, and therefore recommended that the Commission grant SpaceX's Gen2 Starlink constellation in part and defer in part.[82] Kuiper points out that many of the concerns with SpaceX's application, as amended, stem from the sheer size of its proposed constellation, including the concerns about space safety, interference into other NGSO systems, and EPFD emissions.[83] Kuiper argues a partial grant would allow SpaceX to begin deploying its Gen2 Starlink system without the severe impacts other operators fear coming to pass, while the Commission continues to evaluate the complex and novel issues on the record before it.[84] Kuiper suggests this approach would be similar to the Commission's approach with the Gen1 system, where it provided SpaceX a partial grant for ten satellites to allow SpaceX to begin deploying its satellites while consideration of the record continued.[85] In this instance, Kuiper recommends that the Commission grant SpaceX authority to deploy the satellites included in one of its eighteen ITU filings, with appropriate conditions to protect other operators and space safety.[86] Professor Andy Lawrence also argues that any

[77] *See* SpaceX October 4, 2022 Letter, Exhibit B.

[78] *See* 47 CFR § 25.113(i).

[79] *See* The Balance Group Opposition at 1.

[80] *Id.* at 3-4.

[81] *See Viasat, Inc. v. FCC*, 47 F.4th 769 (D.C. Cir. 2022).

[82] *See* Kuiper June 24, 2022 *Ex Parte* at 1-2; Kuiper August 4, 2022 *Ex Parte* at 1.

[83] *See* Kuiper June 24, 2022 *Ex Parte* at 2; Kuiper August 4, 2022 *Ex Parte* at 2.

[84] *See* Kuiper June 24, 2022 *Ex Parte* at 1-2; Kuiper September 6, 2022 *Ex Parte* at 1-2.

[85] *See* Kuiper June 24, 2022 *Ex Parte* at 3-4.

[86] *See* Kuiper June 24, 2022 *Ex Parte* at 4; Kuiper August 4, 2022 *Ex Parte* at 2. Kuiper's proposed conditions include requiring SpaceX to protect participants in earlier processing rounds, requiring SpaceX to share its beam-pointing information, limiting SpaceX's operations to at or below 580 km, and both denying SpaceX's waiver request to begin operations prior to obtaining an ITU filing and requiring SpaceX to specify that its entire constellation will jointly comply with the ITU and Commission applicable EPFD limits. Kuiper states that the Commission should apply these conditions to grant of any subset of SpaceX's Gen2 Starlink satellites. *See* Kuiper

(continued….)

authorization of SpaceX's proposed Gen2 Starlink constellation should happen incrementally to assess the impact on astronomy and the space ecosystem.[87]

19. We find a partial grant for 7,500 satellites is in the public interest, as conditioned in this Order. This action will allow SpaceX to begin deployment of its Gen2 Starlink satellites, which hold the prospect for improved broadband to unserved and underserved regions of the United States and worldwide. The satellites will incorporate updated technology that will improve overall Starlink system capacity. We note the specific subset of 7,500 satellites we authorize today, which may be deployed at altitudes of 525 km, 530 km, and 535 km, will also result in deferral of consideration of SpaceX's proposed satellites at lower and higher altitudes, for which some parties have raised concerns that are unique to the particular orbits involved. The smaller number of satellites will allow continued monitoring of deployment based on conditions adopted in this Order, prior to consideration of the much larger number of satellites SpaceX requests over the long term. We also note that SpaceX recently notified the Commission that following issuance of a Gen2 Starlink license, it intends to seek a modification of its V-band authorization to harmonize the orbital parameters of those V-band space stations with those requested in the Gen2 Starlink application and operate them using additional radio equipment to be added to a subset of SpaceX's proposed Gen2 Starlink satellites, and not as separate spacecraft.[88] SpaceX states that this modification will not increase, and may slightly reduce, the number of V-band space stations.[89] Given this information, we note that, including its 4,408 Gen1 Starlink satellites and the 7,500 Gen2 Starlink satellites authorized today and not counting the 7,518 V-band satellites SpaceX no longer intends to launch, the total number of satellites SpaceX is authorized to deploy is not increased by our action today, and in fact is slightly reduced, as compared to the total number of satellites SpaceX would potentially have deployed absent today's action. We also note that the Commission has on a number of occasions granted authority for constellation deployments in smaller, incremental tranches.[90] Here, the public interest would be served by taking this approach in order to permit monitoring of developments involving this large-scale deployment and permit additional consideration of issues unique to the other orbits SpaceX requests.[91] We therefore authorize the launch of up to 7,500 satellites in the three shells SpaceX plans to populate first, 525 km, 530 km, and 535 km.

B. Public Interest Analysis

20. According to SpaceX, the Gen2 Starlink constellation will provide faster speeds, lower latency, more backhaul capacity, and the ability to serve more customers.[92] SpaceX states the Starship launch vehicle will carry more satellites and place them in a way that allows for faster activation, and the Gen2 Starlink constellation will build upon the Gen1 Starlink constellation by arranging satellites in a manner to maximize capacity and bring satellite broadband connectivity to unserved and underserved areas of the United States and worldwide, including areas long thought to be impossible to serve and areas

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June 24, 2022 *Ex Parte* at 2-3; Kuiper August 4, 2022 *Ex Parte* at 2-4. We discuss these proposed conditions in greater detail below.

[87] *See* Andy Lawrence September 18, 2022 Letter at 2.

[88] *See* SpaceX October 27, 2022 Letter at 2.

[89] *Id.*

[90] *See, e.g.*, Spire, Hawkeye 360.

[91] *See generally* SpaceX Third Modification Partial Grant, 36 FCC Rcd 122 (IB 2021)(granting SpaceX authority to deploy ten satellites to modified operational altitudes while the Commission continued to consider the more complex issues raised on the record of the third SpaceX modification of its Gen1 Starlink system).

[92] *See* SpaceX August 2, 2021 *Ex Parte* Attachment at 3; SpaceX September 22, 2021 *Ex Parte* at 1; SpaceX November 10, 2021 *Ex parte* Attachment at 3; SpaceX December 6, 2021 *Ex Parte* at 1; SpaceX December 20, 2021 *Ex Parte* at 1; SpaceX Consolidated Opposition at I, 3; SpaceX May 18, 2022 *Ex Parte* at 1.

facing natural or manmade disasters.[93] SpaceX aims for its Gen2 Starlink constellation to help close the homework gap, facilitate telework and telehealth, improve precision agriculture technology, and support first responders and national security needs.[94] Viasat asserts that the sheer size of the proposed Gen2 Starlink constellation raises a number of substantial risks to competition, the interference environment, space safety, and the human environment that the Commission must consider when evaluating whether a grant of the Gen2 Starlink application, as amended, is in the public interest.[95] Viasat alleges that granting the Gen2 Starlink constellation would be contrary to the public interest because it would foreclose competition,[96] by precluding other operators' access to shared spectrum[97] and orbital resources.[98] Viasat states that SpaceX would also have no incentives to share spectrum or orbital resources with other operators because it will have significant leverage in negotiations with other operators.[99] SpaceX argues that it has demonstrated in its application, as amended, that its Gen2 Starlink constellation will maintain safe space, protect other operators, and minimize its impact on the human environment.[100] Furthermore,

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[93] *See* SpaceX Amendment, Narrative at 1-2; SpaceX Consolidated Opposition at I, 3; SpaceX April 7, 2022 Letter at 1; SpaceX May 18, 2022 *Ex Parte* at 1.

[94] *See* SpaceX Amendment, Narrative at 8; SpaceX Consolidated Opposition at I, 3.

[95] *See* Viasat Petition at I, V, 2-4; Viasat Reply at 1; Viasat May 16, 2022 Letter at 1. Viasat points out that the Commission recognized these risks when authorizing SpaceX's much smaller third modification of its Gen1 Starlink constellation, but the Commission granted that modification based on assumptions about and continued monitoring of SpaceX's real-world performance. In this case, Viasat maintains the Commission cannot assume away these risks to the public interest, and so the Commission should defer consideration of Gen2 Starlink at the very least until SpaceX has completed deployment of Gen1 Starlink. *See* Viasat Petition at I, V, 2-4; Viasat Reply at 2.

[96] *See* Viasat Petition at I, 2, 4-12; Viasat Reply at I, 2-9; Viasat May 16, 2022 Letter at 1, 3-4, n.15.

[97] *See* Viasat Petition at I-II, 4-9; Viasat Reply at III, 2-3. Viasat's argument is that SpaceX would foreclose access to shared spectrum from other operators because SpaceX's system will cause interference to smaller systems 100% of the time, which would trigger band-splitting between the operators, causing loss of capacity for the smaller operators while SpaceX would be unaffected because of its vast number of satellites and consequent ability to choose other satellites to avoid the same loss of capacity. Viasat states the problems stem from specific traits of the Gen2 Starlink constellation, including the colossal number of satellites and their configuration, not, as SpaceX argues, the Commission's sharing rules in general. *See* Viasat Reply at 4. Viasat further argues that the public interest harms Gen2 Starlink would cause would also directly contradict the goals of section 25.261: to allow equal access to available spectrum, to foster an environment where no licensee can impede the operations of any other licensee and to allow multiple operators to use the full bandwidth of spectrum for a majority of operating time. According to Viasat, Gen2 Starlink would prevent smaller operators from accessing spectrum on equal terms with SpaceX, limiting that access to a fraction of the available operating time, and allowing SpaceX to impede other operators' access to spectrum. *See* Viasat Reply at 4-5 (citing *The Establishment of Policies and Service Rules for the Non-Geostationary Satellite Orbit, Fixed Satellite Service in the Ku-Band,* 17 FCC Rcd 7841, at para. 27, 29 (2002)).

[98] *See* Viasat Petition at I-II, 10-12; Viasat Reply at III, 6-7. Viasat alleges the size of SpaceX's proposed Gen2 Starlink constellation would effectively preclude 86 percent of the altitudes between 360 km and 700 km for other use, and other operators would not be able to access LEO without SpaceX's permission. Viasat states this is not solely because of the sheer number of satellites, but also because of SpaceX's proposed orbital tolerances of -50 km and +70 km, which Viasat argues are overly wide and effectively create two vast shells of Gen2 Starlink satellites, one from 290 km to 430 km and the other from 475 km to 684 km. *See* Viasat Petition at 11; Viasat Reply at III, 6-7. Viasat further argues the Commission recognized in the *SpaceX Third Modification Order* that it will be difficult for SpaceX to share orbital resources with other operators, and so it restricted SpaceX's operations to below 580 km to avoid overlap with Kuiper's constellation, and now the Commission is evaluating deployment of more than ten times the number of satellites at issue in the SpaceX Third Modification Order. *See* Viasat Petition at 12; Viasat Reply at 7-8.

[99] *See* Viasat Petition at I-II, 4—10, 12.

[100] *See* SpaceX Consolidated Opposition at 39-43; SpaceX May 18, 2022 *Ex Parte* at 1. SpaceX points to the Commission's finding in the *SpaceX Third Modification Order* that other operators would be able to share LEO with

(continued….)

SpaceX argues the Gen2 Starlink constellation will be a pro-competitive force in the American market.[101] SpaceX states Gen2 Starlink will complement Gen1 Starlink in the same way terrestrial operators densify their networks, to better meet American consumers' needs.[102]

21. We address the specific issues raised by the parties to this proceeding below. We conclude that a partial grant of the application, subject to conditions, will effectively facilitate SpaceX's efforts to deploy satellites with next generation capabilities that will help to address the pressing need for improved broadband connectivity, including in unserved and underserved areas of the United States, while not materially changing the total number of satellites authorized to SpaceX. Our action also will further the US leadership in space-based services, facilitating coverage globally and helping the efforts to close the digital divide around the world.

C. Waiver Requests

1. Standard of Review

22. As part of our grant, we also address SpaceX's waiver requests. Generally, the Commission may waive any rule for good cause shown.[103] Waiver is appropriate where the particular facts make strict compliance inconsistent with the public interest.[104] In making this determination, we may take into account considerations of hardship, equity, or more effective implementation of overall policy on an individual basis.[105] Waiver is therefore appropriate if special circumstances warrant a deviation from the general rule and such deviation will serve the public interest.[106]

2. Request for Waiver of In-Band TT&C Requirement

23. We grant SpaceX's request for waiver of our rules in order to permit TT&C operations in the 13.85-14.0 GHz band, as conditioned. Our rules require that TT&C signals be transmitted within frequency bands assigned for regular communications, preferably at the band edges.[107] We find that grant of this waiver is warranted. First, the requested band is immediately adjacent to the 14.0-14.5 GHz band used by the SpaceX system for user terminal uplink transmissions; second, SpaceX anticipates that it will provide TT&C from only two locations in the United States (on the East and West Coasts respectively); and third, SpaceX will comply with the requirements of footnotes to both the U.S. and international frequency allocation tables pertaining to this band,[108] and will not claim protection from radiolocation

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SpaceX's Gen1 Starlink system and argues that the same is true for its Gen2 Starlink system. SpaceX also argues that several other operators have deployed satellites in altitudes similar to the Gen1 Starlink constellation, and many other operators have filed applications to deploy NGSO satellites to similar orbits, even after SpaceX filed its Gen2 Starlink application, and so SpaceX's application has demonstrably not foreclosed access to orbital resources or competition. SpaceX points out that it has not opposed other applications for systems in similar orbits and has in fact supported several other applications, and SpaceX argues that it does not have a veto power in the Commission's satellite licensing process. *See S*paceX Consolidated Opposition at 39-41 (citing *SpaceX Third Modification Order*, 36 FCC Rcd at 8032-33, para. 66).

[101] *See* SpaceX Consolidated Opposition at 39-43.

[102] *Id.* at 39.

[103] 47 CFR § 1.3.

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

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

[106] *Northeast Cellular*, 897 F.2d at 1166.

[107] *See* 47 CFR § 25.202 (g)(1).

[108] *See* 47 CFR § 2.106, fns. 5.502 and US356.

transmitting stations operating in accordance with the U.S. Table of Frequency Allocations.[109] Furthermore, we note that while the Commission has restricted FSS deployment in the 13.75-14.0 GHz band to gateways only, it has specifically defined gateways to include TT&C operations.[110]

3. Request for Waiver of Downlink PFD Limits and Associated Certification Requirement

24. SpaceX states that Gen2 Starlink does not comply with the Ka-band power flux-density (PFD) limits using the interference calculation methodology applied in the rule, which is in turn based on provisions incorporated by reference from the ITU Radio Regulations.[111] SpaceX states that it is not able to certify that Gen2 Starlink will comply with the ITU PFD limits governing NGSO FSS systems in the 17.7-19.3 GHz band.[112] SpaceX states that, as with its Gen1 Starlink constellation, the ITU methodology for establishing the Ka-band PFD limits in these bands was not developed with a capability to scale up for application to dynamically controlled NGSO constellations with more than 840 satellites.[113] In the SpaceX Gen1Starlink Authorization, the Commission imposed a condition under which SpaceX must provide a technical showing demonstrating that its operation will protect an FS station with the characteristics described in Recommendation ITU-R SF.1483.[114] We found that SpaceX satisfied this requirement in the *SpaceX Third Modification Order*.[115] To that end, in this proceeding, SpaceX has submitted a technical showing with respect to the Gen2 Starlink System and protection of FS stations.[116] We find that SpaceX's technical showing demonstrates it will protect a terrestrial FS station in the Ka-band with the characteristics described in Recommendation ITU-R SF.1483. In view of this technical showing, we find that it would serve the public interest to grant the waiver.

4. Request for Waiver of Various Limitations in the Schedule S Software

25. As required by the Commission's rules,[117] SpaceX has submitted with its application a completed Schedule S, which contains certain technical information in a prescribed form. However, SpaceX has found that it cannot accurately describe its system in certain respects due to limitations in Schedule S itself.[118] SpaceX cites six aspects of the Gen2 System that fall into this category: (1) the impracticability of submitting complete orbital parameter data for the Gen2 System using the Schedule S

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[109] *See* SpaceX Gen2 Amendment, Waiver Requests at 1-2.

[110] *See Amendments of Parts 2 and 25 of the Commission's Rules to Permit Operation of NGSO FSS Systems Co-Frequency with GSO and Terrestrial Systems in the Ku-Band Frequency Range*, 16 FCC Rcd 4096, para. 29 (2000) (*Ku-Band NGSO Order*); 47 CFR § 25.103 (definition provides that an "NGSO FSS gateway earth station may also be used for telemetry, tracking, and command transmissions and is not for the exclusive use of any customer.").

[111] *See* SpaceX Gen2 Amendment, Waiver Requests at 2. *See also* 47 CFR 25.146 (a)(1), which states:

> "(a) An NGSO FSS applicant proposing to operate in the 10.7-30 GHz frequency range must certify that it will comply with:
>
> (1) Any applicable power flux-density levels in Article 21, Section V, Table 21-4 of the ITU Radio Regulations (incorporated by reference, § 25.108), except that in the 19.3-19.4 GHz and 19.6-19.7 GHz bands applicants must certify that they will comply with the ITU PFD limits governing NGSO FSS systems in the 17.7-19.3 GHz band."

[112] *See* SpaceX Gen2 Amendment, Waiver Requests at 2.

[113] *Id.* at 2-3.

[114] *Id.* at 3. *See also* SpaceX Gen1 Authorization, 33 FCC Rcd at 3405, para. 35.

[115] *See SpaceX Third Modification Order*, 36 FCC Rcd at 8026, para. 52.

[116] *See* SpaceX Gen2 Amendment, Waiver Requests at 3. Technical Attachment, Annex 1 at A1-A10.

[117] *See* 47 CFR § 25.114(a)(1).

[118] *See* SpaceX Gen2 Amendment, Waiver Requests at 5-7.

web form; (2) the inability to enter "not applicable" under the section 25.114(c)(4)(v) request for maximum and minimum Saturation Flux Density values, as this question only applies to "bent pipe" systems; (3) the inability to enter a negative value for maximum Effective Isotropic Radiated Power (EIRP) for some of SpaceX's TT&C beams; (4) the inability to enter more than two digits for the active service arc end angle; (5) the inability to enter any channel plan other than a single, static channel plan; and (6) the impracticability of entering all possible contours for a representative satellite at all altitudes as contemplated by section 25.114(c)(4)(vi)(B).[119] SpaceX has provided information on how it completed the Schedule S and additional information to compensate for these difficulties, as appropriate, and SpaceX requests that we waive these aspects of Schedule S, to the extent necessary.[120] Because SpaceX has implemented work-arounds to provide the relevant information on its application, we find that a waiver of the requirement to complete certain aspects or fields of Schedule S is warranted.

D. Certification of Compliance with Applicable Equivalent Power Flux Density Limits and Request for Waiver of Requirement for ITU Finding Prior to Initiation of Service

26. Under the applicable rules, an applicant proposing operations in the 10.7-30 GHz frequency range must certify that it will comply with applicable EPFD limits in Article 22, Section 2, and Resolution 76 of the ITU Radio Regulations, which have been incorporated by reference into our rules.[121] Additionally, prior to beginning service, an NGSO operator licensed to operate in the 10.7-30 GHz frequency range must obtain a favorable or qualified favorable finding from the ITU regarding its compliance with applicable EPFD limits, in accordance with Resolution 85 of the ITU Radio Regulations.[122] The operator must then communicate the ITU finding to the Commission and submit the input data files used for the ITU validation software for public disclosure.[123] A number of operators raise concerns involving SpaceX's certification of compliance with EPFD limits.[124] SpaceX's initial approach of splitting its proposed constellation into eighteen separate filings,[125] and SpaceX's actual compliance with applicable single-entry EPFD limits[126] and aggregate EPFD limits.[127]

27. As an initial matter, we decline to reconsider our rule relying on ITU review for

[119] *Id.*

[120] *Id.*

[121] *See* 47 CFR § 25.146(a)(2).

[122] *See* 47 CFR § 25.146(c).

[123] *Id.*

[124] We note that DISH and others initially argued that SpaceX's certification was insufficient because it did not appear to be based on any data or analysis. These parties pointed out that SpaceX had offered to make its input datafiles for the ITU software available for interested parties to confirm SpaceX's compliance with applicable EPFD limits, but when they requested the datafiles from SpaceX in January 2022, SpaceX stated that the input datafiles did not exist because SpaceX had not yet completed them after amending its application in August 2021. In other words, these parties argue that SpaceX certification was baseless, because it certified it would comply with the applicable EPFD limits in its amendment without even knowing if it could in fact comply. *See generally* DISH Motion for Abeyance; Viasat January 31, 2022 Letter; SES/O3b February 1, 2022 Letter; Echostar/Hughes Comments.

[125] *See, e.g.,* Viasat Petition at 15-17, 24; SES/O3b Petition at I, 2, 7-8, 13; Echostar/Hughes Reply at 1-2; Kuiper Reply at 20-21; SES/O3b Reply at I, 2-3, 4-5; Viasat Reply at III, 9, 10; GSO Operators October 14, 2022 Letter at 1.

[126] *See, e.g., Vias*at August 24, 2022 Letter at 2, Technical Annex; Kuiper Reply at 18-19; DISH Reply at 14-16.

[127] *See, e.g.,* SES/O3b Petition at II, 2-3, 12, 15-17; SES/O3b Reply at I-II, 2-3, 7-8; Viasat Petition at II, 13-14, 22; Viasat Reply at 3, 5-6, 11, 12; DISH Reply at 18-19; Viasat May 16, 2022 Letter at 1-2; Viasat July 18, 2022 Letter Technical Annex.

evaluating compliance with EPFD limits, as DISH requests.[128] We continue to find that the ITU is in the best position to review compliance with applicable EPFD limits. As discussed above and in the *SpaceX Third Modification Order*, under our rules, any analysis demonstrating compliance, or lack of compliance, with applicable EPFD limits must be completed using the ITU-approved validation software.[129] We therefore decline to reconsider the three studies DISH submitted in the *SpaceX Third Modification* proceeding, which it incorporates by reference into this proceeding,[130] and we also decline to consider the additional analyses submitted by DISH and Viasat analyzing Gen2 Starlink using software modified to evaluate EPFD compliance at different locations than the ITU-approved software.[131] We also decline to adopt DISH's request to inform the ITU that Gen2 Starlink cannot be modeled by the ITU-approved software,[132] as we see no evidence on the record that this is the case—in fact multiple operators, including DISH, have used the ITU-approved software to model SpaceX's system.

28. We also reject DISH's assertion that the Commission is unlawfully delegating its authority to the ITU. "[A] federal agency entrusted with broad discretion to permit or forbid certain activities may condition its grant of permission on the decision of another entity . . . so long as there is a reasonable connection between the outside entity's decision and the federal agency's determination."[133] Such a connection exists here. A "favorable" finding by the ITU provides verification that the operator of a non-geostationary satellite system complies with the ITU's EPFD limits. By complying with those limits, the operator satisfies its "obligation" under our rules not to "cause unacceptable interference to" geostationary satellite networks.[134] Thus, a "favorable" finding by the ITU is clearly linked to our determination that a licensee can provide non-geostationary fixed-satellite service without causing harmful interference. Moreover, there is no improper subdelegation here because the ITU merely provides us "with factual information" --that is, whether SpaceX complies with the ITU's power limits.[135]

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[128] *See* DISH Petition at 8, 24-26. DISH argues that its three studies from the SpaceX third modification proceeding demonstrate that the Gen1 Starlink system will cause interference in real-world scenarios, and the ITU validation software did not model that correctly, so it is impossible that the ITU validation software will correctly model Gen2 Starlink. *Id.*

[129] *See* SpaceX Third Modification Order, 36 FCC Rcd at 8021, para. 40 ("the relevant analysis under the Commission's rules is analysis using ITU-approved software.").

[130] *See* DISH Petition at 5-6, 13-15.

[131] *Id.* at Exhibit 1; DISH Reply at 7-8; GSO Operators October 14, 2022 Letter at 2. DISH states that it made several assumptions in this study because at the time it did not have SpaceX's EPFD analysis. *See* DISH Petition, Exhibit 1; DISH Reply at 7-8. The study further states that assessing the impact of neighboring satellites would also worsen the interference environment, and this impact cannot be ignored given the sheer number of proposed satellites. *See* DISH Petition, Exhibit 1; DISH Reply at 7-8. Viasat's analysis examines interference into a GSO earth station in Miami, Florida, and Viasat found that SpaceX would exceed the EPFD limits with emissions at levels from 2.6 times the EPFD limits (when considering one of SpaceX's ITU filings) and up to 18.6 times the limits (when considering the entire Gen2 Starlink constellation). *See* GSO Operators October 14, 2022 Letter at 2. The GSO operators argue that SpaceX's analysis uses unrealistic assumptions, such as theoretical GSO earth stations located in the middle of the Caribbean Sea or the Pacific Ocean, locations entirely outside the United States and where GSO earth stations are unlikely to exist at all, and so SpaceX's analysis does not demonstrate it will protect GSO earth stations. *Id.*

[132] *See* DISH Petition at 8, 24-26. DISH argues that its three studies from the SpaceX third modification proceeding demonstrate that the Gen1 Starlink system will cause interference in real-world scenarios, and the ITU validation software did not model that correctly, so it is impossible that the ITU validation software will correctly model Gen2 Starlink. *Id.*

[133] *See United States Telecom Ass'n v. FCC*, 359 F.3d 554, 567 (D.C. Cir. 2004).

[134] 47 CFR § 25.289.

[135] *United States Telecom*, 359 F.3d at 567.

We also find no merit in DISH's claim that it has been denied due process.[136] To begin with, DISH has no constitutionally protected property right to use its satellites to provide FCC-licensed service.[137] Therefore, DISH cannot assert a due process violation.[138] In any event, there was no due process violation here. DISH has received a full opportunity to participate in this proceeding. The Due Process Clause requires nothing more.

29. SpaceX argues that the current methodology of evaluating compliance with EPFD limits is overly protective of GSO operations and too restrictive for NGSO operators.[139] As discussed above, we decline to deviate from our rule of relying on ITU review of compliance with EPFD limits. This issue is outside the scope of this licensing proceeding.[140]

30. While we follow the general approach set forth in the *SpaceX Third Modification Order*, we also recognize the differences in the issues raised by the record before us in this proceeding, as noted by Viasat and Kuiper.[141] We note that several operators state that they have analyzed SpaceX's compliance with applicable EPFD limits by running SpaceX's input datafiles through the ITU-approved software without any modifications. Viasat, DISH, and Kuiper state that they found that evaluating the eighteen separate filings on an individual basis, as SpaceX did in the analysis provided in its Consolidated Opposition, would result in significant exceedance to the applicable EPFD limits.[142] DISH claims that when running the SpaceX input files through the ITU validation software, combining SpaceX's 18 separate filings into one input datafile but making no modifications to SpaceX's input parameters or the parameters of the software, Gen2 Starlink will violate the EPFD limits in the 12.2-12.7 GHz band by as

[136] *See* DISH September 23, 2022 Letter at 2-3, 6-9. DISH originally raised this argument before the D.C. Circuit in its appeal of the *SpaceX Third Modification Order*, but as it acknowledges, the court did not reach the merits of its arguments because it was not raised before the Commission. DISH therefore raises this argument before the Commission in this proceeding. *Id.* SpaceX disputes DISH's stance in its October 17, 2022 Letter. *See* SpaceX October 17, 2022 Letter at 4-5.

[137] *See FCC v. Sanders Bros. Radio Station*, 309 U.S. 470, 475 (1940) (an FCC licensee does not obtain "a property right as a result of the granting of a license"); *Mobile Relay Assocs. v. FCC*, 457 F.3d 1, 12 (2006) (the right to use spectrum under an FCC license "does not constitute a property interest protected by the Fifth Amendment").

[138] *See Cleveland Bd. of Educ. v. Loudermill*, 470 U.S. 532, 538 (1985).

[139] *See* SpaceX Consolidated Opposition at IV, 23-24, Exhibit 2; SpaceX August 19, 2022 Letter at 6; SpaceX October 17, 2022 Letter at 3. SpaceX argues the current methodology for evaluating compliance with EPFD limits "pil[es] a series of worst-case assumptions on top of one another," that the current regime forces operators to reduce power across their systems, even in locations where there are no GSO customers, and also penalizes NGSO operators for using more efficient steerable beams, which reduces capacity for customers. *See* SpaceX Consolidated Opposition at IV, 23-24, Exhibit 2. Kuiper agrees with SpaceX that the ITU validation software is too conservative, and the rules are ambiguous regarding multiple ITU filings, but Kuiper also agrees with the GSO operators that an operator could use multiple ITU filings to get around the EPFD limits. *See* Kuiper Reply at 21.

[140] As the D.C. Circuit has explained, "an agency need not--indeed, should not--entertain a challenge to a regulation, adopted pursuant to notice and comment, in an adjudication or licensing proceeding." *Viasat Inc. v. FCC*, 47 F.4th at 776 (quoting *Trib. Co. v. FCC*, 133 F.3d 61, 68 (D.C. Cir. 1998)). Therefore, in this proceeding, the Commission "must 'adhere to its own rules and regulations.'" *Ibid*. (quoting *AT&T Corp. v. FCC*, 448 F.3d 426, 434 (D.C. Cir. 2006). We note that the ongoing work of ITU-R Working Party 4A involve the methodology to be used to determine conformity of an NGSO satellite system in the FSS with the EPFD limits contained in Article 22 of the Radio Regulations, and the World Radio Conference 23 Agenda item 7 Topic D2 considers any agreed revisions to Recommendation ITU-R S.1503-3. https://www.itu.int/en/ITU-R/study-groups/rcpm/Pages/wrc-23-studies.aspx.

[141] *See* Kuiper Comments at 27-28; Kuiper Reply at 17; Viasat Petition at 22-23; Viasat Reply at 15-16; Viasat September 19, 2022 Letter at 6-7, N.26; GSO Operators October 14, 2022 Letter at 3-4.

[142] *See* Viasat August 24, 2022 Letter at 2, Technical Annex; Kuiper Reply at 18-19; DISH Reply at 14-16. *See also* DISH November 28, 2022 Letter at 1-2.

much as 4.5 dB for 45 CM direct-broadcast satellite (DBS) antennas.[143] Viasat states that it conducted its analysis of the Gen2 Starlink constellation as a whole by first running all eighteen filings through the ITU validation software, with no alterations to the software or the datafiles SpaceX provided, then combining the resulting EPFD curves using standard techniques for the sum of independent variables.[144] Viasat states that its analysis demonstrates Gen2 Starlink, when considered as a whole, would violate the EPFD limits in every frequency band.[145] Viasat states that the single-entry EPFD limits are exceeded by as much as 7.6-11.8 dB depending on the case.[146] Viasat claims that it found several cases where SpaceX would violate the EPFD limits 1%, 10%, and even 100% of the time, and it argues that violations of this magnitude could well cause significant interference to GSO operations and degrade service from DBS, direct-to-home (DTH), and other GSO networks SpaceX seeks to compete with.[147]

31. SpaceX has submitted a single combined filing to the International Bureau, including an input datafile and output file for all of its proposed Gen2 Starlink satellites at the staff's request so as to facilitate preparation for ITU coordination activities.[148] In this record, SpaceX confirms that this combined filing demonstrates compliance with all applicable EPFD limits.[149] We treat this representation on the record as part of SpaceX's certification of ITU compliance. We also find that SpaceX's segmentation of its system into 18 separate ITU filings is reasonable as SpaceX consulted ITU staff on how to present datafiles for purposes of PFD analysis,[150] and followed the general practice of presenting the complete technical parameters for spectrum assignments in an individual file. The parties' characterization of SpaceX's method used to prepare ITU data files as intended to manipulate the ITU process is not well founded. With respect to EPFD, we find that SpaceX's certification of compliance with the EPFD limits,[151] along with the conditions we adopt herein, including the requirement to obtain a finding from the ITU that explicitly indicates the ITU has considered the joint effect of SpaceX's multiple ITU filings, would ensure that SpaceX's Gen2 Starlink system will comply with the EPFD limits which should protect GSO operations from harmful interference[152]

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[143] *See* DISH Reply at 1-2, 7-8, 12, 17-18; GSO Operators October 14, 2022 Letter at 1-2, 2-3.

[144] *See* Viasat July 18, 2022 Letter at 3, Technical Annex.

[145] *Id.*

[146] *Id.* Technical Annex.

[147] *Id.* at 3, Technical Annex.

[148] *See* 47 CFR § 0.457(d)(1)(vii)(B).

[149] *See* SpaceX October 27, 2022 Letter at 2. SpaceX also cites the *SpaceX Third Modification Order* in support of its approach of splitting its system into multiple ITU filings. *See* SpaceX Consolidated Opposition, at 28 (citing *SpaceX Third Modification Order*, 36 FCC Rcd at 8018, para. 34); SpaceX October 4, 2022 Letter at 1; SpaceX November 10, 2022 Letter at 1.

[150] *See* SpaceX August 19, 2022 Letter, at 6, 7.

[151] *See* SpaceX October 27, 2022 Letter at 2 (stating that its combined EPFD data files, when analyzed with the ITU-approved validation software, comply with the applicable EPFD limits). *See* SpaceX Gen2 Amendment, Technical Attachment at 14 (certifying the Gen2 Starlink constellation, as amended, will comply with all EPFD limits); *see also e.g.,* SpaceX Consolidated Opposition, at 31; SpaceX August 19, 2022 Letter at 8-9; SpaceX November 10, 2022 Letter at 1.

[152] Viasat, DISH, and SES/O3b argue that because SpaceX split its system into 18 separate ITU filings, its ITU filings did not reflect how its system would actually operate and the ITU would not be capable of accurately reviewing SpaceX's EPFD compliance. These operators further posit that SpaceX split its system in an attempt to get around the EPFD limits. *See* Viasat Reply at III, 9, 10, 14; SES/O3b Petition at 14; DISH Reply at 2, 16; DISH Nov. 28, 2022 Letter at 1-2.

32. Kuiper, SES/O3b, and Viasat propose some additional conditions to allow SpaceX to operate without causing harmful interference to GSO operations.[153] We decline to adopt Kuiper's proposed condition to require SpaceX to operate its satellites with the power levels proposed in its original application.[154] As SpaceX has certified that its entire Gen2 Starlink constellation, including all proposed 29,988 satellites, will comply with the applicable EPFD limits, we find Kuiper's proposed condition would be unnecessary for this partial grant. This is particularly true given that we only authorize SpaceX to deploy 7,500 of its satellites in this Order, roughly one quarter of SpaceX's proposed Gen2 Starlink constellation. Similarly, we decline to adopt Viasat's proposed condition, which would require review by the Commission and interested parties of a combined EPFD data file to include all of SpaceX's Gen1 Starlink and Gen2 Starlink satellites as analyzed by a modified ITU software.[155] As we continue to rely on the ITU's review, Viasat's proposed condition, which would require modifications to the ITU-approved software, would be inappropriate.[156] However, as a condition of the waiver to permit operations prior to completion of the ITU review process, we do require SpaceX to provide its input and output data files using its combined EPFD analysis to interested parties, similar to how we conditioned the *SpaceX Third Modification Order*. We also require SpaceX to obtain a finding from the ITU that explicitly indicates the ITU has considered the joint effect of SpaceX's multiple ITU filings, as the Commission conditioned Kuiper's authorization in 2020.[157]

33. SES/O3b requests that we condition any grant of Gen2 Starlink such that SpaceX "must

[153] *See* Kuiper Reply at 17-22; SES/O3b Petition at 14-15; SES/O3b Reply at 12.

[154] *See* Kuiper Reply at 17-22. Kuiper states the EPFD levels are considerably higher in the amendment than in the original application, and this is caused by an increase in EIRP masks. According to Kuiper, requiring SpaceX to use the lower EIRP masks described in its original application would resolve many of the complex issues the Commission must grapple with for this application. *Id.*

[155] *See* Viasat August 24, 2022 Letter at 3-5. Specifically, Viasat proposes the Commission condition any grant of the Gen2 Starlink application such that, prior to launching any satellites, SpaceX is required to submit, publicly and on the record, an EPFD analysis evaluating all 34,396 satellites included in Gen1 Starlink and Gen2 Starlink. Viasat further elaborates that this analysis should evaluate all 34,396 Starlink satellites as a single system (including Gen1 Starlink and Gen2 Starlink satellites), no matter how many ITU filings SpaceX has split its satellites into, and the EPFD analysis should be completed using Transfinite's Visualyse EPFD software and should: "(i) evaluate a representative grid of 24 test points located across the United States; and (ii) consider all orbital locations at which the Commission has licensed Ka-band satellites or authorized Ka-band satellites to serve the United States." Viasat emphasizes that only after the Commission finds that SpaceX will comply with all applicable single-entry EPFD limits should SpaceX be permitted to deploy the satellites covered by the analysis, conditioned on operations consistent with the parameters in the analysis, including but not limited to PFD masks, EIRP masks, GSO avoidance angle, and Nco values. Viasat next proposes, if SpaceX's analysis does not demonstrate compliance with all applicable single-entry EPFD limits, the Commission should require SpaceX to develop a comprehensive operating plan for meeting all EPFD limits at all test points and for all orbital locations, such as "reducing the number of operating Starlink satellites and/or the planes in which they operate, modifying PFD or EIRP masks, increasing avoidance angle, or reducing Nco values." Viasat requests that SpaceX then be required to submit its operating plan publicly on the record, along with a new EPFD analysis consistent with the updated parameters in its comprehensive operating plan, to demonstrate compliance with all applicable single-entry EPFD limits, and if the Commission approves the plan and the analysis, SpaceX may then deploy its satellites subject to the condition that it operates these satellites consistent with the updated parameters in its comprehensive operating plan and compliant EPFD analysis. Similarly, Viasat argues that before SpaceX makes changes to the input parameters of its operations, SpaceX should be required to get Commission approval for a new EPFD analysis. Viasat argues that this approach will allow SpaceX to choose the parameters it will operate under while also ensuring compliance with EPFD limits. *Id.*

[156] *See SpaceX Third Modification Order*, 36 FCC Rcd at 8021, para. 40 ("the relevant analysis under the Commission's rules is analysis using ITU-approved software.").

[157] *See* GSO Operators October 14, 2022 Letter at 1 (citing *Kuiper Systems, LLC,* Order and Authorization, 35 FCC Rcd 8324, para. 26 (2020) (Kuiper NGSO Authorization).

make available to any requesting party within 30 days of the request: the data used as input to the ITU-approved validation software to demonstrate compliance with applicable Equivalent Power Flux Density (EPFD) limits as well as the EPFD results it obtained by running the ITU software, along with confirmation that the EPFD input data files and results reflect the operations of its complete system pursuant to all ITU filings associated with its NGSO satellite constellation."[158] We find it is in the public interest to continue to require SpaceX to provide its EPFD input datafiles to requesting parties, particularly given our grant of SpaceX's partial waiver request to allow it to begin operations prior to obtaining an ITU finding. We therefore condition this partial grant accordingly: SpaceX must make available to any requesting party the data used as input to the ITU-approved validation software to demonstrate compliance with applicable limits, including the data that combine the Gen2 satellites into one consolidated file.

34. Subsequent to SpaceX's submission of its combined input datafile and output file for all of its proposed Gen2 Starlink satellites, and prior to this grant, Viasat, DISH, and Kuiper requested the Commission require SpaceX to provide its combined data file on the record, and Viasat requested that we allow all interested parties at least 45 days to review the data file and provide their comments to the Commission.[159] As discussed above, the data files were provided to the International Bureau staff in response to the staff's request to facilitate ITU coordination. We reject Viasat's and DISH's requests as these requests are based on the mistaken premise that we would be considering the substance of the combined data file—rather than focusing on SpaceX's certification—in reaching our decision in this licensing proceeding.[160] The conditions we apply to this authorization, including the requirement that SpaceX obtain a favorable ITU finding regarding EPFD compliance and that the finding from the ITU explicitly indicate the ITU has considered the joint effect of SpaceX's multiple ITU filings, as well as the requirement for SpaceX to provide its combined EPFD datafile to interested parties, provide important protections to GSO operations from harmful interference. Additionally, although we grant a partial waiver of our rules to permit SpaceX to commence operations prior to obtaining such a finding from the ITU, as discussed below, SpaceX proceeds at its own risk and must adjust its operations if it does not receive a favorable finding from the ITU. Notably, SpaceX has certified that the combined files do satisfy the applicable EPFD limits, pursuant to our rules.[161] We conclude that nothing in our rules requires other parties' independent confirmation of SpaceX's EPFD analysis using the ITU software to protect them from harmful interference. Since we need not and do not consider the substance of the combined data file in reaching our decision here, we thus reject parties' requests for access to those data,

[158] SES/O3b Petition at 14-15; SES/O3b Reply at 12. Additionally, SES/O3b states, "to enable reproduction of the results, the EPFD data input information must include all SRS and mask databases used to evaluate compliance, along with the software settings needed to run the Transfinite program." SES/O3b Petition at 15; *see also* Viasat January 31, 2022 Letter at 4-5; Viasat Petition at 18-19, 28. Viasat argues without this information, it is impossible to evaluate whether SpaceX's input parameters are reasonable. *See* Viasat Reply at 15. SES/O3b points out that SpaceX is requesting deployment with neither Commission nor ITU review, and there needs to be some assurance SpaceX will not cause harmful interference to GSO operators. *See* SES/O3b Reply at 12-13.

[159] *See* DISH November 4, 2022 Letter at 1, 2; Viasat November 7, 2022 Letter at 1, 3; DISH November 16, 2022 Letter; GSO Operators November 17, 2022 *Ex Parte* at 2; Kuiper November 17, 2022 Letter. SpaceX and these operators debate whether SpaceX's submission to the Bureau constitutes an unauthorized *ex parte* communication under the Commission's rules. *See* DISH November 4, 2022 Letter at 1; Viasat November 7, 2022 Letter at 2; SpaceX November 10, 2022 Letter at 2; DISH November 16, 2022 Letter; GSO Operators November 17, 2022 *Ex Parte* at 2; Kuiper November 17, 2022 Letter.

[160] As noted above, by having the combined data file the Commission is in a position to coordinate with the ITU separate and apart from any analysis we conduct in this proceeding.

[161] The Commission's rules impose an enforceable duty of truthfulness on licensees, *see* 47 CFR § 1.17(a)(1), (b)(1), 47 U.S.C. § 312(a), and the Commission properly relies on representations made in licensing proceedings. *See Contemp. Media, Inc. v. FCC*, 214 F.3d 187, 193 (D.C. Cir. 2000) ("[E]ffective regulation is premised upon the agency's ability to depend upon the representations made to it by its licensees").

and for time to evaluate them, prior to our issuance of this Order. The International Bureau staff's request for this information was solely pursuant to the discharge of the Commission's obligation as the relevant administration in order to ensure that the ITU may evaluate this question on a complete record in accordance with its established procedures.[162] In the event any GSO operators may experience actual harmful interference from SpaceX, they may report such interference to the Commission and we will take appropriate action.

35. As to Viasat's concerns regarding SpaceX's GSO avoidance angle,[163] SpaceX has clarified that it intends to operate at full power when at an angle of 18 degrees or more with respect to the GSO arc, but it intends to continue operations at smaller angles, reducing power to comply with EPFD limits in accordance with our rules, down to angles less than 10 degrees with respect to the GSO arc.[164] We note that Viasat has raised no further concerns regarding SpaceX's GSO avoidance angle. We find SpaceX's proposed GSO avoidance angle plan would be sufficient to protect GSO operators from harmful interference. We also find it unnecessary to condition this authorization to require SpaceX to maintain a GSO avoidance angle sufficient to protect GSO operators, as Viasat requests.[165] We are conditioning SpaceX to operate its constellation with all technical parameters described in its application, as amended, and any supplemental information submitted on the record, and this would include its GSO avoidance angle.

36. SES/O3b, Viasat, and DISH also argue that for purposes of compliance with aggregate EPFD limits, SpaceX's Gen1 Starlink and Gen2 Starlink systems must be considered as a single system, and that based on their analysis, these operators have found that SpaceX will violate the aggregate EPFD limits.[166] SpaceX argues that the plain language of the Commission's Order adopting the certification requirement, that "[a]ny NGSO FSS *system* operating in compliance with these limits is considered as having fulfilled its obligation under Article 22 of the ITU Radio Regulations not to cause unacceptable interference to any GSO network," makes clear that the rule applies not to all operations of an applicant as SES/O3b and Viasat suggest, but to individual systems.[167] Furthermore, SpaceX argues that Gen1 Starlink and Gen2 Starlink are separate systems and will otherwise be treated as separate systems by the Commission, including for purposes of milestone and bond requirements, for processing round rules, and for regulatory fees, and so the Commission should treat Gen2 Starlink as distinct from Gen1 Starlink in this respect as well.[168] SpaceX points out that its licenses have been conditioned, and will continue to be conditioned, on SpaceX coordinating with other NGSO operators to meet the aggregate EPFD limits.[169] We decline to require SpaceX to combine its Gen1 Starlink and Gen2 Starlink systems for purposes of

[162] Independently, insofar as Viasat argues that constitutional due process requires that it have access to the datafile, *see* Viasat November 7, 2022 Letter at 3, we also separately reject that argument on the grounds that Viasat has not identified a constitutionally-protected interest that is implicated.

[163] *See* Viasat Petition at 20-22.

[164] *See* SpaceX August 19, 2022 Letter at 9.

[165] *See* Viasat Petition at 21.

[166] *See, e.g.,* SES/O3b Petition at II, 2-3, 12, 15-17; SES/O3b Reply at I-II, 2-3, 7-8; Viasat Petition at II, 13-14, 22; Viasat Reply at 3, 5-6, 11, 12; DISH Reply at 18-19; Viasat May 16, 2022 Letter at 1-2; Viasat July 18, 2022 Letter Technical Annex.

[167] *See* SpaceX Consolidated Opposition, at 28 (quoting *Update to Parts 2 and 25 Concerning Non-Geostationary, Fixed-Satellite Service Systems and Related Matters,* 32 FCC Rcd 7809, para. 32 (2017)); SpaceX August 19, 2022 Letter, at 8-9.

[168] *See* SpaceX August 19, 2022 Letter, at 8-9.

[169] *See* SpaceX Consolidated Opposition, at 42. Viasat objects that this condition is not sufficient, as SpaceX will use all the allotted aggregate EPFD on its own, and so there will be no negotiations because there will be no room for other NGSO systems to operate without violating the aggregate EPFD limits. *See* Viasat Reply, at 6.

meeting aggregate EPFD limits. SpaceX must coordinate with other operators in good faith to meet the aggregate EPFD limits.

37. *Partial Waiver Request to Initiate Service*. As discussed above, under section 25.146(c) of our rules, an NGSO FSS operator licensed to operate in the 10.7-30 GHz frequency range must obtain a favorable or qualified-favorable finding regarding its compliance with all applicable EPFD limits from the ITU Radiocommunication Bureau prior to the initiation of service.[170] This requirement is in accordance with Resolution 85 of the ITU Radio Regulations, which the Commission has incorporated by reference into its rules.[171] However, SpaceX requests a partial waiver of this requirement so it may commence operations prior to receiving an ITU finding.[172] SpaceX states that the backlog of applications being reviewed by the ITU means SpaceX is unlikely to receive a finding within a timeframe that matches its aggressive deployment strategy, and without a waiver, it would be forced to delay deployment, thereby delaying service to unserved and underserved Americans and causing gigahertz of spectrum to go underutilized.[173] SpaceX notes the Commission waived this requirement for its Gen1 Starlink constellation, allowing SpaceX to proceed at its own risk and requiring it to adjust its operations should it receive an unfavorable finding from the ITU.[174] SpaceX argues this waiver strikes the right balance between ensuring compliance with applicable EPFD limits while permitting SpaceX to begin operations and requests the Commission grant this waiver, with the condition that SpaceX must still receive a favorable or qualified-favorable finding from the ITU and must adjust its operations should it receive an unfavorable finding, as it did for the Gen1 Starlink constellation.[175]

38. Multiple commenters argue that SpaceX has not demonstrated good cause to grant the waiver.[176] Viasat and Kuiper argue the fact that the Commission granted such a waiver for Gen1 Starlink does not entitle SpaceX to a similar waiver for Gen2 Starlink, especially given the increased interference concerns raised on the record for Gen2 Starlink, and Viasat points to several distinctions between the two applications which weigh against granting a waiver for Gen2 Starlink.[177] Viasat further argues that the

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[170] *See* 47 CFR § 25.146(c).

[171] *See* 47 CFR § 25.146(c) (citing 47 CFR § 25.108).

[172] *See* SpaceX Gen2 Amendment, Waiver Requests at 3. We note that SpaceX originally described its request as a request for waiver of section 25.146(a), which requires certification of compliance with all applicable PFD and EPFD limits in the 10.7-30 GHz bands, as opposed to section 25.146(c), which requires operators to obtain a favorable or qualified favorable finding from the ITU prior to commencing operations. *Id*.; *see also* 47 CFR § 25.146(a), (c).

[173] *See* SpaceX Gen2 Amendment, Waiver Requests at 4.

[174] *Id.*

[175] *Id.*

[176] Specifically, these commenters argue that waiver would undermine the purpose of the rule; the inconvenience to SpaceX and its business plans is of SpaceX's own making; SpaceX should be subject to the same processes and requirements as other NGSO operators; the Commission's grant of a similar waiver to SpaceX in the past and the D.C. Circuit's ruling on the appeal of the *SpaceX Third Modification Order* do not justify a waiver in this case; and the rationale for the waiver for Gen1 Starlink, to speed deployment to unserved and underserved areas of the United States, has been satisfied and does not apply to the Gen2 Starlink satellites, especially since SpaceX has not yet completed deployment of its Gen1 Starlink system. *See* DISH Petition, at 22-24; SES/O3b Petition at 10-11; Viasat Petition, at II-III, 30-31; Viasat Reply, at 18; Echostar/Hughes Reply, at 2-3; Kuiper Comments, at 19, 21; Kuiper Reply, at 15; SES/O3b Reply, at 8-9, 11; DISH Reply, at 4, 7, 21, 22-24.

[177] *See* Kuiper Reply, at 16; Viasat Petition, at 31-32; Viasat Reply, at 18-19. Viasat and SES/O3b point out that the waiver for the Gen1 Starlink constellation was based on SpaceX's analysis of its entire system. While that analysis is still disputed, Viasat and SES/O3b recognize that the Commission did not base its decision solely on SpaceX's certification, and it should not do so here. *See* Viasat Petition, at 31-32; SES/O3b Petition at 9-10; SES/O3b Reply at 5.

D.C. Circuit's decision on the *SpaceX Third Modification Order* does not require the Commission to grant the waiver in this case, especially given Viasat's belief that there is substantial evidence that SpaceX will violate the EPFD limits.[178] DISH, Viasat, and Kuiper also argue that the rationale for the waiver that was granted for Gen1 Starlink—the need to speed deployment to close the digital divide—has been satisfied and is not an effective rationale for Gen2 Starlink, especially given that SpaceX has not completed deployment of Gen1 Starlink.[179]

39. SpaceX points out that the waiver it seeks would only be a partial waiver—SpaceX would still need to secure a favorable or qualified favorable finding from the ITU and adjust its operations if necessary.[180] In other words, the waiver allows SpaceX to deploy its Gen2 Starlink satellites at its own risk.[181] SpaceX will only be able to deploy a limited number of satellites before the ITU completes its review, and should it receive an unfavorable finding and need to adjust its operations, the effect of this limited number of satellites will be far less than the effect of the entire constellation.[182] SES/O3b argues that limited number could be in the thousands,[183] and given SpaceX's history, SpaceX will continue to modify its Gen2 Starlink system, requiring additional ITU filings and creating an indefinite stretch of time where GSO operators have no assurance that their operations will be protected, while SpaceX launches even more satellites.[184] Viasat argues that grant of the waiver would result in no regulatory body conducting meaningful review of SpaceX's EPFD compliance, and so SpaceX's argument that grant of the waiver would still leave adequate protections for GSO operators is a meritless defense.[185] Viasat states that given the significant concerns raised on the record, the waiver should be denied.[186]

40. We find it is in the public interest to grant SpaceX's partial waiver request and allow it to begin deployment as soon as possible to bring next-generation service to unserved and underserved areas of the country and globally. We recognize that this is a different record from the SpaceX Gen1 Starlink application, but as discussed above, we remain confident in our certification requirements and the ITU review process. We agree with SpaceX that the same factors that existed when we granted a partial waiver for Gen1 Starlink exist today: the benefits to the public in allowing SpaceX to begin deployment of its more advanced Gen2 Starlink system as quickly as possible, the timeframe for expected ITU review of SpaceX's filings, and SpaceX's certification and EPFD analysis. We also emphasize that this is only a partial waiver of our rules. SpaceX must still obtain a favorable or qualified-favorable ITU finding and communicate that finding to us, however SpaceX may commence operations with the 7,500 satellites authorized today prior to receiving that ITU finding. We also note that deployment under this partial waiver is at SpaceX's own risk. Should SpaceX receive an unfavorable finding from the ITU, it must

[178] *See* Viasat September 19, 2022 Letter, at 7.

[179] *See* DISH Petition at 22-24; DISH Reply at 21-22; Viasat Petition at 31-32; Viasat Reply at 18-19; Kuiper Reply at 17. Viasat and SES/O3b also argue SpaceX's justification that it needs to avoid delay so it can deploy faster falls flat, especially given that SpaceX did not produce its EPFD input datafiles and analysis until February 2022. Inconvenience to the applicant is not good cause for a waiver. *See* SES/O3b Reply at II, 9, 11; Viasat Reply at 19-20.

[180] *See* SpaceX Consolidated Opposition at 31.

[181] *Id.*

[182] *Id.*

[183] *See* SES/O3b Reply at 11.

[184] *See* SES/O3b Petition at 11-13; SES/O3b Reply at II, 9, 11. SES/O3b argues that GSO operators could be without protection for years, and if the ITU finds SpaceX must adjust its operations to come into compliance with the applicable EPFD limits, that would only apply going forward—there is no cure for past interference. *See* SES/O3b Reply at II, 9, 11.

[185] *See* Viasat Petition at 28-31; Viasat Reply at 20.

[186] *See* Viasat Petition at 28-31; Viasat Reply at 20.

adjust its operations accordingly to come into compliance with all applicable EPFD limits. Finally, we note that in the event GSO operators experience harmful interference from SpaceX, they may report such interference to the Commission and we will take appropriate action. Therefore, for the reasons set forth above, we grant SpaceX's request for a waiver of section 25.146(c) of our rules.

E. Frequencies Included in the 2020 Processing Round

41. SpaceX proposes communications between its satellites and user terminals in the Ku-band and between its satellites and both user terminals and gateway earth stations in the Ka-band.[187] Below, we address SpaceX's proposed use of, and specific comments regarding, each frequency band included in the 2020 processing round. We also address general conditions regarding SpaceX's participation in the 2020 processing round, including SpaceX's obligations to its fellow 2020 processing round participants and operators licensed in earlier Ku- and Ka-band processing rounds.

1. Ku-Band Frequencies

42. SpaceX proposes to communicate between its Gen2 Starlink satellites and customer user terminals in the 10.7-12.75 GHz (space-to-Earth), 12.75-13.25 GHz (Earth-to-space), and 14.0-14.5 GHz (Earth to space) frequency bands.[188] SpaceX also proposes TT&C downlink operations in the 12.15-12.25 GHz band and TT&C uplink operations in the 13.85-14.0 GHz band.[189] We note that SpaceX does not request general authority to operate in the 12.7-12.75 GHz band in the United States but does request authority to transmit to individually licensed earth stations.[190] Specifically, SpaceX proposes a minimum antenna gain of 34 dBi and a maximum antenna gain of 44 dBi.[191] SpaceX also proposes maximum EIRP density between -11.9 dBw/MHz and -8.3 dBw/MHz, depending on the operational altitude of the satellites.[192] SpaceX states that as a satellite steers its Ku-band beam, it adjusts power to maintain a constant PFD on the surface of the Earth.[193] SpaceX states all of its Ku-band operations will comply with the PFD limits on the surface of the Earth.[194] Specifically, SpaceX explains its operations will comply with the PFD limits in the 10.7-11.7 GHz band, and because these limits are lower than the PFD limits in the 11.7-12.7 GHz band, SpaceX will also comply with the limits in those bands.[195] Additionally, SpaceX states the maximum EIRP for its downlink TT&C operations in the 12.15-12.25 GHz band is always lower than the minimum EIRP for user links in this band, and so the PFD is less than the PFD produced by the user links, and so SpaceX's TT&C downlink operations in the 12.15-12.25 GHz band comply with the PFD limits as well.[196] SpaceX has clarified that it will observe a minimum elevation angle of 25 degrees for Ku-band communications with all satellites below 62 degrees latitude and will only operate with a minimum elevation of 5 degrees for user terminals in polar regions above 62 degrees latitude,

[187] *See* SpaceX Gen2 Application, Narrative at 10.

[188] *Id.*

[189] *Id. at* 11.

[190] *Id.* at 11, n.17. SpaceX states it intends to communicate in the 12.7-12.75 GHz band in other areas of the world outside the United States. *Id.*

[191] *Id.*, Technical Attachment at 7.

[192] *Id.* Technical Attachment at 7. We note that in its original application, SpaceX proposed maximum EIRP values from -12.2 dBW/MHz to -7.3 dBw/MHz. *See* SpaceX Gen2 Application, Technical Attachment at 8.

[193] *See* SpaceX Gen2 Amendment, Technical Attachment at 6.

[194] *Id.* at 12.

[195] *Id.* at 11.

[196] *Id.* at 11, n.8.

consistent with its proposed operations in the Ka-band and E-band.[197] We grant SpaceX's request to communicate in the 10.7-12.7 GHz (space-to-Earth), 12.75-13.25 GHz Earth-to-space, and 14.0-14.5 GHz Earth-to-space frequency bands, subject to the conditions below. We also grant SpaceX's request to communicate in the 12.7-12.75 GHz (space-to-Earth) frequency band outside the United States.

43. In the 10.7-11.7 GHz frequency band, SpaceX's operations are authorized up to the applicable PFD limits set forth in section 25.208(b) of our rules and up to the applicable EPFD limits of Article 22 of the ITU Radio Regulations, as well as Resolution 76 (Rev. WRC-15) of the ITU Radio Regulations. SpaceX's operations in the 10.7-11.7 GHz band must also be coordinated with the radioastronomy observatories listed in footnote US131 of the United States Table of Frequency Allocations[198] to achieve a mutually acceptable agreement regarding the protection of the radio telescope facilities operating in the 10.6-10.7 GHz band.

44. SpaceX's operations in the 11.7-12.2 GHz band are similarly authorized up to the applicable PFD limits in Article 21 of the ITU Radio Regulations, and up to the applicable EPFD limits of Article 22 of the ITU Radio Regulations, as well as Resolution 76 (Rev. WRC-15) of the ITU Radio Regulations.

45. SpaceX's operations in the 12.2-12.7 GHz band are authorized up to the PFD limits in section 25.208(o) of our rules[199] and Article 21 of the ITU Radio Regulations, and up to the EPFD requirements of Article 22 of the ITU Radio Regulations, as well as Resolution 76 (Rev. WRC-15) of the ITU Radio Regulations. DISH objects to SpaceX's proposed use of the 12.2-12.7 GHz band.[200] In addition to its comments on SpaceX's compliance with applicable EPFD limits discussed above, DISH argues that the nearly sevenfold increase in the number of satellites from SpaceX's Gen1 Starlink to a combined Gen1 Starlink and Gen2 Starlink will result in sidelobe energy from more than one thousand satellites affecting any given area, which is equivalent to the effects of six or more satellites focusing on that area.[201] DISH argues this is true even if SpaceX's NCo, the number of co-frequency, co-polarization satellite beams transmitting to any given spot on the Earth's surface, is one.[202] DISH and Viasat also object that allowing SpaceX proposed use of the 12.2-12.7 GHz band would violate the condition on Gen1 Starlink requiring SpaceX to operate with an NCo of 1 in the band because SpaceX is treating Gen1 Starlink and Gen2 Starlink as separate constellations that can both communicate with the same user terminals.[203] DISH argues that SpaceX has admitted that it will effectively operate with an NCo of 2 across its Gen1 Starlink and Gen2 Starlink systems, which would gut the condition in the *SpaceX Third Modification Order* meant to protect DBS systems in the 12.2-12.7 GHz band from interference from

[197] *See* SpaceX August 19, 2022 Letter at 6. Originally, SpaceX stated that it plans to operate Ku-band user links with a minimum elevation angle of 25 degrees but will use a minimum elevation angle of five degrees when communicating with satellites in the 604 km and 614 km shells. This appeared to differ from SpaceX's proposed elevation angles for its Ka-band and E-band communications, for which SpaceX proposes minimum elevation angles of five degrees only in regions above 62 degrees latitude. *See* SpaceX January 7, 2022 Response to Satellite Division Information Request at 4-5.

[198] *See* 47 CFR § 2.106, fn. US131.

[199] *See* 47 CFR § 25.208(o).

[200] *See* DISH Petition at 1.

[201] *Id.* at 4-5, 15-19.

[202] *Id.* at 4-5, 15-19. DISH again cites the three studies it submitted on the record of the SpaceX Third Modification proceeding to demonstrate that the sidelobe energy from the SpaceX satellites will result in an effective NCo greater than one, even if SpaceX's nominal NCo is 1. *Id.* at 5-6, 13-15. *See also* DISH November 28, 2022 Letter at 2 (citing DISH Reply at Exh. 1).

[203] *Id.* at 16; Viasat July 18, 2022 Letter at 1; DISH October 27, 2022 Letter at 2. SpaceX has clarified that it will operate with an NCo of 1 across the entire Gen2 Starlink constellation, which it reiterates as separate from the Gen1 Starlink constellation. *See* SpaceX August 19, 2022 Letter at 7; SpaceX October 17, 2022 Letter at 3.

SpaceX's system.[204]

46. DISH is correct that we found in the *SpaceX Third Modification Order* that limiting SpaceX's operation in the 12.2-12.7 GHz band to an NCo of 1 would be sufficient to protect DBS systems from harmful interference,[205] however we agree with SpaceX that its Gen2 Starlink system is a separate system from its Gen1 Starlink system. If we were analyzing this situation with a SpaceX system and an NGSO system operated by another operator, we would not require the two systems to maintain a combined NCo of 1. We would instead require both systems to maintain an NCo of 1 on an individual basis, and we find the same approach is appropriate in this case. SpaceX is required to operate within the EPFD limits and a system operating within the EPFD limits is deemed not to cause harmful interference to GSO systems. We also note that while transmitting to the same geographic location from one satellite in each of its systems could increase SpaceX's capacity, SpaceX will need to operate so as not to cause interference to itself. The measures that SpaceX takes to prevent its own systems from interfering with each other should also reduce the risk that SpaceX's operations will cause harmful interference to the GSO operators. We find all these factors are sufficient to protect DBS operators like DISH. We therefore condition this authorization, consistent with SpaceX's commitment on the record of this proceeding, such that SpaceX must operate its Gen2 Starlink constellation with an NCo of 1, in the 12.2-12.7 GHz (space-to-Earth) frequency band. In other words, SpaceX may not use more than one satellite beam from any of its authorized Gen2 Starlink satellites in the same frequency in the same or overlapping areas at a time. As discussed above should DBS or other GSO operators experience actual interference from SpaceX, the Commission will take appropriate action, which could include, but is not limited to, requiring SpaceX to operate with an NCo of 1 across both its Gen1 Starlink and Gen2 Starlink constellations in this band.

47. DISH also argues that the increase in satellites operating below 400 km will result in more frequent, though briefer, instances of potential interference for DBS customers.[206] DISH recognizes that SpaceX plans to reduce the EIRP of these satellites and only communicate with these satellites with minimum earth station elevation angles of 25 degrees, but DISH argues the exponential increase in the number of satellites negates these mitigation efforts.[207] We note that in this partial grant, we are authorizing 7,500 satellites that will operate at altitudes from 525 km to 535 km, well above 400 km and comparable to the altitudes of the Gen1 Starlink satellites. Therefore, we do not address DISH's arguments on this point.

48. RS Access objected to the initial lack of a geographic limitation for SpaceX's proposed minimum elevation angles of 5 degrees in the Ku-band, particularly in the 12.2-12.7 GHz frequency band.[208] Given that SpaceX has clarified it will observe a minimum elevation angle of 25 degrees outside of polar regions (i.e. below 62 degrees latitude),[209] we find RS Access's concerns resolved. We also note that this partial grant does not include authority for SpaceX to deploy its 604 and 614 km shells at this time. We nonetheless condition this authorization to require SpaceX to utilize a 25 degree minimum

[204] *See* DISH September 23, 2022 Letter at 3, 6. *See also* DISH November 28, 2022 Letter at 2-3 (stating that DISH is not seeking a cumulative NCo of 1 across all NGSO systems combined).

[205] *See SpaceX Third Modification Order*, 36 FCC Rcd at 8019-20, paras. 37-39.

[206] *See* DISH Petition at 6-7, 21-22.

[207] *Id.* at 6-7, 21-22 (citing SpaceX Gen2 Application, Technical Attachment at 17, 20).

[208] *See* RS Access Petition, at 1-2, 6-9. RS Access argues a minimum 5 degree elevation angle is technically impractical due to topological and morphological obstacles and degradation caused by the long path between the satellites and earth stations and will cause service problems for SpaceX and interference to terrestrial systems, and SpaceX has provided no technical need or justification for its request. *Id.* at 1-2, 6-9; RS Access Reply at 1, 2-4. RS Access acknowledges however, that enlisting an elevation angle as low as five degrees can become necessary for "edge cases," such as systems serving high-latitude areas. RS Access Reply at 3-4.

[209] *See* SpaceX August 19, 2022 Letter at 6.

elevation angle for its user terminals, except for operations above 62 degrees latitude, where SpaceX may observe a minimum elevation angle of 5 degrees.

49. SpaceX's operations in the 12.75-13.25 GHz (Earth-to-space) frequency band must be in accordance with footnote 5.441 to the International Table of Frequency Allocations,[210] which states that operations in this band are subject to application of the provisions of No. 9.12 for coordination with other NGSO systems in the fixed-satellite service.[211] Footnote 5.441 further states that NGSO 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.[212] Additionally, Footnote 5.441 requires that NGSO systems in the fixed-satellite service in the 12.75-13.25 GHz (Earth-to-space) frequency band shall also be operated in such a way that any unacceptable interference that may occur during their operation shall be rapidly eliminated.[213] SpaceX's operations in the 12.75-13.25 GHz band are also limited to communications with individually-licensed earth stations, in accordance with footnote NG57 to the United States Table of Frequency Allocations.[214] SpaceX states that it may seek authorization for blanket-licensed user terminals in the United States.[215] We note that effective September 19, 2022, the filing of applications for new earth station licenses, and modifications to earth stations already authorized, to operate in the 12.7 GHz band are subject to a freeze, pending the outcome of the Commission's ongoing rulemaking proceeding regarding use of the 12.7-13.25 GHz band.[216]

50. We grant SpaceX's request to use the 13.85-14.0 GHz band for TT&C uplink operations, as discussed above. For its TT&C operations in the 13.85-14.0 GHz band, SpaceX must comply with footnotes 5.502 and US356 to the International and United States Table of Frequency Allocations.[217] We also note that for SpaceX's operations in the 13.85-14.0 GHz band, reception is permitted at levels up to the EPFD limits of Article 22 of the ITU Radio Regulations.

51. Additionally, for SpaceX's operations in the 14.0-14.5 GHz band, reception is permitted at levels up to the EPFD limits of Article 22 of the ITU Radio Regulations. Regarding operations in the 14.0-14.5 GHz band, we note that both NASA and NSF, along with Professor Andy Lawrence, Professor Roberto Trotta, and the Royal Astronomical Society, raise concerns about interference to radioastronomy from SpaceX's use of the 14.0-14.5 GHz band.[218] NASA has provided conditions for previous SpaceX

[210] *See* 47 CFR § 2.106, fn. 5.441.

[211] *Id.*

[212] *Id.*

[213] *Id.*

[214] *See* 47 CFR § 2.106, fn. NG56.

[215] *See* SpaceX Gen2 Application, Technical Attachment at 4, n.5.

[216] *See 180-day Freeze on Applications for New or Modified Authorizations for the 12.7 to 13.25 GHz band*, Public Notice, DA 22-974 (rel. Sept. 19, 2022). On October 27, 2022, the Commission extended the temporary freeze pending the outcome of GN Docket No. 22-352. *Expanding Use of the 12.7-13.25 GHz Band for Mobile Broadband or Other Expanded Use*, Notice of Inquiry and Order, GN Docket No. 22-352, FCC 22-80 (rel. Oct. 28, 2022).

[217] *See* 47 CFR § 2.106, fns. 5.502 and US356.

[218] *See* NTIA Letter, NASA Letter at 3, NSF Letter at 1; *see also* Andy Lawrence September 18, 2022 Letter, at 3 (noting that every satellite in the sky increases the noise that radioastronomy telescopes must deal with in detecting objects in the sky and the impact of the Gen2 Starlink constellation on radioastronomy could be much worse than the constellation's impact on visible astronomy, which we discuss below); Roberto Trotta October 6, 2022 Letter, at 2 (expressing concerns about SpaceX's impact on sites like the Square Kilometer Array); RAS November 10, 2022 Letter at 1 (raising concerns about the Gen2 Starlink constellation's impact on radio astronomy because of the size of its antennas and power levels of its transmissions). We note that Professor Lawrence, Professor Trotta, and the Royal Astronomical Society do not refer to specific frequency bands in their discussion of impacts to radioastronomy from the Gen2 Starlink constellation.

licenses to protect the radioastronomy service and urges us to continue coordinating license grants through the appropriate channels.[219] NSF states that it is currently working with SpaceX to update its coordination agreement to protect the radioastronomy service for the Gen2 Starlink satellites, but in general NSF is concerned that large satellite constellations will impact radioastronomy observatories, which have traditionally relied on remote locations to avoid interference.[220] We note that SpaceX is working with NASA to address its concerns and has begun coordination with NSF to reach an agreement to protect the radioastronomy service from harmful interference from the Gen2 Starlink satellites. Consistent with past authorizations for SpaceX's operations, we also note that SpaceX's operations in the 14.47-14.5 GHz band are subject to footnote US342 of the United States Table of Frequency Allocations,[221] and all practicable steps must be taken to protect the radio astronomy service from harmful interference.[222]

52. We also note that in the 14.0-14.2 GHz band, NASA operates Tracking and Data Relay Satellite System facilities at three locations: Guam (latitude 13°36′55″ N, longitude 144°51′22″ E); White Sands, New Mexico (latitude 32°20′59″ N, longitude 106°36′31″ W and latitude 32°32′40″ N, longitude 106°36′48″ W); and Blossom Point, Maryland. For transmissions in the 14-14.2 GHz band from certain NGSO FSS earth stations located within 125 kilometers of these three sites, earth station operations must take account of these NASA facilities.[223]

2. Ka-Band Frequencies

53. SpaceX requests Ka-band operations between its Gen2 Starlink satellites and both its user terminals and its gateway earth stations.[224] SpaceX proposes downlink communications with its user terminals in the 17.8-18.6 GHz, 18.8-19.3 GHz, and 19.7-20.2 GHz frequency bands, and user uplink communications in the 28.35-29.1 GHz and 29.5-30.0 GHz bands.[225] SpaceX proposes operations in the space-to-Earth direction with its gateway earth stations in the 17.8-18.6 GHz and 18.8-19.3 GHz bands and Earth-to-space communications between its gateways and its satellites in the 27.5-29.1 GHz (Earth-to-space) and 29.5-30.0 GHz (Earth-to-space) frequency bands.[226] SpaceX also requests TT&C downlink operations in the 18.55-18.6 GHz band.[227] In the Ka-band, SpaceX proposes a minimum antenna gain of 34.5 dBi and a maximum antenna gain of 44.5 dBi, with maximum EIRP density from 17.9 dBw/MHz to 21.5 dBw/MHz, depending on the operational altitude of the satellites.[228] As with its Ku-band beams, SpaceX states that as a satellite steers its Ka-band beam, it adjusts power to maintain a constant PFD on the surface of the Earth.[229] SpaceX explains that two Ka-band gateway beams are transmitted at the same frequency, right hand circular polarization and left hand circular polarization, and 32 satellites may communicate with the same gateway at the same time, for a maximum of 64 co-frequency beams

[219] *See* NTIA Letter, NASA Letter at 3.

[220] *See* NTIA Letter, NSF Letter at 1.

[221] *See* 47 CFR § 2.106, fn. US342.

[222] *See also infra* Section III.I. Protection of Science Missions Using Electromagnetic Spectrum.

[223] *See* 47 CFR § 25.228(j).

[224] *See* SpaceX Gen2 Application, Narrative at 10.

[225] *Id.* Narrative at 10, Technical Attachment at 4.

[226] *Id.* Narrative at 10, Technical Attachment at 4.

[227] *Id.* Narrative at 11.

[228] *Id.* Technical Attachment at 10; SpaceX Gen2 Amendment, Technical Attachment at 8. We also note that in its original application, SpaceX proposed maximum EIRP densities from 17.6 dBw/MHz to 22.5 dBw/MHz for user links and from 14.6 dBw/MHz to 19.5 dBw/MHz for its gateway links. *See* SpaceX Gen2 Application, Technical Attachment at 11.

[229] *See* SpaceX Gen2 Amendment, Technical Attachment at 7.

transmitting to the same gateway.[230] On the other hand, SpaceX states that its Ka-band user beams can communicate with either the right hand circular polarization or the left hand circular polarization, or both, and "user beams from a given satellite will have only one co-frequency beam per spot."[231] We grant SpaceX's request for communications in the Ka-band, subject to certain conditions set forth below.

54. Prior to commencing operations, SpaceX must complete coordination with federal systems for its space-to-Earth operations in the 17.8-18.6 GHz, 18.8-19.3 GHz, and 19.7-20.2 GHz frequency bands, in accordance with footnote US334 to the United States Table of Frequency Allocations.[232] SpaceX's 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. In addition, SpaceX's operations in the 18.8-19.3 GHz band are authorized up to the PFD limits in Article 21 of the ITU Radio Regulations.

55. In response to Viasat's concerns regarding SpaceX's operations in the 19.7-20.2 GHz band,[233] we also condition SpaceX's Gen2 Starlink operations in the 19.7-20.2 GHz band (space-to-Earth) to require that SpaceX not use more than one satellite beam on the same frequency to the same or overlapping areas at a time. Viasat is correct that in the *SpaceX Third Modification Order* we required SpaceX to observe an NCo of 1 in the 19.7-20.2 GHz (space-to-Earth) band, based on SpaceX's statement that it would otherwise not comply with the applicable EPFD limits in the band.[234] SpaceX is not proposing transmissions to gateway earth stations in the 19.7-20.2 GHz band,[235] and SpaceX's user beams will only operate with one co-frequency, co-polarization transmission to a given location.[236] In other words, SpaceX will be operating its Gen2 Starlink constellation with an NCo of 1 in the 19.7-20.2 GHz frequency band. We therefore maintain the condition we applied in the *SpaceX Third Modification Order* and require SpaceX to operate its Gen2 Starlink system with no more than one beam on the same frequency to the same or overlapping area at a time in the 19.7-20.2 GHz band. As discussed herein, we find that SpaceX's Gen2 Starlink system is a separate system from its Gen1 Starlink system, and both systems must maintain an NCo of 1 on an individual basis. SpaceX is required to operate within the EPFD limits, and a system operating within the EPFD limits is deemed not to cause harmful interference to a GSO system. We therefore condition this authorization, consistent with SpaceX's commitment on the record, such that SpaceX must operate its Gen2 Starlink constellation with an NCo of 1 in the 19.7-20.2 GHz band. Should GSO operators experience actual interference from SpaceX, the Commission will take appropriate action, which could include, but is not limited to, requiring SpaceX to operate with an NCo of 1 across both its Gen1 Starlink and Gen2 Starlink constellations in the 19.7-20.2 GHz band.

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[230] *See* SpaceX Gen2 Application, Technical Attachment at 12.

[231] *Id.*

[232] *See* 47 CFR § 2.106, US334.

[233] *See* Viasat July 18, 2022 Letter at 1. Viasat argues that as with the 12.2-12.7 GHz band, SpaceX's operations in the 19.7-20.2 GHz band with both its Gen1 and Gen2 Starlink systems would vitiate the condition in the *SpaceX Third Modification Order* requiring SpaceX to operate with an NCo of 1.

[234] *See SpaceX Third Modification Order*, 36 FCC Rcd at 8021-22, para. 43 (stating that SpaceX agrees operating four or eight satellites simultaneously in the 19.7-20.2 GHz band would violate the EPFD limits, and does not proposing to operate its gateways with more than one satellite at a time using a given frequency in the 19.7-20.2 GHz band).

[235] *See* SpaceX Gen2 Application, Narrative at 10, Technical Attachment at 4.

[236] *Id.* Technical Attachment at 12 (stating with regard to its Ka-band operations: "Two Ka-band gateway beams are transmitted at the same frequency (RHCP and LHCP), while user beams can use one polarization (either RHCP or LHCP) or both at the same time. User beams from a given satellite will have only one co-frequency beam per spot, but there will be up to thirty-two satellites beaming transmissions to a gateway location, for a maximum of sixty-four co-frequency beams.").

56. Viasat claims that SpaceX has not provided a demonstration that it will protect GSO networks operating outside the United States in the 18.8-19.3 GHz (space-to-Earth) and 28.6-29.1 GHz (Earth-to-space) bands.[237] According to Viasat, Off-axis RF emissions in the Ka-band could interfere with GSO operations outside the United States.[238] Even if NGSO services are operating in portions of the Ka-band without EPFD limits, Viasat notes that the GSO services still have priority for interference protection.[239] Viasat calculates that in order to protect GSO systems operating outside the United States, there would need to be a 600 km gap between earth stations—in other words SpaceX could only operate earth stations in a small area in the center of the United States.[240] Viasat requests that we condition any grant of SpaceX's Gen2 Starlink applications on "SpaceX's completion of coordination agreements with any potentially affected GSO operators with ITU date priority (including Viasat) and the implementation of any mitigation measures *(e.g.,* adoption of an adequate GSO arc avoidance angle) necessary to protect relevant GSO operations."[241] SpaceX argues that no Commission rule requires the demonstration Viasat seeks.[242] Additionally, SpaceX argues that Viasat relies on worst-case scenario assumptions in its analysis, and Viasat treats any interference above the 6% interference to noise ratio as unacceptable interference, as opposed to an event which triggers coordination among operators.[243] SpaceX provides analysis demonstrating that any exceedance of the coordination trigger would occur at worst on an infrequent and short-term basis[244] and argues such instances of interference can be handled by coordinating in good faith with the GSO operators, and SpaceX is aware of its obligation to conduct such good-faith coordination.[245]

57. We conclude that these issues can be successfully handled through coordination and SpaceX need not submit a demonstration that it will not cause harmful interference to GSO operators outside the United States. We decline to adopt Viasat's proposed condition, but we note that SpaceX's operations outside the United States are governed by ITU coordination obligations. SpaceX must comply with these obligations with regard to coordination with foreign-licensed operators conducting operations outside the United States.

58. We also note that SpaceX's satellite reception in the 27.5-28.6 GHz and 29.5-30.0 GHz bands is authorized at levels up to the applicable EPFD limits of Article 22 of the ITU Radio Regulations. SpaceX's operations in the 27.5-28.35 GHz band are secondary with respect to Upper Microwave Flexible Use Service (UMFUS) operations, except for FSS operations associated with earth stations authorized pursuant to section 25.136 of our rules.[246] Finally, SpaceX's 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.

3. Processing Round Sharing Requirements and Information Sharing

59. With respect to other systems authorized as part of the 2020 Ku/Ka-band processing round, SpaceX will be subject to the requirements in our rules addressing spectrum sharing among NGSO

[237] *See* Viasat Petition at 32-33; Viasat Reply at IV, 20-22.

[238] *See* Viasat Petition at 32-33; Viasat Reply at IV, 20-22.

[239] *See* Viasat Petition at 32-33, Viasat Reply at IV, 20-22.

[240] *See* Viasat Petition at 33-34; Viasat Reply at IV, 20-22.

[241] Viasat Petition at 34.

[242] *See* SpaceX April 7, 2022 Letter at 2-3; SpaceX May 18, 2022 *Ex Parte* at 1, Exhibit B at 4.

[243] *See* SpaceX Consolidated Opposition at 29-30; SpaceX May 18, 2022 *Ex Parte* at 1, Exhibit B at 4.

[244] *See* SpaceX Consolidated Opposition at 30, Exhibit 3.

[245] *Id.* at 30.

[246] *See* 47 CFR § 25.136.

FSS systems in the same processing round.[247] NGSO FSS operators must coordinate the use of commonly authorized frequencies with one another in good faith.[248] Absent a coordination agreement between two or more NGSO FSS satellite systems, a default spectrum-splitting procedure applies.[249]

60. With respect to NGSO FSS systems that were authorized as part of prior processing rounds to operate in the frequencies SpaceX requests, at this time we will require SpaceX to share with these systems in accordance with the procedures that the Commission previously applied to Kuiper's 2020 NGSO FSS authorization,[250] with some slight modifications to address the specific circumstances presented by SpaceX's operations. This grant will also ultimately be subject to the outcome of our currently pending rulemaking regarding NGSO FSS spectrum sharing, in which we are reviewing, among other things, how later processing round systems shall protect earlier round systems.[251]

61. In grant of an NGSO FSS license to Kuiper, the Commission required that prior to Kuiper commencing operations, it must certify that it has completed a coordination agreement with, or make a showing that it will not cause harmful interference to, any operational system licensed or granted U.S. market access in prior relevant processing rounds.[252] Kuiper, Kepler, and SES/O3b request that we condition grant of the Gen2 Starlink application with the same condition.[253] SpaceX argues this condition is unnecessary, as the Commission is currently developing rules to clarify spectrum sharing across processing rounds, and SpaceX will comply with those rules.[254] Kuiper responds that conditioning authorization on SpaceX's future compliance with the rulemaking proceeding would not be sufficient, because SpaceX will already have commenced operations without satisfying conditions that may be adopted by the Commission in the rulemaking.[255] Our ongoing rulemaking does not eliminate the need for conditions on this authorization addressing SpaceX's coordination with earlier round systems.[256] Although this grant is conditioned on SpaceX complying with future rules, including any rules adopted in our ongoing spectrum sharing proceeding, based on its plans for deployment, SpaceX will more than likely have begun operations by the time any updated rule comes into effect, and so we find it is necessary generally to address the issue of protection of earlier-round systems in this grant.

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[247] *See* 47 CFR § 25.261.

[248] 47 CFR § 25.261(b).

[249] 47 CFR § 25.261(c).

[250] *See* Kuiper NGSO Authorization, 35 FCC Rcd at 8341, para. 50.

[251] *Spectrum Sharing Rules for Non-Geostationary Orbit, Fixed-Satellite Service Systems; Revision of Section 25.261 of the Commission's Rules to Increase Certainty in Spectrum Sharing Obligations Among NGSO FSS Systems*, Order and Notice of Proposed Rulemaking, FCC 21-1323 (rel. Dec. 15, 2021) (*Section 25.261 NPRM*).

[252] Kuiper NGSO Authorization, 35 FCC Rcd at 8341, para. 50.

[253] *See* Kuiper Reply at 10. Kuiper argues that both its system and SpaceX's Gen2 system are participants in the 2020 processing round, and both are required to protect earlier-round participants. *Id.* at 11. SES/O3b and Kepler agree with Kuiper and argue that until any new rules come into effect, the Commission must follow the precedent it established with Kuiper's authorization and treat similarly situated operators similarly. *See* SES/O3b Reply at 15-16; Kepler Reply at 5-6.

[254] *See* SpaceX Consolidated Opposition, at 36-37 (citing *Section 25.261 NPRM*).

[255] *See* Kuiper Reply at 12-13; *see also* SES/O3b Reply at 15-16. Specifically, Kuiper argues that the proposed rule in the ongoing section 25.261 rulemaking proceeding would require SpaceX to demonstrate either that it has reached a coordination agreement or that it will not cause harmful interference to earlier-round systems prior to commencing operations, and that conditioning authorization on SpaceX's future compliance with the proposed rule would not be sufficient because SpaceX will already have commenced operations without satisfying either of these conditions. *See* Kuiper Reply at 12-13; *see also* SES/O3b Reply at 15-16.

[256] *See* SpaceX Consolidated Opposition at 36-37.

62. The Commission has previously emphasized the importance of coordination among NGSO FSS operators, noting in particular that coordination provides the best opportunity for efficient spectrum sharing; and that the Commission might intervene if the coordination discussions were not being conducted in good faith.[257] The Commission has also stated that it expects operators to negotiate in good faith with an aim to accommodating later-filed applicants.[258] We fully anticipate that all parties will negotiate in good faith, and SpaceX will be able to reach a coordination agreement with operators authorized in previous processing rounds. To this end, we condition this authorization such that SpaceX must coordinate its Gen2 Starlink system operations with other operational systems that were licensed or granted U.S. market in certain prior NGSO FSS processing rounds – specifically those referred to in Public Notices DA 16-804, 31 FCC Rcd 7666 (IB 2016) and DA 17-524, 32 FCC Rcd 4180 (IB 2017). In the event that such coordination cannot be successfully completed, SpaceX must make a showing to the Commission demonstrating and certifying that its operations will not cause harmful interference to those operational systems, which will be subject to Commission approval. In the event that it were to become necessary for SpaceX to make such a demonstration to the Commission, SpaceX may commence operations at its own risk, on a non-interference, unprotected basis with respect to any operations authorized in earlier processing rounds for which coordination has not been completed, prior to the approval of its showing by the Commission.

63. We have every expectation that SpaceX will be able to complete coordination with the previous-round operations. SpaceX has a rapid deployment schedule planned for its Gen2 Starlink satellites,[259] and it would serve the public interest to allow SpaceX to begin providing its next generation broadband service without undue delay, as conditioned herein and upon filing of its certified showing, with the understanding that SpaceX will be operating at its own risk until either the completion of coordination agreements through good faith negotiations or the Commission's approval of SpaceX's showing as sufficient to demonstrate that SpaceX's Gen2 Starlink system can operate without causing harmful interference to any operational systems. While Kuiper argues that the possibility of a delay in launch should not vitiate the processing round framework,[260] we find that the condition we apply will uphold the processing round framework and its emphasis on coordination, while still enabling the rapid provision of next generation satellite services.

64. Kuiper requests that we require SpaceX to share beam pointing information to facilitate coordination with other NGSO operators and allow for more efficient mitigation of potential interference.[261] Specifically, Kuiper requests that we require SpaceX to share "operational information about where its satellite beams are positioned and which satellites are actively transmitting and receiving from each of its earth stations, sufficient to identify anticipated interference events in advance," in other words, "SpaceX should be required to share with NGSO FSS licensees using commonly authorized frequencies: (1) where its satellite beams are directed and (2) with which of its in-view satellites each of its earth stations will be actively communicating."[262] Kuiper argues that each of the nearly 30,000

[257] *See, e.g.*, *NGSO FSS Order*, 32 FCC Rcd at 7825, para. 48; Kuiper NGSO Authorization, at para. 49.

[258] *NGSO FSS Order*, 32 FCC Rcd at 7825, 7829, paras. 48, 61; Kuiper NGSO Authorization, at at para. 49.

[259] This is distinct from the Kuiper system, which at the time of its 2020 authorization was still some time away from initial deployment and provision of service.

[260] *See* Kuiper Reply at 11, 12. Kuiper also notes that if SpaceX wanted to avoid delay, it should have acted sooner to coordinate with earlier-round systems. In other words, Kuiper argues that any delay in SpaceX's launch plans caused by this condition is of SpaceX's own making. *Id.* at 12; *see also* SES/O3b Reply at 13-14. We observe that SpaceX has already completed coordination with OneWeb at this time, and that the filing of a showing of non-interference with the Commission shall only be done in the event that SpaceX cannot successfully complete coordination with other operational systems.

[261] *See* Kuiper Comments at I, III, 3, 13, 16-17; Kuiper Reply at 7-10.

[262] Kuiper Comments at 3.

proposed Starlink satellites have an expansive coverage area that will overlap with the coverage areas of many other satellites.[263] Absent beam pointing information detailing which satellite is transmitting to which earth station or group of earth stations, Kuiper argues other NGSO operators must assume each satellite is constantly transmitting over its entire coverage area, which is not how the satellites will operate in fact.[264] Similarly, other operators will need to assume, incorrectly, that SpaceX's earth stations could be transmitting or receiving from any of their in-view satellites.[265] These inefficiencies are made worse by the sheer size of the proposed Gen2 Starlink constellation.[266]

65. SpaceX objects to Kuiper's proposed condition, arguing that we are currently considering new rules to require such information sharing from NGSO operators in its ongoing section 25.261 rulemaking, and it would be unfair to prejudge the outcome of that proceeding by unilaterally imposing such a requirement on SpaceX.[267] Kuiper argues that given the sheer size of Gen2 Starlink, the Commission should not wait for the rulemaking to be resolved but instead impose these requirements on SpaceX, as well as conditioning any grant of SpaceX's Gen2 Starlink application, as amended, on the outcome of the rulemaking.[268] Kuiper maintains that whatever the Commission decides in its ongoing rulemaking, Gen2 Starlink is unprecedented in scale and presents unique concerns that the Commission must address.[269] Kuiper notes that, in the rulemaking proceeding, SpaceX supports information sharing among NGSO operators such as the condition Kuiper has proposed, and so Kuiper argues it likely has the technical ability to share its beam pointing information, whereas other operators objecting to the rulemaking may not have that technical ability.[270] Kuiper posits that the Commission could find it is in the public interest to require SpaceX to share its beam pointing information for Gen2 Starlink while later finding it is not in the public interest to require such sharing from all operators.[271] Kuiper states that if SpaceX is correct that no other 2020 processing round operator will be ready to launch before SpaceX, then there will be no additional burden on SpaceX; if other operators are ready to launch, then Kuiper argues that is all the more reason to require SpaceX to share its beam pointing information to assist in coordination efforts and mitigate potential interference.[272] Kuiper states that the Commission has the power to condition licenses if it is in the public interest, regardless of whether that condition is codified in a Commission rule.[273]

66. As discussed above, we condition this authorization to require SpaceX to comply with future Commission rulemakings, including any rules adopted as a result of our ongoing spectrum sharing proceeding. The potential sharing of beam pointing information is currently under consideration in an ongoing rulemaking proceeding, and parties in that proceeding have raised significant technical and practical issues regarding the sharing of such information. The record before us is insufficient to

[263] *Id.* at II-III, 13-16.

[264] *Id.*

[265] *Id.*

[266] *Id.*

[267] *See* SpaceX Consolidated Opposition at 37 (citing *Section 25.261 NPRM*, at para. 23). SpaceX also points out that it is unlikely that Kuiper or any other 2020 processing round operator begins deploying its system before the Commission completes its rulemaking, so these operators have no need for SpaceX's beam pointing information now. *Id.* at 37-38.

[268] *See* Kuiper Comments at 16-17; Kuiper Reply at 9; *see also Section 25.261 NPRM*.

[269] *See* Kuiper Reply at 8.

[270] *Id.*

[271] *Id.*

[272] *Id.* at 9.

[273] *Id*. (citing 47 U.S.C. § 303(r)).

conclude that this grant must be conditioned on SpaceX providing this information to help mitigate potential interference risks posed by SpaceX's proposed constellation and to facilitate coordination at this stage. Moreover, by our action today, we are further limiting any potential future issues by granting only 7,500 of the nearly 30,000 proposed satellites. Therefore, we decline to impose Kuiper's proposed condition and will defer consideration of this issue to the ongoing rulemaking proceeding. We expect that operators will not withhold information necessary to effectuate good faith coordination.

F. Frequencies Outside of the 2020 Processing Round

67. SpaceX requests to operate in the 71.0-76.0 GHz (space-to-earth) and 81.0-86.0 GHz (Earth-to-space) bands (E-Band or 70/80 GHz bands) for communications between satellites and gateway earth stations.[274] Although the Commission has not yet adopted band-specific service rules for these frequencies, SpaceX states it will operate in these frequencies consistent with the U.S. Table of Frequency allocations.[275] We note that the 71.0-76.0 GHz and 81.0-86.0 GHz bands are allocated on a co-primary basis to federal and nonfederal operations in the fixed and mobile services, fixed-satellite and mobile satellite services, mobile broadcasting, broadcasting-satellite service, space research, and radio astronomy.[276]

68. SpaceX also states that some of its satellites will contain small radiofrequency emergency beacons to be used during orbit-raising.[277] These emergency beacons will operate in the 137.00-138.00 MHz (space-to-Earth) and 148.00-150.05 MHz (Earth-to-space) frequency bands.[278] SpaceX states that use of these frequencies has been authorized by Germany, and SpaceX intends to conduct communications using these frequencies only outside of the United States, and does not seek U.S. market access for use of these frequencies.[279]

69. Pending further review and coordination with Federal users, we defer acting on SpaceX's request to use the E-Band as well as any action regarding SpaceX's described use of the emergency beacons.

G. Orbital Debris Mitigation

1. Background and Satellite Maneuverability

70. SpaceX has submitted an orbital debris mitigation plan as required under our rules, in connection with its request for operations with Gen2 Starlink. In response to SpaceX's mitigation plan, a number of parties have raised concerns, which we address here only with respect to the 7,500 satellites, to be operated in orbital shells centered at altitudes from 525 km to 535 km, that we are authorizing in this grant. To the extent that the parties' concerns are related to the deployment of SpaceX's full request for nearly 30,000 satellites, including in other orbital shells, we defer consideration of those issues.

71. We find SpaceX's orbital debris mitigation plan to be sufficiently developed to support our authorization of 7,500 satellites, 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 disposal are not met. This grant is also subject to the outcome of our ongoing orbital debris proceeding[280]

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[274] *See* SpaceX Gen2 Application, Narrative at 10.

[275] *Id.* Technical Attachment at 4.

[276] *See* 47 CFR § 2.106.

[277] *See* SpaceX August 19, 2022 Letter at 6, n.17; SpaceX October 4, 2022 Letter at 2, Exhibit A.

[278] *See* SpaceX October 4, 2022 Letter Exhibit A at 1.

[279] *See* SpaceX August 19, 2022 Letter at 6, n.17; SpaceX October 4, 2022 Letter at 2, Exhibit A.

[280] *See generally 2020 Orbital Debris Order and FNPRM*, 35 FCC Rcd 4156; *Space Innovation; Mitigating Orbital Debris in the New Space Age*, Second Report and Order, FCC 22-74 (2022) (2022 Orbital Debris Disposal Order).

and any other relevant rulemakings.

72. *Maneuverable Satellites*. SpaceX states that it makes its constellation safer by providing highly accurate satellite position data to other operators, and by receiving and acting upon conjunction warnings from two independent providers. SpaceX states that its satellites to be deployed as part of Gen2 Starlink are highly-maneuverable and designed with a propulsion system that will respond quickly and at a high cadence, so that SpaceX can coordinate with relevant operators in advance and act on the conjunction warnings it receives.[281] SpaceX states that all of its satellites will have sufficient propellant to conduct collision avoidance maneuvers through all phases of their missions. SpaceX has budgeted sufficient propellant for 5,000 propulsive maneuvers over the lifetime of each satellite, including 350 planned collision avoidance maneuvers. SpaceX indicates that, similar to Gen1 Starlink, SpaceX will use 0.00001 (1/100,000) as its trigger for collision avoidance maneuvers.[282]

73. *Use of automated collision avoidance.* Viasat raises several concerns about SpaceX's collision avoidance system. Viasat asserts that SpaceX is ignoring the collision risk that could result from maneuvering to avoid one conjunction event[283] and raises concerns that SpaceX's autonomous collision avoidance system does not allow for inter-operator coordination.[284] To these concerns, SpaceX explains that when it receives a conjunction warning involving another active satellite, it reaches out to that satellite operator to conduct physical coordination.[285] SpaceX states that it will assume the responsibility to conduct collision avoidance maneuvers if the other satellite is non-maneuverable or if it does not receive a response from the other satellite's operator.[286] While its autonomous collision avoidance system is the default mechanism for developing and executing collision avoidance maneuvers, SpaceX explains it can command individual satellites not to maneuver should the other operator involved in the conjunction event prefer to conduct a maneuver instead, and in addition SpaceX has reached coordination agreements with other operators establishing baseline operations in the event of conjunction warnings.[287] SpaceX states there are circumstances where it is preferrable for the other operator to conduct collision avoidance maneuvers, such as a case of a satellite transiting slowly through SpaceX's shells using electric propulsion, and in such cases SpaceX will ask the operator to conduct the maneuver.[288] Furthermore, contrary to Viasat's claim, SpaceX explains its automated collision avoidance system considers collision risks posed by maneuvers to avoid possible conjunctions.[289] SpaceX argues that should its satellites lose its primary propulsion capability, it can still vent gas to maneuver in a cold gas thruster mode, so long as the satellite attitude continues under control.[290] We find that the concerns raised by Viasat are ones that SpaceX has both anticipated and is adequately addressing at this time.

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[281] *See* SpaceX Consolidated Opposition at III, 5, 6; SpaceX April 7, 2022 Letter at 3.

[282] *See* SpaceX January 7, 2022 Response to Satellite Division Information Request at 6; SpaceX Consolidated Opposition, at III, 6, 7-8, 9. SpaceX points out this trigger for collision avoidance maneuvers is an order of magnitude more sensitive than the industry standard of one in ten thousand. *See* SpaceX Consolidated Opposition at III, 6, 7-8, 9.

[283] *See* Viasat Petition at 49. Viasat argues that while it is impossible to calculate this residual risk, it becomes a substantial risk when multiplied by a total of 34,396 satellites (including all Gen1 Starlink and Gen2 Starlink satellites). *Id.*

[284] *Id.* at 49-50.

[285] *See* SpaceX Consolidated Opposition at 10; SpaceX October 4, 2022 Letter at 3.

[286] *See* SpaceX Consolidated Opposition at 10; SpaceX October 4, 2022 Letter at 3.

[287] *See* SpaceX Consolidated Opposition at 11; SpaceX October 4, 2022 Letter at 3.

[288] *See* SpaceX August 19, 2022 Letter at 4; SpaceX October 4, 2022 Letter at 3.

[289] *See* SpaceX Consolidated Opposition at 10-11.

[290] *See id.* at 9.

74. *Residual Risk.* In our order on SpaceX's Third Modification for Gen1 Starlink, we recognized that spacecraft collision maneuvers would not reduce the risk to zero, and that there will be some residual risk.[291] The Commission also observed that calculations of residual risk based on collision probabilities as specified in conjunction warnings may not provide a reasonable measure of this residual risk, and may present an artifact of risk modelling methods rather than actual risks. Viasat, however, maintains that millions of conjunction events with less than 1/100,000 probability of occurring still add up to a significant risk.[292] We decline to assess residual risk using the method utilized by Viasat, for the same reason stated in the *SpaceX Third Modification Order*.

75. NASA raises a distinct and broader concern with respect to Gen2 Starlink, noting that while individual SpaceX satellites may be deemed to have a collision risk of zero because of their propulsive capabilities with a constellation of this size, error-free systems and a collision risk of zero should not be assumed.[293] In response to this concern, we will apply reporting conditions as adopted for Gen1 Starlink in the *SpaceX Third Modification Order* to Gen2 Starlink, including reporting the number of collision avoidance maneuvers. In order to address NASA's observation that systems cannot be assumed to be error free, we also are broadening this condition to include reporting with respect to any collision avoidance system outages or unavailability, either on a system wide basis or for individual satellites, due to any cause other than disabling of the system for a single satellite in order to facilitate operator-to-operator coordination. An "outage" would include any individual satellite anomaly that results in a satellite not achieving targeted risk mitigation via maneuver.

76. *NASA Operational Concerns*. NASA operates science and human spaceflight programs and notes several concerns about likely operational impacts on those missions caused by the large number of satellites SpaceX proposes to deploy,[294] including impacts due to the current capacity of object tracking and conjunction screening relied on by NASA and other operators.[295] NASA also raises several longer term concerns with the use of autonomous collision avoidance systems, recommending that SpaceX conduct analysis to demonstrate the autonomous collision avoidance system is sufficiently scalable to the entire constellation size, including inter-constellation conjunctions.[296] NASA also notes the need to account for operating at low altitudes during periods of increased solar activity. NASA also expresses concern about other constellations utilizing autonomous collision avoidance systems in the same altitudes as SpaceX and recommends SpaceX also commission a risk analysis regarding "the efficacy of autonomous-vs.-autonomous constellation conjunction assessments and mitigation actions."[297]

77. SpaceX explains that its autonomous collision avoidance system has been evaluated by NASA's Conjunction and Risk Analysis program in connection with the Gen1 Starlink system, and the autonomous collision avoidance system is also relied on by NASA.[298] SpaceX states it is continuing to

[291] *SpaceX Third Modification Order*, 36 FCC Rcd at 8028-29, para. 58.

[292] *See* Viasat Petition at 48; Viasat Reply at 40-41.

[293]NTIA Letter, NASA Letter at 2. NASA notes that it does not intend its comments to oppose grant of the Gen2 Starlink application, but it does want deployment of so many satellites to happen prudently to protect the long-term sustainability of the LEO environment. NTIA March 10, 2022 Letter, Attachment at 1.

[294] *See* NTIA Letter, NASA Letter at 1.

[295] *Id.* at 2. SpaceX has provided physical dimensions for all three satellite designs to be launched as part of its Gen2 Starlink constellation. *See* SpaceX October 4, 2022 Letter, Exhibit B.

[296] *See* NTIA Letter, NASA Letter at 2.

[297] *Id.* NASA requests to review such analysis to ensure the ISS and other NASA assets are protected.

[298] *See* SpaceX Consolidated Opposition at III, 6, 7-8, 9.

work with NASA to address its concerns.[299] SpaceX states that it holds frequent meetings with NASA to share information, present analysis results, and continually improve SpaceX's operations regarding the scaling of SpaceX's autonomous collision avoidance system, how to improve interoperability between multiple systems with autonomous collision avoidance systems, and improving coordination between the ISS and Gen2 Starlink satellites operating below the ISS, among other issues.[300] SpaceX states that through its partnership with NASA, both NASA and SpaceX are confident NASA's assets can remain safe while sharing space with Gen2 Starlink, and neither NASA nor SpaceX have identified issues that cannot be resolved by continued coordination.[301] Given our authorization of 7,500 satellites, all planned for regular operation at altitudes above ISS, and given SpaceX's statements regarding its continued coordination with NASA, we believe that NASA's concerns are in the process of being addressed and encourage continuing work to ensure a shared understanding of SpaceX's advanced system, and the implementation of any refinements that facilitate operator-to-operator coordination with both NASA and other operators. The incremental approach we are taking for authorization of Gen2 Starlink will allow continued monitoring of progress in addressing NASA's concerns.

78. *Allocating maneuver responsibility between constellations.* Kepler, a constellation operator whose satellites currently do not include a propulsive maneuver capability, proposed a condition requiring SpaceX to bear responsibility for collision avoidance maneuvers.[302] SpaceX objected to this condition, arguing such a condition would incentivize other operators not to invest in collision avoidance systems of their own.[303] We decline to adopt a condition that would, in effect, remove responsibility from other operators with respect to collision avoidance. As we concluded in the *SpaceX Third Modification Order*, physical coordination is the responsibility of all operators, including operators operating spacecraft that lack propulsion. However, we also note SpaceX's commitment to continue conducting collision avoidance maneuvers when the other operator lacks propulsion and to continue coordinating in good faith with other operators with propulsion.[304] We continue to consider constellation collision risk issues in a pending rule making proceeding, and our action here is without prejudice to adoption of modified rules that could include new requirements for constellation operators.

79. *Collision Risk at Specific Operational Altitudes.* Viasat and Kuiper assert that the 468 satellites SpaceX proposes to operate in the 604 km and 614 km shells will not comply with the Commission's individual satellite collision risk metric of 0.001.[305] Viasat also expresses concern with satellites planned for operations at 360 km.[306] Since we do not authorize satellites planned for operations at these altitudes in this grant, we do not reach these issues.

80. *Orbital Tolerances.* The satellites authorized in this grant are planned for operations in orbital shells centered at altitudes from 525 km to 535 km. SpaceX has requested orbital tolerances of +70 km and -50 km, i.e., the satellites in any orbital shell can be maintained for regular operations anywhere within an altitude range of 70 kilometers above or 50 kilometers below the center altitude. The Gen2 Starlink satellites in the authorized shells would, if this request is granted, be authorized for regular

[299] *Id. at* 10; SpaceX April 8, 2022 Letter at 7.

[300] *See* SpaceX August 19, 2022 Letter at 5.

[301] *Id.*

[302] *See* Kepler Comments at 2; Kepler Reply at 1-2, 3.

[303] *See* SpaceX Consolidated Opposition at 10; 20; SpaceX April 7, 2022 Letter at 5-6.

[304] *See* SpaceX Consolidated Opposition at 10-11; 20; SpaceX August 19, 2022 Letter at 4.

[305] *See* Viasat Petition at III, 37; Viasat Reply at 28; Viasat May 16, 2022 Letter at 2; Viasat May 18, 2022 Letter at 2, 4, 7; Kuiper Reply at 5-6.

[306] *See* Viasat October 4, 2022 Letter at 4-5. SpaceX later stated there had been an administrative error in its DAS calculations and provided the correct large object collision risk value for the satellites at 360 km, demonstrating that they do comply with the Commission's collision risk limit. *See* SpaceX October 6, 2022 Letter at 2, n.10.

operations at altitudes ranging from as low as 475 km to as high as 605 km.[307] This represents a substantially larger range of altitudes than for the Gen1 Starlink satellites. SpaceX states that this orbital tolerance will allow the satellites in Gen2 Starlink to retain their operational life in periods of high drag and maintain low passive decay times in the event the satellite becomes non-maneuverable.[308]

81. If we were to authorize SpaceX's operations with the orbital tolerance requested, Gen2 Starlink satellite operations would be permitted at altitudes within the altitudes at which Kuiper's constellation will operate, beginning at altitudes around 580 km and above. Kuiper requests that we require SpaceX to limit the orbital tolerances of its satellites to keep its operations below 580 km.[309] Kuiper does not object to orbital overlap with smaller systems and agrees with SpaceX that nothing in the Commission's rules limits which orbits an operator may choose, but Kuiper emphasizes the risks posed by the overlap of two systems operating at the scale of Kuiper's and SpaceX's proposed operations and requests that the Commission require SpaceX to operate all Gen2 Starlink satellites at or below 580 km.[310]

82. The record does not reflect with any specificity a need for Gen2 Starlink satellite operations at altitudes above 580 km, as opposed to the +45 to +55 km tolerance that can be achieved if operations are maintained below 580 km. We also note that one of the reasons for larger orbital tolerances that SpaceX identifies—effects of solar radiation on the orbits of spacecraft—is less pronounced for the particular orbital shells authorized by this grant than for lower altitudes. We will follow the approach of the *SpaceX Third Modification Order*,[311] and require SpaceX to restrict its Gen2 Starlink operations to below 580 km. We condition this authorization accordingly. However, this action is without prejudice to any determination we may make with respect to requirements such as orbital separation or coordination for large constellations as is currently under consideration in a separate rule making proceeding.

2. Satellite Failures

83. In the *SpaceX Third Modification Order*, the Commission considered issues raised on the record about the satellite failure rate for Gen1 Starlink. The Commission evaluated the collision risk posed by the Gen1 Starlink system as a whole, should any of its satellites lose maneuverability and therefore fail to complete post-mission disposal as planned. Such failures result in satellites that during their remaining orbital lifetime present a collision risk because they cannot be maneuvered to avoid other non-maneuverable objects, whether debris or active spacecraft. Similar to the record developed in that proceeding, SpaceX's satellite failure rate for Gen1 Starlink continues to be a matter of significant contention in this record, as is the means by which we should account for SpaceX's satellite failures. We take an approach to assessing this issue generally consistent with the *SpaceX Third Modification Order*, taking into account the performance of the system as a whole. As discussed below and in response to comments, we adopt a reporting condition including a modified metric both for reporting and as a benchmark for triggering any necessary additional review.

84. SES/O3b requests that we require similar reporting from SpaceX as in the *SpaceX Third*

[307] *See* Viasat Petition at 11; Viasat Reply at III, 6-7.

[308] SpaceX August 19, 2022 Letter at 4.

[309] *See* Kuiper Comments at 8, 9; Kuiper Reply at 5. Since we do not authorize any SpaceX satellites for operations in the 604 km and 614 km shells in this grant, we do not address Kuiper's request that the Commission require SpaceX to alter these planned operational altitudes.

[310] *See* Kuiper Comments at I, 2-3; Kuiper Reply at 2, 3-7. The majority of Kuiper satellites will operate between 590 km and 630 km, with orbital tolerances of ±9 km. *See* Kuiper Comments at 2, 3, 6-8. Viasat also supports Kuiper's requested condition, noting that the Commission has recognized the risks posed by orbital overlap of two large systems and that SpaceX has provided no information on how it plans to coexist with Kuiper in these orbits. *See* Viasat Petition at 42; Viasat Reply at 28.

[311] *See SpaceX Third Modification Order*, 36 FCC Rcd at 8032-33, para. 66.

Modification Order, an ongoing assessment of failure rates, with pauses in further deployment if necessary.[312] LeoLabs proposes an approach based on realized collision risk rather than projected collision risk.[313] LeoLabs proposes that SpaceX's authorization to continue deploying satellites should be based on the actual realized collision risk burden of up to 100 object years, i.e., the number of years each failed satellite remains in orbit, summed across all failed satellites. SpaceX argues that LeoLabs' suggestion is new and untested, and its formula is based on arbitrary factors.[314]

85. Deployment at the altitudes addressed in this Order will allow most Gen2 Starlink satellites to comply with our new five year rule under typical solar conditions, even if the failure occurs at the operational altitude, and particularly if orbital tolerances are maintained at the low end of requested ranges. Failed disposals do, however, present a collision risk, and we include, as a condition of this authorization, reporting requirements generally consistent with the reporting requirements specified in the *SpaceX Third Modification Order*. Based on the approach suggested by LeoLabs for specifying a metric that looks to realized collision risk, we incorporate a metric for disposal failures after which SpaceX will not be permitted to deploy additional satellites. The metric of 100 object years LeoLabs proposes provides a useful benchmark, if triggered, for pausing deployment and reassessing spacecraft reliability. We recognize that this metric is, as SpaceX observes, new and untested, but we believe an incremental approach based on a clear benchmark is appropriate in the context of a planned deployment that is at a scale not previously undertaken and also untested. We will retain flexibility to revise this condition if upon further analysis and consideration in our ongoing rule making proceeding it is determined that an alternative approach is warranted. The adopted metric recognizes that failures at lower altitudes present lower risk than at higher altitudes, where remaining orbital lifetimes are longer, and roughly corresponds to the failure of twenty or more satellites in the orbital shells around 500 kilometers that are the subject of this license grant. We will require SpaceX to submit a semiannual report on the number of satellites launched and disposal failures, including for disposal failures a projection of the remaining orbital lifetime of the failed satellites. If the cumulative number of years for all failed satellites exceeds 100, SpaceX must cease satellite deployment while the sources of satellite failure are reviewed to determine whether there are any adequate and reliable mitigation measures going forward.

3. Other Issues

86. *Casualty risk.* At least one party raised concerns about a potential casualty risk from SpaceX's satellites reentering the Earth's atmosphere upon demise.[315] SpaceX states that using NASA DAS software, it has confirmed that like its Gen1 Starlink satellites, its Gen2 Starlink satellites will fully demise upon reentry into Earth's atmosphere, presenting no casualty risk. Accordingly, there is no need to include a specific condition concerning this matter.

87. *Starship and Falcon 9 deployment mechanism.* We asked SpaceX to clarify whether Starship's satellite deployment mechanism will use spacers or stiffening rods, which would generate additional debris.[316] While SpaceX initially stated the deployment mechanism for Starship had not yet been finalized as of January 2022,[317] SpaceX has since informed the Commission that it will not use spacers or stiffening rods for the deployment mechanism for Gen2 Starlink satellites deployed on

[312] *See* SES/O3b Petition at II, 3, 17-18 (citing *SpaceX Third Modification Order*, 36 FCC Rcd at 8049, para. 97u); SES/O3b Reply at I, 1-2, 16.

[313] *See* LeoLabs March 29, 2022 Letter at 2, 4. We note that LeoLabs filed its letter both in the record of the SpaceX Gen2 application and amendment as well as in the docket for the Commission's ongoing orbital debris proceeding.

[314] *See* SpaceX July 13, 2022 Letter at 1-2.

[315] *See* Sierra Solter Hunt September 23, 2022 Letter at 1.

[316] *See* Satellite Division December 23, 2021 Information Request at 3.

[317] *See* SpaceX January 7, 2022 Response to Satellite Division Information Request at 7.

SpaceX's Starship launch vehicle.[318] However, SpaceX does state that it will use spacers and tension rods for the initial satellites deployed on its Falcon 9 launch vehicle.[319] SpaceX describes its deployment mechanism and procedures for satellites launched on its Falcon 9 launch vehicles as follows: "In deploying multiple satellites with each launch, SpaceX uses four separate rod assemblies, each consisting of two rods, to hold the stacked satellites in place within the fairing. To deploy the stack of satellites from the launch vehicle, the rods release the satellites to separate them prior to further orbit raising activities. Thereafter, the rods — which are made of lightweight aluminum and are only 1.5 inches in diameter and about six meters long — naturally re-enter the Earth's atmosphere."[320] SpaceX has used its internal software which it describes as leveraging the capabilities of NASA's DAS but with higher fidelity analysis, to calculate that these rods have an expected orbital lifetime of at most 36 days (assuming the highest deployment SpaceX plans).[321] SpaceX also states these rods will fully demise in the atmosphere and pose no casualty risk.[322] Although it is unclear at this point how many launches will utilize these deployment mechanisms, given the short orbital lifetime and full demise of this operational debris, and in light of longer-term plans for deployment using a different method, we take no further action at this time concerning spacers and tension rods. As plans for deployment of the Gen2 Starlink system are refined, including through modifications and further actions to address additional frequency bands, we retain discretion to address this matter further if necessary.

88. *Starlink's impact on launch and reentry opportunities.* NASA raises concerns that the number of Gen2 Starlink satellites SpaceX proposes could cause the loss of launch and reentry opportunities for NASA missions to the ISS as well as planned planetary missions such as Europa Clipper.[323] NASA therefore recommends that SpaceX commission an analysis of "launch window availability against the current catalog compared to the current catalog plus the proposed full constellation" to ensure Gen2 Starlink will not result in loss of access to space.[324] As discussed herein, SpaceX is continuing to work with NASA, and we believe this issue is best addressed through continued coordination and an incremental approach to authorization of Starlink deployment. We further condition this grant on SpaceX coordinating with NASA.

89. *Lethal nontrackable debris and other risks.* Viasat argues that SpaceX completely ignores the risks posed by lethal nontrackable debris, the estimated one million pieces of debris ranging in size from 1 cm to 10 cm.[325] SpaceX argues that it has taken steps to protect its satellites from lethal nontrackable debris, including design and orientation of its satellites and being a customer of LeoLabs higher fidelity radar data and conjunction information.[326] Viasat claims that none of these mitigations

[318] *See* SpaceX October 4, 2022 Letter at 4.

[319] *Id.*

[320] *See* SpaceX Gen2 Application, Technical Attachment at 37.

[321] *Id.*

[322] *Id.*

[323] *See* NTIA Letter, NASA Letter at 4. SpaceX proposes approximately twenty thousand satellites between 328 km and 360 km, which are common phasing altitudes for vehicles visiting ISS. Additionally, NASA's planned planetary missions like Europa Clipper have instantaneous or short launch windows, and loss of those launch windows could severely impact those missions. *Id.*

[324] *Id.*

[325] *See* Viasat Petition at III, 40-41; Viasat Reply at 28, 37-38.

[326] *See* SpaceX April 8, 2022 Letter at 5-6. SpaceX explains it minimizes the height of each satellite to minimize exposure to the flux most lethal nontrackable debris approaches from (within 5 degrees of the local horizon). SpaceX satellites have a flat-plate chassis and spend most time flying flat with respect to the local horizon to accomplish this. *Id.* LeoLabs also noted it was adding lethal nontrackable debris to its catalog of tracked objects in summer 2022. *See* LeoLabs March 29, 2022 Letter at 5.

satisfy its concerns because SpaceX has not quantified the risks from lethal nontrackable debris, so there is no way of knowing if the risk is tolerable with SpaceX's mitigations.[327] Given the conditions concerning ongoing monitoring, we conclude that even if SpaceX has not sufficiently mitigated this risk, unacceptably high disposal failure rates will be identified and addressed.

H. Authority for Orbit-Raising, Deorbit, and Testing Operations

90. SpaceX also requests authority in its license for communications during transition phases before and after reaching its authorized operational altitudes.[328] This would include authority to perform telemetry, tracking and command (TT&C) functions during orbit-raising and de-orbit maneuvers.[329] This would also include authority for testing communications equipment performance during the orbit-raising process, which would be conducted on a non-protected, non-harmful interference basis. SpaceX's choice to test its satellites at low altitudes is one of the factors on which SpaceX based its orbital debris mitigation plan, as it allows SpaceX to deorbit any failed satellites and minimize the risk of satellites experiencing a disposal failure at their operational altitudes, which lessens the collision risk posed by the constellation. SpaceX clarified that while it intends to use Starship to avoid parking orbits and orbital precession for its satellites by deploying them directly into their orbital planes, it still intends to deploy its satellites at low insertion altitudes to conduct testing before orbit-raising the satellites to their operational altitudes.[330] SpaceX originally stated that in some cases, such as Starlink satellites launching on a rideshare with other satellites, it will deploy its satellites directly into their operational altitudes,[331] but later clarified that it does not intend to deploy any of its Gen2 Starlink satellites directly into their operational orbits.[332] SpaceX also confirms that during transit, it will generally take responsibility for collision avoidance maneuvers.[333] SpaceX asserts that with nearly 30,000 satellites in Gen2 Starlink with a design life of five years, it is likely that it will be engaged in launch and deorbit activities on an ongoing basis. SpaceX argues that granting the requested authority as part of the space station license would obviate the need for SpaceX to file—and the Commission to process—a never-ending stream of applications for STA to cover operations as satellites are raised into and deorbited out of the constellation.[334]

91. We find that granting SpaceX authority for these transition phase operations is in the public interest with the conditions adopted herein. SpaceX's practice of testing its satellites at injection altitude, before orbit-raising, allows it to deorbit 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 with its Gen1 Starlink satellites on an ongoing basis without issue since 2019 pursuant to STA and authority granted in the *SpaceX Third Modification Order*, we conclude that granting SpaceX authority to conduct these operations pursuant to the license for its Gen2 Starlink constellation would lessen the burden on Commission resources to process STAs. We conclude that granting SpaceX authority for these types of operations under this license, with the same

[327] *See* Viasat May 18, 2022 Letter, at 12.

[328] SpaceX Gen2 Application, Technical Attachment at 2.

[329] *See* 47 CFR §§ 25.282, 25.283.

[330] *See* SpaceX January 7, 2022 Response to Satellite Division Information Request at 5; SpaceX August 19, 2022 Letter at 4.

[331] *See* SpaceX January 7, 2022 Response to Satellite Division Information Request at 5.

[332] *See* SpaceX October 4, 2022 Letter at 4.

[333] *See* SpaceX August 19, 2022 Letter at 4.

[334] See SpaceX Gen2 Application, Technical Attachment at 2. SpaceX states that despite grant of eleven space station STAs to cover orbit-raising and de-orbit activities for its first-generation constellation, it has received no reports of interference or other issue from any other licensed operator.

conditions we applied in the *SpaceX Third Modification Order*[335] will sufficiently ensure that other operators do not encounter harmful interference resulting from these operations. We also condition this authorization, consistent with the information SpaceX provided, such that SpaceX may not deploy any of the 7,500 Gen2 Starlink satellites authorized in this grant directly to their operational altitudes.

I. Protection of Science Missions Using Electromagnetic Spectrum

92. In the *SpaceX Third Modification Order*, we concluded that it would serve the public interest under the Communications Act for SpaceX to ensure that it does not unduly burden astronomy and other research endeavors because of the reflectivity of its satellites and their impact on optical astronomy.[336] Accordingly, we stated that we would continue to monitor this situation and SpaceX's efforts to achieve its commitments in that record.[337] In response to SpaceX's application for Gen2 Starlink, NASA, NSF, and several individual astronomers and amateur astronomy groups raise concerns regarding the protection of science missions involving astronomy.

93. In letters submitted through NTIA, NASA and NSF raise concerns regarding the potential impact of reflected sunlight on science missions using radio and optical electromagnetic spectrum.[338] In particular, NASA states that it has about fourteen Earth observation missions operating at altitudes above the Gen2 Starlink satellites, and it is concerned reflected sunlight from nearly 30,000 Gen2 Starlink satellites will interfere with those missions.[339] NASA also states that the Hubble telescope is in an orbit at 535 km and SpaceX's proposed satellites operating above Hubble's orbit could double the number of degraded Hubble images by leaving streaks of reflected sunlight on those images.[340] NASA also expresses concerns about the potential impact on its wide-field ground-based telescopes which survey for asteroids that could potentially impact the Earth. NASA estimates that with the addition of nearly 30,000 SpaceX satellites, there could be a Starlink satellite in every asteroid survey image taken by these telescopes, potentially impacting NASA's ability to fulfill its Congressional mandate.[341] NASA states that in an effort to ensure a mutually beneficial space environment to meet commercial and scientific needs, it hopes to obtain additional information from SpaceX regarding Gen2 Starlink operational parameters, and to work with SpaceX to minimize any impacts to NASA's science objective through

[335] *See SpaceX Third Modification Order*, 36 FCC Rcd at 8049, paras. 97q, 97t.

[336] *Id.* at 8047, para. 87.

[337] *Id.*

[338] *See generally* NTIA Letter, NASA Letter, NSF Letter. In addition several astronomers, amateur astronomy groups, and individuals also filed comments asking for denial or indefinite deferral of the Gen2 Starlink constellation to protect optical astronomy. *See* Andy Lawrence September 18, 2022 Letter; The Astronomical Society of Edinburgh September 23, 2022 Letter; Sierra Solter Hunt September 23, 2022 Letter; Tyler Kokjohn September 26, 2022 Letter; Samantha Lawler September 30, 2022 Letter; Carrie Nugent September 30, 2022 Letter; Meredith Rawls October 5, 2022 Letter; Roberto Trotta October 6, 2022 Letter; Graeme Cuffy October 11, 2022 Letter; RAS November 10, 2022 Letter. Several of these individuals additionally highlight the precedential effect the Commission's decision in granting the Gen2 Starlink constellation would have, given the many large constellations planned for the future. *See, e.g.,* Andy Lawrence October 18, 2022 Letter at 2, 6; Meredith Rawls October 5, 2022 Letter at 1; Roberto Trotta October 6, 2022 Letter at 1-2.

[339] *See* NTIA Letter, NASA Letter at 2.

[340] *Id. at* 3. Graeme Cuffy, an amateur astronomer, quotes NASA's comments regarding SpaceX's impact on the Hubble telescope to highlight the impact to astronomy. *See* Graeme Cuffy October 11, 2022 Letter at 1.

[341] *See* NTIA Letter, NASA Letter at 3. Sierra Solter Hunt, Samantha Lawler, Roberto Trotta, and Graeme Cuffy echo NASA's concerns about impact on NASA's missions tracking near earth objects which could strike the Earth. *See* Sierra Solter Hunt September 23, 2022 Letter at 1; Samantha Lawler September 30, 2022 Letter at 1; Roberto Trotta October 6, 2022 Letter at 2; Graeme Cuffy October 11, 2022 Letter at 1.

"robust mitigations."[342]

94. NSF emphasizes the key role of ground based optical, infrared and radio astronomy for scientific investigation and discovery.[343] NSF states that it facilitated a coordination agreement for SpaceX's Gen1 Starlink system pursuant to Footnote US 131 of the United States Table of Frequency Allocations[344] between SpaceX and the radio astronomy sites listed in that footnote, and that discussions for a mutually agreeable coordination agreement are currently ongoing for Gen2 Starlink.[345] NSF also states that it is working with operators to develop recommendations to minimize the impact on optical and infrared astronomy, given that sunlight reflections from satellites, depending on the optical brightness, may degrade images taken by optical telescopes. Mitigations encouraged by NSF include "reducing optical brightness to 7th magnitude or fainter via darkening, deflecting light away from the Earth, or attitude maneuvering, moving orbital elevations to ~700 km or lower, provision of orbital information for astronomers to work on scheduling observations around satellite locations, and other ideas to be developed."[346]

95. A number of astronomers also express concerns in this record regarding the success of SpaceX's past mitigations and the prospects of its proposed mitigations going forward. Meredith Rawls, a PhD researcher at the University of Washington's Department of Astronomy, recognizes that SpaceX has expended significant resources to work with astronomers to mitigate the effects of sunlight reflections from Starlink satellites, but she argues these mitigation measures are "voluntary, insufficient, and in the case of Starlink Gen2, untested."[347] Professor Andy Lawrence also notes that SpaceX halted its experiments with "visorsat and darksat"[348] due to issues with heat, drag, power, and communications problems.[349] These astronomers argue that the vast number of Gen2 Starlink satellites, along with their

[342] NTIA Letter, NASA Letter at 3. *See also* Carrie Nugent September 30, 2022 Letter, at 1 (expressing concerns regarding the effects of satellites on astronomers' ability to detect asteroids that could impact the earth and requesting that the Commission carefully evaluate the serious risks the Gen2 Starlink constellation poses to this vital work). Professor Nugent recently conducted a survey of planetary defense experts, who were asked, "There has been a rapid increase in the number of artificial satellites launched, with US Federal Communications Commission filings indicating that tens of thousands could be launched in coming years. How concerned are you about these satellites directly or indirectly (via Kessler syndrome) interfering with near-Earth object discovery?" Professor Nugent reports that 100 percent of respondents stated they were at least slightly concerned, and 42 percent were seriously or extremely concerned. *See* Carrie Nugent September 30, 2022 Letter at 1.

[343] NTIA Letter, NSF Letter at 1.

[344] 47 CFR 2.106, fn. US131 ("[i]n the band 10.7-11.7 GHz, non-geostationary satellite orbit licensees in the fixed-satellite service (space-to-Earth), prior to commencing operations, shall coordinate with the following radio astronomy observatories to achieve a mutually acceptable agreement regarding the protection of the radio telescope facilities operating in the band 10.6-10.7 GHz").

[345] NTIA Letter, NSF Letter at 1.

[346] *Id.*

[347] *See* Meredith Rawls October 5, 2022 Letter at 1.

[348] As part of its program to reduce the brightness of Starlink, SpaceX tested an experimental darkening treatment on one satellite (Darksat) and also deployed satellites with a visor (Visorsat), a deployable shield. In the SpaceX Third Modification proceeding, SpaceX described these efforts as an iterative process, as a technical challenge, and stated that it is working in close collaboration with the astronomy communities. *See SpaceX Third Modification Order*, 36 FCC Rcd at 8041-43, para. 86. In the *SpaceX Third Modification Order*, we recognized that SpaceX is still testing some of these solutions and SpaceX will continue to work on reducing reflectivity of its satellites. *Id*. at 8043, para. 87.

[349] *See* Andy Lawrence September 18, 2022 Letter at 2.

larger size, will significantly worsen the impacts on optical astronomy.[350] Professor Samantha Lawler and Meredith Rawls argue that the addition of nearly 30,000 Starlink satellites will disrupt the entire field of astronomical research.[351] Professor Roberto Trotta of Imperial College London and the International School for Advanced Learning in Trieste, Italy, states the 30,000 Gen2 Starlink satellites could corrupt up to 50 percent of astronomical images, and the damage to the night sky and the field of astronomy could be irreversible.[352] The Royal Astronomical Society asks that we delay approval of the Starlink Gen2 constellation until SpaceX has demonstrated that it will meet the standards set out in a report overseen by the International Astronomical Union (IAU).[353] Professor Lawrence, Meredith Rawls, Graeme Cuffy, and the Astronomical Society of Edinburgh also raise concerns regarding the increasing impact on amateur astronomy and astrophotography.[354]

96. SpaceX has presented detailed information in the record regarding its mitigation efforts to reduce the brightness of sunlight reflections from its satellites.[355] SpaceX states that it "expects the second-generation satellites to be darker than the first-generation satellites due to its brightness mitigation efforts."[356] SpaceX explains that its Gen2 Starlink satellites will use "three advanced brightness mitigation techniques:" dielectric mirror film, solar array mitigation, and darkening paint.[357] SpaceX also states that its goal is to make Gen2 Starlink "satellites invisible to the naked eye when they are on station serving users, covering the vast majority of each satellite's lifetime."[358] In addition, SpaceX continues to work with a wide variety of astronomers, observatories, and astronomy-related groups "to help minimize the effects of satellites on imagery."[359] SpaceX states that it continues to collaborate with NASA to ensure its science missions are not affected by reflected sunlight from SpaceX's satellites, including regular meetings and coordination.[360] SpaceX also states that it is continuing to work with the astronomy community to implement recommendations from NSF and astronomers.[361] In particular, SpaceX explains that its engineers have "developed analysis software tools and adapted traditional optical engineering ray tracing software to better predict brightness for new satellite designs and concepts of operation," allowing

[350] *Id. at* 3-4; The Astronomical Society of Edinburgh September 23, 2022 Letter at 1; Meredith Rawls, October 5, 2022 Letter at 1; Roberto Trotta October 6, 2022 Letter at 1.

[351] Samantha Lawler September 30, 2022 Letter at 1; Meredith Rawls October 5, 2022 Letter at 1. Tyler Kokjohn, a private citizen with no stated affiliation with the astronomy community, also raises concerns about the Gen2 Starlink constellation's impact on astronomy in his home state of Arizona. *See* Tyler Kokjohn September 26, 2022 Letter.

[352] *See* Roberto Trotta October 6, 2022 Letter at 1, 2.

[353] *See* RAS November 10, 2022 Letter at 2. The Royal Astronomical Society also requests that we apply similar considerations to future filing requests, and end the exemption of large satellite constellations from environmental impact. *Id.* We do not address these two additional requests here, as they are outside the scope of this proceeding.

[354] *See* Andy Lawrence September 18, 2022 Letter at 3-4; Meredith Rawls October 5, 2022 Letter at 1; Graeme Cuffy October 11, 2022 Letter at 1. Professor Lawrence points out that frustration has been growing in these communities, and it is nearly impossible to find an image that does not contain satellite streaks—he provides examples of two images degraded by reflected sunlight from satellites. *See* Andy Lawrence September 18, 2022 Letter at 3-4. The Astronomical Society of Edinburgh, a group of amateur astronomers, also describes how satellite streaks in its members' images have hampered projects with professional astronomers such as searching for meteors or hunting outbursting young stars. *See* The Astronomical Society of Edinburgh, September 23, 2022 Letter.

[355] *See* SpaceX August 1, 2022 *Ex Parte*, Attachment B.

[356] *Id*.

[357] *Id*.

[358] *Id.*

[359] *Id.*

[360] *See* SpaceX Consolidated Opposition at 44; SpaceX August 1, 2022 *Ex Parte* at 1.

[361] *See* SpaceX Consolidated Opposition at 52-53; SpaceX August 1, 2022 *Ex Parte*, Attachment B.

it to incorporate brightness mitigations into the initial design of its satellites.[362] According to SpaceX this has produced mitigations that the astronomy community supports, and which have allowed SpaceX to incorporate the satellite brightness into the design process of its Gen2 Starlink satellites.[363] SpaceX states its mitigations have included geometry changes, material specifications, and maneuvering operations to reduce satellite brightness and aim reflected sunlight away from the Earth, and SpaceX engineers have developed a satellite coating to mitigate diffuse reflectance.[364] SpaceX states that its satellites will be bright enough to be visible to the naked eye immediately after launch and orbit-raising and deorbit phases, as well as during collision avoidance burns, as during these times SpaceX cannot maneuver to mitigate reflected sunlight while also meeting mission objectives, but SpaceX also states it is continuing to refine its mitigation practices to resolve this problem.[365] Additionally, SpaceX explains that the low altitudes of its satellites mean they do not reflect sunlight during the darkest parts of the night, and that SpaceX makes highly accurate satellite tracking details available so astronomers can avoid its satellites.[366]

97. Under the Communications Act, we may grant an application only upon a finding that the "public convenience, interest, or necessity will be served thereby."[367] In light of the concerns raised by NASA, NSF, and the astronomy community, we continue to find, as we did in the *SpaceX Third Modification Order*, that it is in the public interest to continue to monitor SpaceX's ongoing efforts to diminish the average brightness of its satellites to ensure that SpaceX does not unduly burden astronomy and other scientific endeavors.[368] We encourage SpaceX to continue its good faith efforts and coordination with NASA, NSF, and other stakeholders in an effort to ensure a mutually beneficial sustainable space environment to maximize public interest benefits.[369] We find SpaceX's approach of building mitigations into the initial design of its satellites is promising, coupled with SpaceX's ongoing coordination with NASA, NSF, and the astronomy community.

98. To ensure a sustainable operating environment for services using electromagnetic spectrum, we condition this authorization to require SpaceX to continue to coordinate and collaborate with NASA to promote a mutually beneficial space environment that would minimize impacts to NASA's science missions involving astronomy and to require SpaceX to coordinate with NSF to achieve a mutually acceptable coordination agreement to mitigate the impact of its satellites on optical ground-based astronomy. We also condition this authorization to require SpaceX to submit an annual report to the Commission, by January 1st each year, covering the preceding year and containing the following information: (1) whether it has reached a coordination agreement with NSF addressing optical astronomy; and (2) any steps SpaceX has taken to reduce the impact of its satellites on optical astronomy, including but not limited to darkening, deflecting light away from the Earth, attitude maneuvering, and provision of orbital information to astronomers for scheduling observations around satellites' locations.

99. The conditions we adopt today will ensure that SpaceX's Gen2 Starlink satellites are being built, deployed and operated in a manner that serves the public interest by facilitating co-existence with other critical services, including those using various ranges of electromagnetic spectrum, enabling safe operation and reduced interference, and preserving sustainability of the space environment and

[362] SpaceX Consolidated Opposition at 52-53; *see also* SpaceX August 1, 2022 *Ex Parte*, Attachment B.

[363] *See* SpaceX Consolidated Opposition at 52-53; SpaceX August 1, 2022 *Ex Parte*, Attachment B.

[364] *See* SpaceX Consolidated Opposition at 53; SpaceX August 1, 2022 *Ex Parte*, Attachment B.

[365] *See* SpaceX August 1, 2022 *Ex Parte*, Attachment B.

[366] *See* SpaceX Consolidated Opposition at 53; SpaceX August 1, 2022 *Ex Parte*, Attachment B.

[367] 47 USC § 307(a). SpaceX Consolidated Opposition at 44; SpaceX August 1, 2022 *Ex Parte* at 1 (arguing that the Commission does not have "jurisdiction over satellite reflectivity issues").

[368] *See SpaceX Third Modification Order*, 36 FCC Rcd at 8043, para. 87.

[369] *Id*. (noting SpaceX's representation that it had diminished the average brightness of its satellites and made commitment to the astronomy community regarding further reduction in the visibility of its satellites).

orbital resources.[370]

100. Professor Andy Lawrence also notes that the astronomy community, including the team at the Vera Rubin Observatory where he conducts research, has recommended satellites have an apparent magnitude of 7 or greater, an order of magnitude dimmer than visibility to the naked eye (the higher the apparent magnitude, the dimmer the object).[371] Professor Lawrence argues that there is no information in the SpaceX application regarding the predicted apparent magnitude of SpaceX's Gen2 Starlink satellites and no evidence that SpaceX's proposed mitigations will in fact lessen the impact on astronomers.[372] In the *SpaceX Third Modification Order*, the Commission took 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.[373] SpaceX states that even though its Gen2 Starlink satellites "are larger than its Gen1 Starlink satellites, SpaceX still expects the second-generation satellites to be darker than the first-generation satellites due to its brightness mitigation efforts."[374] In the record, SpaceX demonstrates that it has continued to improve its satellite design to mitigate the reflectivity of its satellites. SpaceX will continue to work with a wide variety of astronomers, observatories, and astronomy-related groups to help minimize the effects on astronomy.[375] We find SpaceX's ongoing efforts, coupled with the license conditions we impose today, should further address the concerns raised by commenters.

101. Additionally, while satellites operating below 600 km reflect sunlight for shorter amounts of time, Professor Lawrence argues that lower satellites, such as those SpaceX proposes at 350 km, will nonetheless be brighter than those at a higher orbit.[376] Professor Lawrence also predicts that SpaceX will always have several thousand satellites orbit-raising or deorbiting, and he states that orbit-raising and deorbiting satellites can be as bright as 3rd to 5th magnitude.[377] Although SpaceX's satellites might be visible immediately after deployment and orbit-raising and deorbit phases, as during these times SpaceX states that it cannot maneuver to mitigate reflected sunlight while also meeting mission objectives, SpaceX states that it is continuing to refine its mitigation practices to resolve this problem.[378] In addition, the low altitudes of SpaceX's satellites mean they do not reflect sunlight during the darkest parts of the night.[379] The astronomy community recommends that satellites should be operated below 600 km in order to minimize the impact on astronomy.[380] The restriction in this Order requiring SpaceX to maintain operations below 580 km is consistent with the recommendation to operate satellites below 600 km, and so this restriction should also help reduce the brightness of satellites in conjunction with the other

[370] *See, e.g.*, 47 U.S.C. §§ 154(i), 303(e), 303(f),303(r), 303(y), 307(a), 309; *see also* ITU Radio Regulations. *See also, 2020 Orbital Debris Order and FNPRM*, 35 FCC Rcd at 4164, para. 15 (citing *Mitigation of Orbital Debris*, Second Report and Order, 19 FCC Rcd 11567, 11575, para. 15 (2004)).

[371] *See* Andy Lawrence September 18, 2022 Letter at 2.

[372] *Id.* For example, Professor Lawrence argues specific instances of reflected specular light from SpaceX's new satellite coating could be more harmful than the diffuse reflected light from SpaceX's satellites. *Id.*

[373] *See SpaceX Third Modification Order*, 36 FCC Rcd at 8043, para. 87.

[374] *See* SpaceX August 1, 2022 *Ex Parte*, Attachment B.

[375] *Id.*

[376] *See* Andy Lawrence September 18, 2022 Letter at 2.

[377] *Id.*

[378] *See* SpaceX August 1, 2022 *Ex Parte*, Attachment B.

[379] *See* SpaceX Consolidated Opposition at 53; SpaceX August 1, 2022 *Ex Parte*, Attachment B.

[380] *See SpaceX Third Modification Order*, 36 FCC Rcd at 8043, para. 86 (citing Reply of the American Astronomical Society, IBFS File No. SAT-MOD-20200417-00037, at 1 (filed Jan. 7, 2021)); *see also* Viasat Petition at 67.

conditions we impose today. We also do not authorize SpaceX to deploy satellites below 400 km in our action today. We therefore do not need to address Professor Lawrence's concerns regarding the brightness of lower-flying satellites such as those operating at 350 km.

102. As to Professor Lawrence's argument that SpaceX's collaboration with astronomers will not resolve these issues for all astronomers,[381] as well as the Royal Astronomical Society's request that we delay grant of SpaceX's Gen2 Starlink pending a demonstration that it will meet standards in the International Astronomical Union Report,[382] we find that SpaceX's collaboration with NSF and the scientific community should result in mitigations that benefit the professional and amateur astronomy communities in general, and we urge astronomers with specific concerns to work with SpaceX, as their colleagues have done, to address them. In addition, we note the concerns in the record assume we will authorize SpaceX's entire proposed constellation of nearly 30,000 satellites, and commenters accordingly predict drastic impacts on astronomy. We find that granting SpaceX's application only in part should reduce the severity of these concerns as we continue to monitor these issues and examine the impact of these and any future satellites we may authorize for Gen2 Starlink.

J. Environmental Concerns Citing the National Environmental Policy Act

103. Viasat and NRDC/IDA request that the Commission conduct environmental review of the SpaceX Gen2 Starlink application, as amended, under the National Environmental Policy Act of 1969 (NEPA).[383] Viasat and NRDC/IDA raise concerns related to (1) atmospheric effects from rocket launches;[384] (2) atmospheric effects from satellites reentering the atmosphere at the end of their missions;[385] (3) effects of reflected sunlight on the astronomy community and on the general public;[386] and (4) safety concerns arising out of orbital debris and satellite collision risks in space.[387] These parties assert that Gen2 Starlink as proposed may, or will, have a significant impact on the human environment, and argue that the Commission should prepare a programmatic Environmental Impact Statement to analyze the potential consequences of all satellites authorized or to be authorized by the Commission, or that the Commission should prepare an Environmental Impact Statement (EIS) or, at minimum, require SpaceX to prepare an Environmental Assessment (EA) focused on the individual and cumulative effects of SpaceX's satellites before authorizing SpaceX's constellation.[388] Viasat also argues that the technical assessment from the Government Accountability Office (GAO) published in September 2022 "reinforces the need for an environmental review of SpaceX's proposal.[389] In addressing the concerns raised, we

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[381] *See* Andy Lawrence September 18, 2022 Letter at 1-2. Professor Lawrence states he has not joined the working groups analyzing these issues or participated in collaboration with SpaceX in order to maintain an independent view of the situation.

[382] RAS November 10, 2022 Letter at 2.

[383] *See* Viasat Petition at 54-67; NRDC/IDA Comments. We note that NRDC/IDA's comments were filed well-outside the comment filing window, but we will nonetheless treat them as a petition filed under section 1.1307(c) of our rules. *See* 47 CFR § 1.1307(c).

[384] *See* Viasat Petition at IV, 2, 56-58; Viasat Reply at 46; NRDC/IDA Comments at 1-2, 5-6, 7, 8.

[385] *See* Viasat Petition at IV, 2, 58-61; Viasat Reply at 48-50; NRDC/IDA Comments at 1-2, 5-6, 7.

[386] Viasat Petition at IV, 2, 61-67; NRDC/IDA Comments at 9-10.

[387] *See* Viasat Petition at I, IV, 2, 54-67; *see also generally* NRDC/IDA Comments.

[388] *See* Viasat Petition at 56; NRDC/IDA Comments at 1, 2, 3, 4, 7-8, 12.

[389] *See* Viasat October 13, 2022 Letter at 1. We note however that in the technical assessment, GAO states that "In this report, …. [a]lthough we describe certain relevant U.S. laws and regulations for context, we are not adopting the definitions used under the National Environmental Policy Act of 1969 (NEPA). We are not commenting on whether or how these [environmental or other] effects should be analyzed, regulated, or mitigated under NEPA or any other environmental legislation." *See* GAO Technology Assessment, Large Constellations of Satellites, Mitigating (continued….)

follow the approach in the *SpaceX Third Modification Order,* wherein we analyzed whether the preparation of an EA would be required pursuant to our rules, without deciding the novel issue of NEPA's scope vis-à-vis space activities. We conclude that an EIS is not required in connection with this particular licensing action, and that SpaceX is not required to prepare an EA prior to our taking action in this partial grant.

104. Part 1, Subpart I of our rules[390] implements the provisions of NEPA.[391] The rules provide that, except for a specifically enumerated list of conditions that expressly require the preparation of an 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[.]"[392] Under the Commission's rules, the Commission requires its licensees and applicants to determine whether a deployment is categorically excluded from further environmental review and, if not, to prepare an EA when required.[393] Applicants must determine whether a proposed action falls under one of the specified categories in the FCC's rules that would require an EA.[394] Given that the categories set forth in section 1.1307(a) and (b) of our rules largely focus on environmental effects at the earth's surface, space stations generally have not triggered these categories and therefore have been categorically excluded from review.[395]

105. Our rules further state that even if a "particular action" is otherwise categorically excluded from review under NEPA, an interested party who alleges that the action will have a significant environmental impact may submit "a written petition setting forth in detail the reasons justifying or circumstances necessitating environmental consideration in the decision-making process."[396] 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.[397]

106. The Commission has not typically received petitions raising environmental concerns regarding the licensing of space stations, though Viasat submitted a petition in the proceeding for the Third SpaceX Modification to its Gen1 Starlink constellation, and The Balance Group raised comments citing NEPA on that application as well.[398] In the *SpaceX Third Modification Order*, we found the issues Viasat and The Balance Group raised did not warrant preparation of an EA under our rules.[399] Viasat, The Balance Group, and DISH appealed the decision to the U.S. Court of Appeals, D.C. Circuit, which subsequently upheld the *SpaceX Third Modification Order* on August 26, 2022 against DISH's interference-related challenge, while declining on standing grounds to consider the particular NEPA

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Environmental and Other Effects, GAO-22-105166, at 6, n. 7 (Sept 2022) (GAO Technology Assessment); SpaceX October 24, 2022 Letter at 2.

[390] 47 CFR § 1.1301.

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

[392] 47 CFR § 1.1306(a).

[393] *See* 47 CFR § 1.1301, *et seq*.

[394] *See* 47 CFR §§ 1.1306, 1.1307(a), (b).

[395] *See* 47 CFR §§ 1.1307(a)-(b).

[396] 47 CFR § 1.1307(c).

[397] 47 CFR § 1.1307(c). 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).

[398] *See SpaceX Third Modification Order*, 36 FCC Rcd at 8036, para. 74.

[399] *See SpaceX Third Modification Order*, 36 FCC Rcd at 8036, para. 75.

claims that Viasat and the Balance Group raised.[400]

107. *Legal and Procedural Framework.* We first establish the legal framework for consideration of these claims. As an initial matter, BBILAN seeks "review and removal" of the Commission's "categorical exclusion from NEPA for satellite licensing."[401] We find that these comments effectively seek a broader rulemaking proceeding,[402] and thus are not appropriately addressed in the context of this licensing proceeding, which is an individualized decision under our generally applicable rules as they currently exist.[403] BBILAN discusses the Commission's regulatory framework implementing NEPA as a whole, rather than its approach regarding this application, as amended. We also note that BBILAN does not cite any specific laws or regulations to support its claim that the Commission's categorical exclusion is incorrect as a matter of law, nor does it otherwise demonstrate that the Commission lacked legal authority to adopt the categorical exclusion, even if it believes it should be altered now.

108. We next address the scope of our review. Parties argue that we should consider the potential environmental impacts arising from the Commission's entire satellite licensing regime, requesting that the Commission prepare a programmatic Environmental Impact Statement (EIS) that would address the potential consequences of the proposed operations of all commercial satellite operators before authorizing further satellite deployment.[404] We find NRDC/IDA's request for a programmatic EIS encompassing all commercial satellite licensing to be outside the scope of this licensing proceeding. Similar to BBILAN's request to review the Commission's categorical exclusion framework, we conclude that this request by NRDC/IDA is more squarely presented within the context of the Commission's overall regulatory framework, particularly given that claims under NEPA have not previously been raised in the context of licensing satellite constellations, with the exception of the SpaceX Third Modification application.

109. *Applicability of NEPA.* SpaceX recognizes that in the *SpaceX Third Modification Order*, we did not reach the threshold issue of whether NEPA applies to activities in outer space, however SpaceX urges us to now find that NEPA does not apply to activities in outer space, because without such a threshold ruling, Viasat will continue to "weaponize" NEPA against its competitors.[405] Given that the

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[400] *See generally Viasat, Inc. v. FCC*, 47 F.4th 769 (D.C. Cir. 2022). The D.C. Circuit concluded that the Balance Group lacked Article III standing, and that Viasat's asserted injuries either did not satisfy Article III or did not fall within the zone of interests protected by NEPA. *Id.*

[401] *See* BBILAN Comments at 6, 8. BBILAN argues that satellite licensing in general raises serious environmental and food security risks, "including toxic waste from rocket fuels and motors, light pollution which interferes with insects and agricultural production, health effects of emissions from space launches, RF/EMF radiation from linked base and earth stations, depletion of the ozone layer and associated climate change effects." *Id. at* 5.

[402] We note that these issues have been raised in a petition for rulemaking of the Healthy Heavens Trust Initiative, which is a project of BBILAN. *Id. at* 1, n.1.

[403] *See, e.g.*, *Viasat, Inc. v. FCC*, 47 F.4th 769, 776 (D.C. Cir. 2022) ("an agency need not—indeed should not—entertain a challenge to a regulation, adopted pursuant to notice and comment, in an adjudication or licensing proceeding" (quoting *Trib. Co. v. FCC*, 133 F.3d 61, 68 (D.C. Cir. 1998), internal quotation marks omitted)).

[404] *See* NRDC/IDA Comments at 12.

[405] *See* SpaceX Consolidated Opposition at VII, 45, 46-47; SpaceX May 18, 2022 *Ex Parte* at 1, Exhibit B at 6; SpaceX August 1, 2022 *Ex Parte* at 1-2; SpaceX October 20, 2022 Letter at 2; SpaceX October 24, 2022 Letter at 2. SpaceX argues, for example, that the CEQ has found that NEPA does not apply "extraterritorially", *see* SpaceX Consolidated Opposition, at 46 (citing 40 CFR § 1508.1(q)(1)(i)), and also makes arguments citing to the Treaty on Principles Governing Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (Outer Space Treaty), in arguing that NEPA does not apply to activities that occur in outer space, *see* SpaceX Consolidated Opposition, at 46 (quoting Treaty on Principles Governing Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies art. II, Jan. 27, 1967, 18 U.S.T. 2410, 610 U.N.T. S. 205, https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/outerspacetreaty.html)). Viasat (continued….)

applicability of NEPA in this area presents what we have described as "novel questions,"[406] we will follow our lead in the *SpaceX Third Modification Order*, and assume, without deciding, that NEPA applies. Accordingly, we do not make a finding regarding the extent to which NEPA does or does not apply to the various claims.[407] In the *SpaceX Third Modification Order*, we stated that as a threshold matter it was not clear that all of the issues raised by the parties in the record were within the scope of NEPA.[408] As explained in detail below, based on the record in this particular proceeding, we do not find that SpaceX must prepare an EA on the issues raised in the record or that any other additional environmental review is required. In certain instances, we discuss how our responsibilities under the Communications Act address the concerns raised under this section, and explain how the license conditions we adopt herein diminish any likelihood of harm.

110. *Extraordinary Circumstances.* As in the SpaceX Third Modification proceeding, the parties once again debate whether special circumstances must be determined to overcome a categorical exclusion.[409] As we did in the *SpaceX Third Modification Order,* 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.[410]

111. *Standing*. SpaceX argues that Viasat's arguments regarding environmental issues must be dismissed because of lack of standing, citing the August 2022 decision by the Court of Appeals for the D.C. Circuit.[411] Given that we independently reject Viasat's NEPA arguments on the merits, we decline to reach SpaceX's arguments regarding Viasat's standing, consistent with the *SpaceX Third Modification Order*, which likewise considered similar arguments in the record irrespective of whether they were in a properly-filed petition to deny.[412]

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and NRDC/IDA argue, on the other hand, that space is part of the human environment, and make a variety of arguments in support of their view. As noted, we decline to reach this novel issue.

[406] *SpaceX Third Modification Order*, 36 FCC Rcd at 8037, para. 77.

[407] *Id.*

[408] *Id. The* Commission further observed that several of the issues in the record raised 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. *Id.*

[409] SpaceX again urges the Commission to rule on the threshold question of whether special circumstances are required to overcome a categorical exclusion. SpaceX argues that even if NEPA does apply in outer space, a petitioner must demonstrate extraordinary circumstances to overcome the categorical exclusion, and speculative or uncertain claims of environmental impact, especially when the activity has already been categorically excluded, cannot be sufficient to compel environmental review; the Commission must be provided, on the record, evidence that the environmental harm is both significant and sufficiently plausible. *See* SpaceX Consolidated Opposition at VII, 45-49; SpaceX August 1, 2022 *Ex Parte* at 1-2; SpaceX October 20, 2022 Letter at 2. Viasat states that SpaceX is mischaracterizing the standard of proof required under the Commission's rules. Under NEPA, Viasat argues, a federal agency must conduct environmental review if an action may have a significant impact on the human environment—no special circumstances are required. Even if special circumstances are required, Viasat reiterates that SpaceX is planning to deploy more than ten times the number of satellites launched in the entire history of mankind, which could include launches every six days to deploy and maintain the constellation, and there is nothing normal about that activity—in other words, the sheer scope of SpaceX's proposed Gen2 Starlink constellation are the special circumstances that overcome the categorical exclusion. *See* Viasat Reply at 56-59.

[410] *See* 47 CFR § 1.1307(c).

[411] *See* SpaceX August 29, 2022 Letter at 3.

[412] *See, e.g.*, *SpaceX Third Modification Order*, 36 FCC Rcd at 7998-02, para. 5 (noting the various filings in the proceeding including "an Opposition and Motions" filed by the Balance Group); *id*. at 8036, para. 75 ("consider[ing] the claims raised by The Balance Group and Viasat under section 1.1307(c) of our rules").

112. *Scope of NEPA Review with respect to "Commission Action."* NRDC/IDA argue that we should consider the proposed "30,000" Gen2 Starlink satellites in the context of previously authorized SpaceX satellites and SpaceX satellites that it is reasonably foreseeable may be launched in the future, as well as past and future authorizations of other space objects.[413] NRDC/IDA also argue that even if the Commission chooses not to conduct a programmatic review, it must at the very least evaluate the SpaceX proposal now before it in the context of all satellites that the Commission has already authorized, including non-SpaceX satellites.[414] We note that while this partial grant pertains to the authorization of 7,500 satellites, the Commission has previously authorized SpaceX to construct, deploy, and operate 4,408 Gen1 Starlink satellites.[415] The Commission also has previously authorized SpaceX to conduct radiofrequency operations over a separate NGSO system to operate in the V-band (7,518 satellites),[416] but SpaceX has stated that it does not intend to launch separate V-band satellites and will instead seek a license modification to add V-band communications capabilities to a subset of its Gen2 Starlink satellites, and in any event SpaceX's V-band authorization was subject to the Commission's approval of a license modification.[417] Accordingly, in this analysis under our NEPA rules, when considering cumulative effects, we take into account the previously authorized 4,408 Gen1 Starlink satellites, and the 7,500 satellites authorized in this grant in part. We note that our action here is separate from the Commission's previously authorized non-SpaceX satellites, and this action is evaluated and conditioned under our rules based on the record herein. Consistent with our decision in the *SpaceX Third Modification Order*,[418] with respect to future actions, we do not speculate on how the Commission may act on the remaining proposed Gen2 Starlink satellites and other potential applications that may be filed in the future for additional satellites. Rather, consistent with section 1.1307 of our rules, we address whether the particular "action" at issue requires preparation of an EA, while still taking into consideration the cumulative effect of SpaceX's operations.

1. Atmospheric Effects from Rocket Launches

113. Viasat and NRDC/IDA argue that Gen2 Starlink will have a significant environmental impact because of the increased air pollution caused by the vast number of rocket launches required to deploy and maintain such a large constellation.[419] Viasat explains rockets emit ozone-depleting chemicals and inject particles into the stratosphere which absorb and reflect solar energy, warming the stratosphere and cooling the surface of the Earth (radiative forcing).[420] Viasat also quotes the *GAO Technology Assessment*, which states that emissions from rocket launches "could cause a change in the temperature of the upper atmosphere."[421] NRDC/IDA elaborates that stratospheric ozone depletion leads to increased rates of skin cancer, cataracts, and other illnesses in humans, and these ozone-depleting chemicals can

[413] *See* NRDC/IDA Comments at 12.

[414] *Id.*

[415] *See generally SpaceX Third Modification Order*, 36 FCC Rcd 7995.

[416] *See SpaceX V-band Authorization,* 33 FCC Rcd at 11440.

[417] *See* SpaceX October 27, 2022 Letter at 2; *see also SpaceX V-band Authorization,* 33 FCC Rcd at 11447, para. 32o.

[418] *SpaceX Third Modification Order*, 36 FCC Rcd at 8037-38, para. 78.

[419] *See* Viasat Petition at IV, 2, 56-58; Viasat Reply at 46; NRDC/IDA Comments at 1-2, 5-6, 7, 8.

[420] *See* Viasat Petition at 57; *see also* NRDC/IDA Comments at 8. Professor Samantha Lawler, of the University of Regina, states that noctilucent clouds, high-altitude clouds that shine at night, have been directly linked to emissions from rocket launches, and that these rocket launches have already changed the chemistry of our atmosphere and will continue to do so if not checked. *See* Samantha Lawler September 30, 2022 Letter at 2.

[421] *See* Viasat September 13, 2022 Letter at 3 (quoting GAO Technology Assessment, at 1).

also contribute to catastrophic climate change.[422]

114. Viasat recognizes that in the *SpaceX Third Modification Order*, we decided not to conduct NEPA review of SpaceX's launches of the Gen1 Starlink constellation due to the FAA's environmental review of those launches, but Viasat asserts that the FAA's review does not account for the launch cadence SpaceX would need to maintain in order to deploy the Gen2 Starlink satellites and replacements.[423] It is not clear where Viasat's assessment arises from in the context of the FAA's review of the SpaceX launch operations, and the FAA's Final Programmatic Environmental Assessment (PEA) for the SpaceX Starship/Super Heavy Launch Vehicle, for example, notes that the PEA provides a broader analysis of all reasonably foreseeable activities and effects expected to be caused by the proposed permitting or licensing action.[424] NRDC/IDA argue that while the Commission may incorporate the FAA's analysis of environmental impacts from rocket launches into its own analysis, it is not entitled to rely on the FAA's environmental review to the exclusion of its own review.[425] NRDC/IDA argue that the Commission is still required to conduct its own independent review and document the absence of environmental impact on this issue.[426]

115. Under our rules, we need not conduct an environmental review of the Gen2 Starlink satellite launch activity because another federal agency has reviewed the same activity under NEPA.[427] We disagree with Viasat's claim that there is no evidence that the FAA has taken responsibility for environmental review of SpaceX's launch activities with Starship. It has long been clear the FAA was reviewing the environmental impacts of Starship, and in June, 2022, the FAA completed its review under NEPA.[428] SpaceX also intends to launch its Gen2 Starlink satellites using the Falcon 9 launch vehicle, but

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[422] *See* NRDC/IDA Comments, at 1-2, 5-6, 7, 8 (citing David Doniger, *Giving Thanks for the Montreal Protocol — Proof that Companies Actually Can Cooperate* (Nov. 25, 2011), https://www.nrdc.org/experts/david-doniger/giving-thanks-montreal-protocol-proof-countries-actually-can-cooperate).

[423] *See* Viasat Petition at 57-58, N.118, N.119 (citing Derek Wise, *Elon Musk says SpaceX could face 'genuine risk of bankruptcy' from Starship engine production, SPACE EXPLORED* (Nov. 29, 2021), https://spaceexplored.com/2021/11/29/spacex-raptor-crisis/.; Federal Aviation Administration, *Draft Programmatic Environmental Assessment for the SpaceX Starship/Super Heavy Launch Vehicle Program at the SpaceX Boca Chica Launch Site in Cameron County, Texas,* at 14, § 2.2 (Sep. 2021)); Viasat Reply at 47-48. Viasat estimates that the full Gen2 constellation would require at least seven times the number of launches necessary to launch the Gen1 Starlink constellation, consistent with the nearly sevenfold increase in the number of satellites. Viasat estimates SpaceX would require approximately one launch every six days to maintain the Gen2 Starlink constellation. S*ee* Viasat Petition at 56-57; Viasat Reply at 47-48.

[424] FAA's "Final Programmatic Environmental Assessment for the SpaceX Starship/Superheavy Launch Vehicle at the SpaceX Boca Chica Launch Site in Cameron County, Texas" and "Mitigated Finding of No Significant Environmental Impact and Record of Decision for the SpaceX Starship/Superheavy Launch Vehicle Program at the Boca Chica Launch Site in Cameron County, Texas," at 3, June 2022, https://www.faa.gov/space/stakeholder_engagement/spacex_starship.

[425] *See* NRDC/IDA Comments at 8 (citing *Calvert Cliffs' Coordinating Comm., Inc. v. U. S. Atomic Energy Comm'n,* 449 F.2d 1109, 1117-18 (D.C. Cir. 1971)).

[426] *Id.*

[427] *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…."). *See also* SpaceX Consolidated Opposition at VII, 51; SpaceX October 20, 2022 Letter at 5-6.

[428] FAA's "Final Programmatic Environmental Assessment for the SpaceX Starship/Superheavy Launch Vehicle at the SpaceX Boca Chica Launch Site in Cameron County, Texas" and "Mitigated Finding of No Significant Environmental Impact and Record of Decision for the SpaceX Starship/Superheavy Launch Vehicle Program at the Boca Chica Launch Site in Cameron County, Texas," June 2022, https://www.faa.gov/space/stakeholder_engagement/spacex_starship.

as we discussed in the *SpaceX Third Modification Order*, in July, 2020, the FAA completed review of SpaceX's increased launch activity with the Falcon 9, including through 2025.[429] Given the FAA's review of the rocket launches expected to be used to transport the Gen2 Starlink satellites we approve today, we do not find that our action herein may have a significant environmental impact such that we should require SpaceX to prepare a separate EA with respect to rocket launches, which we conclude would simply duplicate the FAA's review. We also find that we need not address the question of whether Viasat provided sufficient evidence of the effects of rocket launches on the atmosphere,[430] as the FAA has taken responsibility for the environmental review of SpaceX's launch activities,[431] including assessment, for example, of the estimated carbon dioxide equivalent emissions.[432] We have every confidence the FAA has conducted, and will continue to conduct as necessary, thorough environmental reviews of SpaceX's launch activities and accordingly we incorporate the FAA's analysis into our own environmental review.[433] In light of the FAA's environmental review of SpaceX's launch activities and FAA's findings, as incorporated into the record for this proceeding, we find we need not require preparation of a separate EA addressing the atmospheric effects of rocket launches or require additional environmental review.[434]

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[429] 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, 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://netspublic.grc.nasa.gov/main/FINAL_%20SpaceX_EA_Roberts%20Rd_10-2-18.pdf; NASA NEPA Finding, Dec. 2018 https://netspublic.grc.nasa.gov/main/FONSI%20for%20EA%20for%20Space%20Exploration%20Technologies%20Opersations%20Area%20KSC--originalsigned.pdf.

[430] SpaceX argues that Viasat provided only vague assertions of environmental harms that SpaceX's rocket launches could cause, no connection between rocket emissions and real environmental harm, and no evidence of the quantities of compounds emitted and the impact of those specific compounds. *See* SpaceX Consolidated Opposition, at 50-51. Viasat argues this is unnecessary as a matter of law and would also be an insurmountable hurdle given how closely SpaceX holds information about its launch vehicles. *See* Viasat Reply, at 47. SpaceX also notes that launch vehicles that use kerosene or methane-based propellants, like SpaceX's launch vehicles, do not create the alumina or chlorine chemicals that Viasat cites as necessitating an environmental review. Furthermore, SpaceX points to the GAO Technical Assessment: "Citing a 2018 World Meteorological Organization report, the GAO found that rocket launches presently have a small effect on total stratospheric ozone (much less than 0.1%)." *See* SpaceX October 20, 2022 Letter, at 6 (citing GAO Technical Assessment, at 13 (quoting World Meteorological Organization, Scientific Assessment of Ozone Depletion: 2018, Global Ozone Research and Monitoring Project Report No. 58 (Geneva, Switzerland: 2018))).

[431] 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).

[432] *See* FAA's "Final Programmatic Environmental Assessment for the SpaceX Starship/Superheavy Launch Vehicle at the SpaceX Boca Chica Launch Site in Cameron County, Texas" and "Mitigated Finding of No Significant Environmental Impact and Record of Decision for the SpaceX Starship/Superheavy Launch Vehicle Program at the Boca Chica Launch Site in Cameron County, Texas," at 53-54, June 2022, https://www.faa.gov/space/stakeholder_engagement/spacex_starship; *see also SpaceX Third Modification Order*, 36 FCC Rcd at 8039-40, paras. 81-82.

[433] *See* SpaceX Consolidated Opposition at 51.

[434] To the extent that we consider cumulative effects from the deployment of SpaceX's Gen1 Starlink, we point to the Commission's Order on the *SpaceX Third Modification*, wherein the Commission concluded that the FAA has prepared its own EA on the SpaceX launches, and pursuant to our rules, no additional consideration of potential

(continued….)

2. Atmospheric Effects from Reentering Satellites

116. Viasat and NRDC/IDA also argue that Gen2 Starlink will have a significant environmental effect because it will exponentially increase the number of satellites that burn up in the atmosphere, introducing dangerous chemicals, including aluminum oxide (alumina) and soot, into the atmosphere.[435] NRDC/IDA argue these chemicals contribute to climate change and subsequent catastrophic climate-change-driven weather disasters, such as wildfires, hurricanes, and heat waves.[436] The parties debate the amount of alumina that will be injected into the atmosphere from SpaceX's Gen2 Starlink satellites and the impacts this alumina will have. Viasat argues that it uses an industry expert's estimate that the Gen2 Starlink satellites will be four times heavier than the Gen1 Starlink satellites and calculates that Gen2 Starlink satellites, as proposed and including replacements, will introduce roughly 156 million pounds of alumina into the atmosphere.[437] Viasat also highlights the difference between alumina created from reentering manmade satellites and alumina created naturally by meteoroids burning up in the Earth's atmosphere.[438] Viasat claims that there will be "two tons" of Starlink satellites burning up daily in the Earth's atmosphere from Gen1 Starlink, and although this may seem small compared to the fifty-four tons of meteoroids entering the Earth's atmosphere daily, Starlink satellites are mostly aluminum while the meteoroids are less than one percent aluminum.[439] Therefore, Viasat argues that if all of SpaceX's proposed satellites are launched, much more alumina will be introduced into the atmosphere that was created by ablating satellites than occurs naturally.[440] SpaceX maintains that the study cited by

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impacts associated with those launches is required. *See SpaceX Third Modification Order*, 36 FCC Rcd at 8040, para. 82.

[435] *See* Viasat Petition at IV, 2, 58-61; Viasat Reply at 48-50; NRDC/IDA Comments at 1-2, 5-6, 7.

[436] *See* NRDC/IDA Comments at 1-2, 5-6, 7.

[437] *See* Viasat Reply at IV-V, 49-51. Viasat states this is about 42 times the amount of alumina the Commission could have expected from its authorization of SpaceX's third modification to its Gen1 Starlink system. *See* Viasat Reply, at IV-V, 49-51. Per satellite, Viasat argues that a Gen1 Starlink satellite will introduce 442 pounds of alumina on reentry, while Gen2 Starlink Satellites will introduce as much as 2,122 pounds of alumina, calculated using the physical characteristics SpaceX CEO Elon Musk provided in a public statement in May 2022. *See* Viasat June 7, 2022 Letter, at 4. Professor Samantha Lawler calculates that 23 Starlink satellites will burn up in the atmosphere every day (based on SpaceX's plan to replace 42,000 satellites every five years), and based on the Gen1 Starlink satellite design, that would introduce nearly 6 tons of alumina into the upper atmosphere every day. *See* Samantha Lawler September 30, 2022 Letter, at 1. The 42,000 satellites Professor Lawler cites would include the 29,988 Gen2 Starlink satellites SpaceX has applied for in the instant application, as amended; the 4,408 Gen1 Starlink satellites SpaceX is currently authorized to deploy; and the 7,518 V-band Starlink satellites SpaceX is also currently authorized to deploy. *See* Samantha Lawler September 30, 2022 Letter at 1. We again note that SpaceX no longer plans to launch separate V-band satellites and will instead seek a modification to add V-band frequencies to a subset of its Gen2 Starlink satellites. *See* SpaceX October 27, 2022 Letter at 2.

[438] *See* Viasat Petition at 60 (citing Aaron C. Boley and Michael Byers, *Satellite mega-constellations create risks in Low Earth Orbit, the atmosphere and on Earth,* SCIENTIFIC REPORTS (2021) (stating that Starlink satellites have a dry mass of about 260kg; 12,000 satellites will total 3100 tonnes. A 5-year cycle would see on average almost 2 tonnes re-entering Earth's atmosphere daily)); Viasat Reply at 48-50.

[439] *See* Viasat Petition, at 60 (citing Aaron C. Boley and Michael Byers, *Satellite mega-constellations create risks in Low Earth Orbit, the atmosphere and on Earth,* SCIENTIFIC REPORTS (2021)); Viasat Reply at 48-50.

[440] *See* Viasat Petition, at 60 (citing Aaron C. Boley and Michael Byers, *Satellite mega-constellations create risks in Low Earth Orbit, the atmosphere and on Earth,* SCIENTIFIC REPORTS (2021)); Viasat Reply at 48-50. Viasat also notes that since this report was published, SpaceX has increased the size and mass of its proposed Gen2 Starlink satellites, and so the difference between anthropogenic and natural alumina introduced into the atmosphere is even greater. *See* Viasat Petition at 61. Viasat also cites the GAO report, which describes a study finding that 75,000 satellites would produce 7 times as much alumina in the upper atmosphere as naturally occurring meteoroids. *See* Viasat October 13, 2022 Letter at 3 (citing GAO Technical Assessment, at 12).

Viasat does not refute SpaceX's argument in the Space X Third Modification proceeding that the alumina produced by SpaceX satellites would be a fraction of a percentage of all metals introduced into the atmosphere naturally by meteoroids.[441] SpaceX measures the aluminum in Gen2 Starlink satellites as comparable to the aluminum the space shuttle injected into the atmosphere over the course of its life.[442] SpaceX once again argues that Viasat has not provided concrete evidence linking reentering satellites to environmental harm.[443] On the other hand, NRDC/IDA argue that growing evidence suggests that these chemicals will contribute to climate change.[444] NRDC/IDA argue that the dispute regarding the magnitude of this impact is sufficient grounds for environmental review, as categorical exclusions are only justified if the proposed action is known to lack significant environmental impacts both individually and cumulatively.[445] And Viasat argues that the *GAO Technical Assessment* describes a study that found that 75,000 reentering satellites could inject seven times the amount of alumina into the upper atmosphere than natural sources such as meteoroids.[446] SpaceX argues that the *GAO Technical Assessment* actually found that "there is a 'lack of observational data' to support such a finding or to warrant mitigation at this time."[447] SpaceX also notes two studies commissioned by the European Space Agency which found the effects on the atmosphere from reentering satellites to be negligible compared to other anthropogenic activities: the studies find reentering spacecraft accounted for "0.0006% to 0.0008% of global annual ozone loss," or "290,000 times less than the annual impact of the aviation sector and 650,000 times less than the annual impact of the road transportation sector."[448] SpaceX argues that using Viasat's estimates for the amount of alumina injected into the atmosphere from the Gen2 Starlink satellites, "annual impact of reentering Gen2 satellites on Earth's albedo—the fraction of solar radiation that is reflected away from Earth—will be negligible compared to natural sources (i.e., just 0.005 of the amount of mineral dust

[441] *See* SpaceX Consolidated Opposition at 56-57. SpaceX argues that Viasat's study simply says that the amount of alumina generated by satellites could potentially exceed the amount of alumina generated by meteoroids. *Id. at* 55-56.

[442] *See* SpaceX May 18, 2022 *Ex Parte*, Exhibit B at 6.

[443] *See* SpaceX Consolidated Opposition at 55-57; SpaceX October 20, 2022 Letter at 2-3.

[444] *See* NRDC /IDA Comments at 1-2, 5-6, 7 (citing Aaron C. Boley & Michael Byers, *Satellite mega-constellations create risks in Low Earth Orbit, the atmosphere and on Earth,* SCIENTIFIC REPORTS (May 20, 2021), https://www.nature.com/articles/s41598-021-89909-7).

[445] *See* NRDC/IDA Comments at 7. Similarly, Professor Lawler and Sierra Solter Hunt state that scientists need time to study the effects of reentering satellites given the possibility that injecting alumina into the atmosphere could create another hole in the ozone layer. *See* Samantha Lawler September 30, 2022 Letter at 1; Sierra Solter Hunt September 23, 2022 Letter at 1.

[446] *See* Viasat October 13, 2022 Letter at 3, n.7 (citing GAO Technical Assessment at 12). Viasat states, "Considering that the nearly 30,000 operating satellites in the 'Gen2' configuration would need to be replaced every five years (if not sooner), and that many of these satellites would be eight times more massive than the original Starlink satellites, it is reasonable to expect that Starlink alone would produce well beyond this level of aluminum emissions over a 15-year license term." *See* Viasat October 13, 2022 Letter at 3, n.7.

[447] *See* SpaceX October 20, 2022 Letter at 3-4 (quoting GAO Technical Assessment at I, 10, 55).

[448] *Id.* at 4 (citing On *the Atmospheric Impact of Demise Upon Reentry*, The Clean Space Blog, ESA (Aug. 11, 2022), https://blogs.esa.int/cleanspace/2022/08/11/on-the-atmospheric-impact-of-spacecraft-demise-upon-reentry/). SpaceX notes that these studies assumed a worst case scenario of an average of 450 tons of reentering satellites every year and a peak of 650 tons of reentering satellites, but SpaceX argues the finding that the impact on the atmosphere is negligible is still appropriate even with Viasat's larger estimates. *Id.* SpaceX also cites to Slimane Bekki et al., Environmental impacts of atmospheric emissions from spacecraft re-entry demise, Eur. Space Agency, at 10, 13 (Sept. 21, 2021), https://indico.esa.int/event/321/contributions/6403/attachments/4335/6538/esa-csid-21-bekki.pdf. *Id.* at 4, fn. 19.

created annually through naturally occurring dust storms from the Sahara Desert alone)."[449] Additionally, SpaceX cites a study which found that alumina is not even created when meteoroids containing aluminum burn up in the atmosphere, and SpaceX argues this undermines Viasat's entire premise.[450]

117. We note that we are not currently authorizing SpaceX to deploy all of its proposed 29,988 satellites, but rather a smaller subset of 7,500 satellites, the effects of which we consider in conjunction with the effects of the previously approved 4,408 satellites. In the event that we consider approving additional satellites in this system, we will consider the additional proposed Starlink satellites on a cumulative basis with those approved. Therefore, the parties' estimated amount of alumina that could be introduced into the atmosphere will not come to pass from our action today. Based on the record, we are not convinced that reentering SpaceX Gen2 Starlink satellites may have a significant environmental impact necessitating an EA. As SpaceX states, the European Space Agency (ESA) initiated two studies, looking into specifically the atmospheric impact of spacecraft demise upon reentry and concluding that the impact was negligible compared to other anthropogenic activities.[451] SpaceX states that as a part of its fundamental commitment to space sustainability, it has worked extensively and collaboratively with federal agencies and the scientific community to establish and implement best practices designed to preserve space and our environment for future generations.[452] SpaceX states that although atmospheric effects of alumina formed during Gen2 Starlink satellite reentry will be negligible or nonexistent, it remains committed to leading the way on space sustainability, and recognizes that further dialogue with the scientific community on this issue would be valuable.[453] Noting GAO's statement that additional "observational data" on the release of alumina from satellite reentry could help the scientific community better quantify emissions and develop "more accurate atmospheric modeling studies," SpaceX commits to work with the scientific community to explore methods to collect observational data on the formation of alumina from satellite reentry, implement reasonable methods that are discovered to the extent practicable, and report findings from these measurements to the Commission.[454]

118. We note that the *GAO Technology Assessment* acknowledges that scientific understanding of emissions from large constellations of satellites in the upper atmosphere is nascent and gathering observational data on this issue would be helpful.[455] Similarly, ESA also states that "while both studies agree that the atmospheric impact of spacecraft reentries is relatively low, there are still uncertainties on aerothermodynamics and atmospheric chemistry-transport modeling and a lack of observational (in-situ) data to evaluate assumptions and models."[456] Given this record, we conclude that the ESA assessment regarding atmospheric impact of spacecraft reentries appears to be the most relevant evidence in the record, focusing specifically on atmospheric effects of reentering spacecrafts, and is

[449] *Id*. at 4-5 (citing J. M. Prospero, *Saharan Dust Transport Over the North Atlantic Ocean and Mediterranean: An Overview,* in 11 THE IMPACT OF DESERT DUST ACROSS THE MEDITERRANEAN. ENVIRONMENTAL SCIENCE AND TECHNOLOGY, 133-151 (S. Guerzo and R. Chester eds., 1996), https://doi.org/10.1007/978-94-017-3354-0_13).

[450] *Id.* at 4 (citing John M. C. Plane et al., Meteor-Ablated Aluminum in the Mesosphere-Lower Thermosphere, 126 J. of Geophysical Research: Space Physics 1 (2021), https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1029/2020JA028792).

[451] *Id.* (citing On the Atmospheric Impact of Demise Upon Reentry, The Clean Space Blog, ESA (Aug. 11, 2022), https://blogs.esa.int/cleanspace/2022/08/11/on-the-atmospheric-impact-of-spacecraft-demise-upon-reentry/).

[452] *See* generally SpaceX October 27, 2022 Letter.

[453] *Id.*

[454] *Id.* at 2.

[455] *See GAO Technology Assessment* at 10-17.

[456] *On the Atmospheric Impact of Demise Upon Reentry*, The Clean Space Blog, ESA (Aug. 11, 2022), https://blogs.esa.int/cleanspace/2022/08/11/on-the-atmospheric-impact-of-spacecraft-demise-upon-reentry/).

sufficiently persuasive for us to conclude that there would not be a significant environmental impact associated with a constellation of 7,500 Gen2 Starlink satellites demising upon reentry, and that there would not be a significant environmental impact cumulatively with previously-approved SpaceX satellites.[457] Although the ESA studies are qualified by the need to gather additional observational data, we observe that most scientific studies could benefit from additional data, and thus we do not find that qualification significant enough to require the preparation of an EA in this case. However, to assist the Commission in potential future determinations regarding larger deployments as well as to encourage best industry practices, we condition this partial grant on SpaceX's commitment to work with the scientific community on this issue to explore methods to collect observational data on formation of alumina from satellite reentry, to implement reasonable methods that are discovered to the extent practicable, and to report findings from these measurements to the Commission annually. We find that approval of this partial grant with such conditions will serve the public interest, convenience, and necessity.

119. The parties also debate the relative merits of satellite disposal by atmospheric reentry.[458] We continue to agree with SpaceX that atmospheric reentry with fully-demisable satellites is preferable to leaving satellites in orbit or constructing satellites from materials that will survive reentry and pose a risk of human casualty.[459] Distinct from NEPA issues, in the 2020 Orbital Debris Order, the Commission found that leaving an NGSO satellite in orbit as debris at the end of its lifetime generally results in increased risk for future space operations.[460] Furthermore, surviving debris from satellites that are disposed of by atmospheric reentry but do not burn up completely can cause harm to human life and property on Earth.[461] As discussed in more detail above, SpaceX has demonstrated compliance with our orbital debris mitigation rules.

3. Effects on the Astronomy Community and Night Sky Observation

120. Viasat and NRDC/IDA next request that the Commission undertake environmental review based on concerns about the brightness of SpaceX's satellites, both from sunlight reflecting off the satellites and from the satellites' impact on diffuse skyglow, the overall brightness of the night sky.[462] The parties argue the brightness of the Gen2 Starlink satellites will have two separate, but related, impacts: impacts on professional and amateur astronomy and impacts on the general public, including human health, enjoyment of nature, and the cultural and religious practices of indigenous communities.[463] As an initial matter, Viasat and NRDC/IDA state that the Commission did not require environmental review based on sunlight reflectivity of satellites in the *SpaceX Third Modification Order* but instead noted SpaceX's continued cooperation with the astronomy community, the reduction in orbital altitude below 600 km of the Gen1 Starlink satellites, and other mitigations SpaceX implemented to reduce

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[457] *See* 47 CFR § 25.1307(c).

[458] SpaceX argues that the best option for post-mission disposal for satellites is atmospheric reentry with fully demisable satellites. *See* SpaceX Consolidated Opposition, at 57. Viasat disputes this argument: while it might be the best option, that does not mean it is a good option, especially given the scale of SpaceX's proposed constellation. *See* Viasat Reply, at 51.

[459] *See SpaceX Third Modification Order*, 36 FCC Rcd at 8040-41, para. 83.

[460] *See 2020 Orbital Debris Order and FNPRM*, 35 FCC Rcd 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").

[461] *See, e.g.,* https://www.unoosa.org/pdf/publications/st_space_49E.pdf.

[462] See Viasat Petition at IV, 2, 61-67; NRDC/IDA Comments at 9-10.

[463] *See* Viasat Petition at IV, 2, 61-67; NRDC/IDA Comments at 9-10.

reflectivity of its satellites.[464] However, the parties argue the vast increase in the number of satellites SpaceX proposes, along with their larger size, will dramatically worsen these impacts, which, they contend, are already being experienced today with SpaceX's partially deployed Gen1 Starlink system, and therefore the Commission must conduct environmental review under NEPA.[465]

121. On SpaceX's impact to astronomy, Viasat and NRDC/IDA state that SpaceX's mitigations have not been effective and the scientific community is now expressing much more concern regarding the impact of large constellations in LEO on astronomical research, and so the Commission cannot rely on SpaceX's claims that it is solving the problem and must conduct review under NEPA.[466] Viasat cites a recent study conducted by the American Astronomical Society (AAS) which found an increase in the number of astronomical images affected by Starlink.[467] Viasat also notes that the Commission originally based its decision to not require environmental review at least in part on the fact that the Gen1 Starlink satellites would be operating below 600 km because the astronomy community has indicated satellites operating below 600 km have much less impact, but SpaceX now proposes to operate 468 satellites above 600 km, 7720 satellites that could operate above 600 km because of SpaceX's proposed expansive orbital tolerances, and an unknown number of satellites that could be transiting through space above 600 km.[468] NRDC/IDA cites NASA's comments in this proceeding, pointing to the impact of these satellites on its missions tracking near earth objects which could strike the Earth, and NRDC/IDA argue that if light pollution from satellites causes these telescopes to miss a dangerous asteroid that strikes the Earth, that would have a significant impact on the human environment indeed.[469] Viasat quotes the *GAO Technology Assessment* for concerns regarding the impact of reflected sunlight on astronomy: "Sunlight reflections and radio transmissions from satellites could disrupt telescopes, which could make it more difficult for astronomers to assess risks associated with near-Earth asteroids or to observe other celestial objects."[470] SpaceX argues that Viasat is mischaracterizing the results of the *GAO Technical Assessment*, which "far from being critical of SpaceX's efforts to mitigate any impact on astronomy, … demonstrates that any effect from the Gen2 satellites on astronomical observations will be minimal."[471]

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[464] *See* Viasat Petition at 61 (citing *SpaceX Third Modification Order*, 36 FCC Rcd at 8043, para. 87); Viasat Reply at 51-53; NRDC/IDA Comments at 11.

[465] *See* Viasat Petition at 61-62; Viasat Reply at 51-53; NRDC/IDA Comments at 11.

[466] *See* Viasat Petition at 67; NRDC/IDA Comments at 11.

[467] *See* Viasat Petition at 62 (citing Przemek Mroz *et al., Impact of the SpaceX Starlink Satellites on the Zwicky Transient Facility Survey Observations,* THE ASTROPHYSICAL JOURNAL LETTERS (Vol. 924, No. 2 2022), https://iopscience.iop.org/article/10.3847/2041-8213/ac470a; Michael Kan, *Starlink Satellites Are Photo Bombing Astronomy Images,* PCMAG (Jan. 18, 2022), https://www.pcmag.com/news/starlink-satellites-are-photo-bombing-astronomy-images.); Viasat Reply, at 51-53; Viasat May 2, 2022 Letter, at 2 (citing Lawrence, M.L. Rawls, M. Jah, M. et al., *The case for space environmentalism*, 6 NATURE ASTRONOMY, 428-435 (2022), https://doi.org/10.1038/s41550-022-01655-6); NRDC/IDA Comments at 11. Professor Andy Lawrence agrees the larger size and vast increase in the number of Gen2 Starlink satellites could increase the total reflected sunlight by an order of magnitude, even making optimistic assumptions about the success of SpaceX's technologies. *See* Andy Lawrence September 18, 2022 Letter at 2.

[468] *See* Viasat Petition at 67; Viasat Reply at 53.

[469] *See* NRDC/IDA Comments at 10-11. Viasat also notes NASA's concerns and the concerns of the astronomy community. *See* Viasat October 13, 2022 Letter at 3.

[470] *See* Viasat October 13, 2022 Letter at 3 (quoting GAO Technical Assessment at 1). We discusseconcerns regarding SpaceX's impact on radioastronomy in Section III.E above.

[471] *See* SpaceX October 24, 2022 Letter at 2 (citing GAO Technical Assessment, at 30). SpaceX quotes the GAO Technical Assessment to explain further: "For example, the report notes that satellite use in general has an effect on amateur astronomy, but 'the effects from many additional satellites in orbit is expected to be minor.' In addition, the (continued….)

122. As discussed above, the record before us clearly demonstrates SpaceX's continued commitment and efforts toward mitigating the impact of reflected sunlight on optical astronomy.[472] We therefore disagree with Viasat's and NRDC/IDA's claims that SpaceX has not made progress in addressing the concerns of the astronomy community. Based on the record before us, we find it is not necessary for us to conduct environmental review under NEPA on this issue. We have assessed these issues under our obligation to ensure grant of this application is in the public interest,[473] and we need not conduct additional review under NEPA where we have thoroughly examined the issues and imposed appropriate conditions on SpaceX to ensure that there will not be a significant impact. As discussed above, we are monitoring this issue to ensure that our licensing action serves the public interest, and we have accordingly imposed license conditions on SpaceX to ensure SpaceX's authorized operations do not unduly burden astronomy and other research endeavors. These conditions include restricting SpaceX's operations to below 580 km, requiring SpaceX to continue to coordinate and collaborate with NASA to promote a mutually beneficial space environment that would minimize impacts to NASA's science missions, requiring SpaceX to reach a coordination agreement with NSF to protect optical ground-based astronomy, requiring SpaceX to coordinate with NSF as well as with specific observatories for operations in specific frequency bands to protect radioastronomy operations, and requiring SpaceX to submit regular reports to the Commission regarding progress in its efforts to protect optical astronomy.[474] We find that these conditions, in addition to SpaceX's planned mitigation efforts, are sufficient to avoid significant environmental effects, and therefore environmental review under NEPA is not warranted for these issues.[475]

123. Regarding impacts of satellite reflectivity on the general public, Viasat and NRDC/IDA argue that Gen2 Starlink's impact on the night sky can have aesthetic, scientific, social and cultural, and health effects."[476] We find that the record does not show that potential effects on the general public,

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effect of satellites on the 'overall brightness of the sky . . . is expected to be minimal even as the number of satellites grows significantly.'" SpaceX October 24, 2022 Letter at 2 (quoting GAO Technical Assessment at 30, 31).

[472] *See supra* Section III.I.

[473] *Id.*

[474] *See* supra Sections III.E and I.

[475] *See* 40 CFR § 1501.4.

[476] *See* Viasat Petition at 61. Similarly, though not requesting review under NEPA, the Astronomical Society of Edinburgh argues deployment of 30,000 additional satellites will completely ruin the night sky, costing humanity "too much of our natural heritage and beauty of the night sky." *See* The Astronomical Society of Edinburgh September 23, 2022 Letter, at 1. NRDC/IDA argues the sunlight reflection caused by SpaceX satellites will impact human health including disruptions to humans' circadian rhythms and stimulation of neuroendocrine and neurobehavioral responses. *See* NRDC/IDA Comments at 9 (citing United Nations Office for Outer Space Affairs, et al, Dark and Quiet Skies for Science and Society: Report and Recommendations (2020) https://www.iau.org/static/publications/dqskies-book-29-12-20.pdf.). NRDC/IDA also argues the increased light pollution will cause significant harm to plants and animals, which humans value for food, quality of life, income from tourism, and religious and cultural reasons. *Id*. (citing Wright, K.P. Jr, McHill, A.W., Birks, B.R., Griffin, B.R., Rusterholz, T. & Chinoy, E.D. 2013; Entrainment of the human circadian clock to the natural light-dark cycle. Curr. Biol. 23:1554-8; Evans, J.A. & Davidson, A.J. 2013, Health consequences of circadian disruption in humans and animal models. Prog Mol Biol Transl Sci. 119:283-323). Sierra Solter Hunt also states that the "constant re-entry burning of satellites may cause global light pollution due to innumerable reflective satellite particles left in orbit," and light pollution is linked to increased cancer risk, *see* Sierra Solter Hunt September 23, 2022 Letter at 1, and Professor Andy Lawrence further argues the SpaceX Gen2 Starlink constellation will impact casual stargazers and indigenous communities, who value the night sky for religious activities and who also live in the darkest areas where reflected sunlight from Starlink satellites will be most noticeable*, see* Andy Lawrence September 23, 2022 Letter at 3. Additionally, NRDC/ IDA states that the increased "light pollution" from SpaceX satellites will harm "the wilderness experience NRDC members and others value for the solitude and escape from technology and urbanization it provides." NRDC/IDA Comments at 10. NRDC/IDA states, "American Psychological Association
(continued….)

plants, and animals may be significant, requiring an EA. SpaceX expects that its Gen2 Starlink satellites will be darker than the first-generation satellites due to its brightness mitigation efforts.[477] SpaceX also states that its goal is to make Gen2 Starlink "satellites invisible to the naked eye when they are on station serving users, covering the vast majority of each satellite's lifetime."[478] In addition, the conditions we adopt today to reduce effects on astronomy services will also address these other satellite sunlight reflectivity concerns involving the general public.

4. Effects from Satellite Collisions in Space

124. Viasat argues that Gen2 Starlink will increase the generation of orbital debris, "which has already endangered life on earth and in orbit," and which creates economic and ecological impacts on Earth.[479] Viasat states that Gen2 Starlink will present a "huge" collision risk, and "[t]he associated debris would pollute the orbital environment and/or threaten direct harm on Earth, including ecological and economic effects here on Earth for U.S. businesses, governments, scientists, consumers, and others."[480] Viasat alleges that all of these are cognizable harms under section 1.1307(c) and NEPA, and SpaceX's orbital debris showing doesn't come anywhere near evaluating all the possible risks posed to the human environment.[481]

125. As noted above, we decline to reach the issue of whether activities that take place entirely in outer space, or that have their impacts in outer space, must be analyzed under NEPA. However, regardless of whether such activities are appropriately analyzed under NEPA, we find that we have conducted the functional equivalent of an EA in analyzing these issues carefully under our extensive orbital debris mitigation analysis, and thus we need not re-assess the risks of orbital debris under NEPA where we have thoroughly assessed those risks.[482] As discussed in detail above, we have reviewed SpaceX's orbital debris mitigation plan and found that SpaceX has satisfied those rules for the subset of satellites we authorize today, and we have included conditions to address orbital debris.[483]

K. Other Matters

126. BBILAN filed a number of comments that apply to satellite licensing in general and repeat arguments made in the Healthy Heavens Trust Initiative's (HHTI) petition for rulemaking, rather

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has linked hiking in the wilderness and other exposure to a host of health benefits, including improved attention, lower stress, better mood, and reduced risk of psychiatric disorders. The light of passing satellites compromises the wilderness experience and its benefits in the same way that 'pinging of a cellphone' does. The 'untrammeled' nature promised by the 1964 Wilderness Act is lost." *Id.*

[477] *See* SpaceX August 1, 2022 *Ex Parte*, Exhibit B.

[478] *Id.*

[479] Viasat Petition at IV-V, 2, 67; Viasat Reply at 54.

[480] Viasat Petition at 67; Viasat Reply at 54. Professor Lawler and Sierra Solter Hunt also express concerns about the Gen2 Starlink constellation's potential impact on the orbital environment, citing the approaching period of "solar maximum" and argue that SpaceX's recent loss of Starlink satellites from a solar storm is evidence that SpaceX cannot safely operate in these conditions. *See* Samantha Lawler September 30, 2022 Letter at 2; Sierra Solter Hunt September 23, 2022 Letter at 1. . Professor Lawler and Professor Trotta also express concern regarding the increasing possibility of a runaway cascade of debris-generating collisions which could render LEO unusable for decades or up to a century. *See* Samantha Lawler September 30, 2022 Letter at 2; Roberto Trotta October 6, 2022 Letter at 2-3.

[481] *See* Viasat Petition at 67; Viasat Reply at 54.

[482] *See* 47 CFR § 1.1307(c); 42 USC § 4332(C).

[483] *See supra* Section III.G (Orbital Debris Mitigation discussion).

than to SpaceX's application, as amended.[484] Specifically, BBILAN claims the Commission's ongoing blanket licensing of satellites presents an imminent international hazard and is in violation of federal law, ongoing litigation, and petitions for rulemaking.[485] BBILAN argues the Commission is engaging in a legally questionable practice of segmenting satellite licensing by granting individual licenses to individual companies rather than looking at all satellite licensing as a whole, which has resulted in a state of "regulatory chaos."[486] BBILAN calls for the Commission to conduct a comprehensive environmental and national security review of all satellite licensing.[487] While these and other reviews are undertaken, BBILAN requests the Commission enact a 180-day pause on all satellite licensing.[488]

127. SpaceX argues these comments are wholly beyond the scope of this proceeding,[489] and we agree. As the D.C. Circuit recently reiterated in affirming the *SpaceX Third Modification Order*, "an agency need not—indeed should not—entertain a challenge to a regulation, adopted pursuant to notice and comment, in an adjudication or licensing proceeding."[490] Here, BBILAN's comments challenge an entire regulatory framework. We find that this Order, which grants authority for SpaceX to construct, deploy, and operate 7,500 satellites, is not the appropriate forum to consider such broad comments.

128. BBILAN and The Balance Group also claim the Commission has failed to consult with other federal agencies, both regarding SpaceX's Gen2 Starlink application, as amended, and the Commission's entire satellite licensing regime.[491] BBILAN argues that federal regulations for non-wartime emergencies require the Commission to consult with the National Security Council and the White House Office of Science and Technology Policy.[492] BBILAN requests the Commission consult with NASA, the Cybersecurity and Infrastructure Security Agency (CISA), the Department of State, the National Institute for Standards and Technology (NIST), Department of Defense (DOD), Department of Agriculture, Department of Energy, National Oceanic and Atmospheric Administration (NOAA), Government Accountability Office (GAO), and the Environmental Protection Agency (EPA), as well as congressional committees, international organizations, and foreign nations on the Commission's entire satellite licensing regime and develop a risk assessment within 180 days.[493] Regarding this specific application, The Balance Group argues that before any grant of authority, the Commission must provide other agencies, including NASA, DOD, EPA, Department of State, the Department of Homeland Security, and the Food and Drug Administration the time, information, and resources to conduct their

[484] *See generally* BBILAN Comments. We note that HHTI is a project of BBILAN, and the cofounders of BBILAN also cofounded The Balance Group, which also submitted an opposition and various motions regarding the SpaceX Gen2 Starlink application and amendment. *See* BBILAN Comments, at 1, N.1; *see also* The Balance Group Opposition, at 2, n.1.

[485] *See* BBILAN Comments at 1.

[486] *Id.* at 2, 7, 8.

[487] *Id.* at 1.

[488] *Id.* at 8.

[489] *See* SpaceX Consolidated Opposition at IX, 67.

[490] *See Viasat Inc. V. FCC*, 47 F.4th 769, 776 (D.C. Cir. 2022).

[491] *See* BBILAN Comments at 1, 2.

[492] *Id.* at 2-3. BBILAN states: "Procedurally, this action is based on FCC Rule 1.401(a-c), 47 CFR Ch. II (10-119 Edition) 202.0 objectives, 202.1 policies, Sections 202.0-202.3 which pertain to the allocation of functions and responsibilities for non-wartime emergencies within the federal government — Emergency Preparedness and Planning during National Emergencies occurring in war as well as peacetime. These Rules make clear that the locus of authority in national emergencies involving telecommunications infrastructure resides in the National Security Advisor and Director of the White House's Office of Science and Technology Policy (OSTP), not the FCC." *Id.* at 2-3.

[493] *Id.* at 2.

own rulemakings and research assessments regarding the SpaceX Gen2 Starlink application, as amended, in compliance with the Administrative Procedure Act (APA).[494]

129. Again, we dismiss BBILAN's comments regarding the Commission's satellite licensing process in general, as they are inappropriate for this licensing proceeding for an individual operator. As to The Balance Group's claims that we have failed to consult with other agencies regarding the SpaceX Gen2 Starlink application, as amended, we note that we have an open and transparent process, and we seek comment on any satellite application under our rules consistent with the APA, and two federal agencies, NASA and NSF, have participated in filing comments through NTIA on this application.

130. BBILAN and the Balance Group also argue that there is no suitable insurance to protect the American people from the harms they have identified, both from the Commission's satellite licensing regime in general and the SpaceX Gen2 Starlink application, as amended, in particular.[495] The Balance Group includes a motion for certification of suitably comprehensive insurance coverage and a motion for certification of indemnity in its comments.[496] It asks: "Has the FCC disclosed whether the SpaceX network as proposed has been duly insured and indemnified against material and catastrophic impacts to (i) national security, (ii) other networks, (iii) the astronomical sciences, (iv) human health, (v) environmental health, (vi) food production, (vii) real estate values related to night sky disruption, (viii) international treaties, and the other matters discussed in the record?"[497] According to The Balance Group, such insurance information must be filed in the public record prior to any grant of the SpaceX application, as amended.[498] Insurance and indemnification are topics included in our ongoing rulemaking proceeding on orbital debris mitigation.[499] All of SpaceX's authorizations, including this partial grant of the SpaceX Gen2 Starlink application, as amended, are conditioned on SpaceX complying with the outcome of future Commission rulemakings.

131. Finally, BBILAN and The Balance Group argue there have been significant developments regarding satellite licensing, including the HHTI petition for rulemaking, The Balance Group's comments on the third SpaceX modification application, HHTI's comments on SpaceX's application for five million earth stations, and the litigation regarding the *Third SpaceX Modification Order*, all of which, according to BBILAN and The Balance Group, the Commission has chosen to ignore, with the exception of the litigation.[500] The Balance Group claims its comments on SpaceX's third modification application were ignored by the Commission and remain unresolved, and it argues the Commission must resolve these issues before proceeding with any grant of the SpaceX Gen2 Starlink application, as amended.[501] The Balance Group also includes a motion to suspend or revoke all of SpaceX's licenses, arguing that SpaceX should not be operating mega constellations while its legal authority to do so is in question.[502] SpaceX argues that the Commission rejecting The Balance Group's arguments or the appeal of the *SpaceX Third Modification Order*, which was still pending at the time the

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[494] *See* The Balance Group Opposition at 4-5.

[495] *See* BBILAN Comments at 6; The Balance Group Opposition at 1, 5.

[496] *See* The Balance Group Opposition at 1, 5.

[497] *Id.* at 5.

[498] *Id.*

[499] *See 2020 Orbital Debris Order and FNPRM*, 35 FCC Rcd at 4237-4245, paras. 176 -192.

[500] *See* BBILAN Comments at 1, 2, N.2, 3-5; The Balance Group Opposition at 3-4. BBILAN and The Balance Group incorporate by reference all of these documents into the record for the SpaceX Gen2 Starlink application and amendment.

[501] *See* The Balance Group Opposition at 3-4.

[502] *Id.* at 5. In support of this argument, The Balance Group incorporates by reference the entire record from the *SpaceX Third Modification Order* and the entire record from the ongoing appeal at the D.C. Circuit. *Id.*

Balance Group filed its motions and SpaceX responded in its Consolidated Opposition, is not a reason to revoke previously granted authority under § 312 of the Communications Act.[503] As discussed above, since The Balance Group and HHTI filed their comments, the D.C. Circuit has ruled on the appeal of the *SpaceX Third Modification Order*.[504] The Balance Group is also incorrect in claiming that we ignored its comments in the *SpaceX's Third Modification Order*: We explicitly addressed and dismissed The Balance Group's comments, with explanations of our reasoning behind our ruling, in the *SpaceX Third Modification Order*.[505] Additionally, we agree with SpaceX that none of these developments are cause to delay action on our partial grant of the SpaceX Gen2 Starlink application, as amended. Under our rules, Gen2 Starlink is a separate system from Gen1 Starlink. Additionally, there is no colorable claim in the record that SpaceX has failed to comply with any of our rules or its license conditions to suspend or revoke all of SpaceX's licenses.

132. In sum, The Balance Group's and BBILAN's comments are either addressed in our analysis above, are more appropriately discussed in rulemaking proceedings, or are beyond the scope of this licensing proceeding. We therefore dismiss the comments filed by BBILAN and the oppositions and motions filed by The Balance Group.

133. Finally, Cameron Nelson, of Tenzing Startup Consultants, and Melissa Shipp filed brief letters urging the Commission to defer or deny SpaceX's Gen2 Starlink application based on the unknown impact of the mix of radiofrequency (RF) emissions from satellites in space on humans, plant, and animal life.[506] As discussed in the *SpaceX Third Modification Order*, a proposed project would require preparation of an EA if it would cause human exposure to RF emissions that exceed the limits in the Commission's rules.[507] The record in this proceeding fails to allege that grant of the SpaceX Gen2 Starlink Application, as amended, would result in human exposure to RF emissions in excess of the Commission's limits, and we therefore decline to require SpaceX to prepare an EA regarding its RF emissions or to defer or deny SpaceX's application on these grounds.

IV. CONCLUSION AND ORDERING CLAUSES

134. Accordingly, IT IS ORDERED, that the Gen2 Starlink Application, as amended, filed by Space Exploration Holdings, LLC (SpaceX), IS GRANTED-IN-PART and DEFERRED-IN-PART to the extent set forth above, pursuant to section 309(a) of the Communications Act of 1934, as amended, 47 USC § 309(a).

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

a. SpaceX must timely provide the Commission with the information required for Advance Publication, Coordination, and Notification of the frequency assignment(s) for this constellation,

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[503] *See* SpaceX Consolidated Opposition at 70-71 (citing 47 USC § 312). SpaceX further argues that the D.C. Circuit denied a request to stay the *SpaceX Third Modification Order* while litigation was pending, meaning that the equities favored continued launches, and furthermore the then ongoing litigation regarding SpaceX's Gen1 Starlink constellation had no bearing on the Gen2 Starlink constellation. *Id.* (citing Order, *Viasat Inc. v. FCC,* No. 21-1123 (D.C. Cir. July 20, 2021)).

[504] *See Viasat Inc. V. FCC*, 47 F.4th 769 (D.C. Cir. 2022).

[505] *See SpaceX Third Modification Order*, 36 FCC Rcd at 8045-46, 8050, paras. 93, 105.

[506] *See* Cameron Nelson October 10, 2022 Letter; Melissa Shipp October 26, 2022 Letter. We note that although concerns about RF emissions were raised in the SpaceX Third Modification proceeding in connection with NEPA, neither of these parties request the Commission review SpaceX's proposed operations under NEPA because of RF emissions. Rather, both of these parties simply request the Commission deny or indefinitely defer the SpaceX Gen2 Starlink application, as amended.

[507] *See* 47 CFR § 1.1307(b).

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, fn.US131, to achieve a mutually acceptable agreement regarding the protection of the radio telescope facilities operating in the 10.6-10.7 GHz band. For the purposes of coordination with these listed facilities or the National Radio Quiet Zone, correspondence should be directed to the National Science Foundation Spectrum Management Unit (Email: esm@nsf.gov).

d. Operations in the 11.7-12.2 GHz (space-to-Earth) frequency band are authorized up to the power flux-density limits in Article 21 of the ITU Radio Regulations, and up to the equivalent power flux-density requirements of Article 22 of the ITU Radio Regulations, as well as Resolution 76 (Rev. WRC-15) of the ITU Radio Regulations.

e. Operations in the 12.2-12.7 GHz (space-to-Earth) frequency band are authorized up to the power flux-density limits in 47 CFR § 25.208(o) and Article 21 of the ITU Radio Regulations, and up to the equivalent power flux-density requirements of Article 22 of the ITU Radio Regulations, as well as Resolution 76 (Rev. WRC-15) of the ITU Radio Regulations.

f. Operations in the 12.2-12.7 GHz (space-to-Earth) frequency band are subject to the condition that SpaceX may not use more than one satellite beam from any of its authorized Gen2 Starlink satellites in the same frequency in the same or overlapping areas at a time.

g. 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, fn. 5.441, which states that operations in this band are subject to application of the provisions of No. 9.12 for coordination with other non-geostationary-satellite systems in the fixed-satellite service. Non-geostationary-satellite systems in the fixed-satellite service shall not claim protection from geostationary-satellite networks in the fixed-satellite service operating in accordance with the Radio Regulations. Non-geostationary-satellite systems in the fixed-satellite service in the 12.75-13.25 GHz (Earth-to-space) frequency band shall be operated in such a way that any unacceptable interference that may occur during their operation shall be rapidly eliminated.

h. Operations of non-geostationary-satellite systems in the 12.75-13.25 GHz (Earth-to-space) frequency band with earth stations in the United States 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. Licensing of earth stations (i.e. filed after Sept. 19, 2022) for operations in the 12.75-13.25 GHz band will be subject to the filing freeze on applications for new or modified authorizations for the 12.7-13.25 GHz band. *See* Public Notice, DA 22-974 (released Sept. 19, 2022); *Expanding Use of the 12.7-13.25 GHz Band for Mobile Broadband or Other Expanded Use*, Notice of Inquiry and Order, GN Docket No. 22-352, FCC 22-80 (rel. Oct. 28, 2022).

i. 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.

j. SpaceX's operations in the 13.85-14.0 GHz band must comply with footnotes 5.502 and US356 to the International and United States Table of Frequency Allocations, 47 CFR § 2.106, 5.502 and US356.

k. 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, fn. US342, and all practicable steps must be taken to protect

the radio astronomy service from harmful interference. Prior to commencing operations in the 14.47-14.5 GHz band, SpaceX must certify that it has updated its coordination agreement with the National Science Foundation to protect the radioastronomy service from harmful interference.

l. SpaceX's operations in the Ku-band are limited to minimum elevation angles of 25 degrees for all user terminals located below 62 degrees north latitude and minimum elevation angles of 5 degrees for user terminals located at or above 62 degrees north latitude.

m. 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.

n. 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.

o. 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 from any of its authorized Gen2 Starlink satellites in the same frequency in the same or overlapping areas at a time.

p. 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.

q. 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.

r. 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.

s. 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. SpaceX must communicate the ITU finding to the Commission, and 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.

t. 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, including the data that combine the Gen2 Starlink satellites into one consolidated file.

u. Operations in the Ku- and Ka-band frequencies authorized in this Order 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 2020 Ku/Ka-band processing round initiated in Public Notice DA 20-325. 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.

v. Prior to commencing operations in the Ku- and Ka-band frequency bands authorized in this Order, SpaceX must certify that it has made a coordination agreement with, or make a showing to the

Commission demonstrating and certifying that its operations will not cause harmful interference to, any operational system licensed or granted U.S. market access in the NGSO FSS processing rounds referred to in Public Notices DA 16-804, 31 FCC Rcd 7666 (IB 2016) and DA 17-524, 32 FCC Rcd 4180 (IB 2017). SpaceX may commence operations at its own risk, on a non-interference, unprotected basis with respect to any operations authorized in earlier processing rounds for which coordination has not been completed, prior to the approval of its showing by the Commission.

w. 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.

x. SpaceX must operate consistent with the technical specifications provided to the Commission, including any supplemental specifications, in connection with this application, as amended, for its Gen2 Starlink constellation, including antenna beam patterns; GSO avoidance angle; physical characteristics; frequencies used for satellite communications, including outside the United States; and other technical information. Should SpaceX wish to alter these technical specifications, it must apply for a license modification from the Commission.

y. 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, i.e., a satellite that loses the capability to maneuver effectively after being raised from its injection, including a discussion of any assessed cause of the failure and remedial actions. For each such satellite, SpaceX shall report an estimated orbital lifetime for the satellite following the failure, and for the Gen2 Starlink constellation the cumulative number of failed satellite object years,

v. Identification of any collision avoidance system outages or unavailability, either on a system-wide basis or for individual satellites. An "outage" would include any individual satellite anomaly that results in a satellite not achieving targeted risk mitigation via maneuver.

z. In the event of satellite failures resulting in more than 100 post-failure object years, SpaceX may not deploy any additional satellites until the Commission has approved a license modification that includes an updated orbital debris mitigation plan addressing reduction in the failure rate or mitigation of the risk of satellite failures.

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

bb. SpaceX may not deploy any satellites designed for operational altitudes below the International Space Station pursuant to this grant-in-part. SpaceX must communicate and collaborate with NASA to enable safe launch windows to support safety of both SpaceX and NASA assets and

missions and to preserve long-term sustainable space-based communications services. SpaceX must report on the progress of its communications and collaboration efforts to the Commission in its regular reports specified in condition y.

cc. SpaceX may not deploy any satellites authorized in this grant directly to their operational altitude.

dd. Upon receipt of a conjunction warning from the 18th Space Control Squadron or other source, SpaceX must review and take all possible steps to assess the collision risk, and mitigate collision risk if necessary. As appropriate, steps to assess and mitigate should include, but are not limited to: contacting the operator of any active spacecraft involved in such warning; sharing ephemeris data and other appropriate operational information with any such operator; modifying spacecraft attitude and/or operations.

ee. SpaceX must continue to coordinate and collaborate with NASA to promote a mutually beneficial space environment that would minimize impacts to NASA's science missions involving astronomy.

ff. SpaceX must coordinate with NSF to achieve a mutually acceptable agreement to mitigate the impact of its satellites on optical ground-based astronomy. SpaceX must submit an annual report to the Commission, by January 1st each year covering the proceeding year containing the following information: (1) whether it has reached a coordination agreement with NSF addressing optical astronomy; and (2) any steps SpaceX has taken to reduce the impact of its satellites on optical astronomy, including but not limited to darkening, deflecting light away from the Earth, attitude maneuvering, and provision of orbital information to astronomers for scheduling observations around satellites' locations.

gg. SpaceX must follow its commitment to work with the scientific community to explore methods to collect observational data on formation of alumina from satellite reentry, to implement reasonable methods that are discovered to the extent practicable, and to report findings from these measurements taken to the Commission, as part of its annual report specified in condition gg.

hh. 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 22-271 and IB Docket 18-818,[508] WTB Docket 20-443,[509] WT docket 20-133,[510] IB docket 21-456,[511] and GN Docket 22-352.[512]

136. 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).

137. 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 **December 31, 2022**, 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

[508] *See generally Orbital Debris R&O & FNPRM*.

[509] *See generally 12.2 GHz NPRM*.

[510] *See generally* 70/80/90 GHz Rulemaking.

[511] *See generally* Section 25.261 NPRM.

[512] *See generally* 12.7 GHz Proceeding.

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 **December 1, 2028**, 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 **December 1, 2031**. 47 CFR § 25.164(b).[513]

c. 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 **December 16, 2028**, 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).

138. IT IS FURTHER ORDERED that SpaceX's request for waiver of section 25.202(g)(1) of the Commission's rules, 47 CFR § 25.202(g)(1), is GRANTED, subject to the conditions set forth above.

139. IT IS FURTHER ORDERED that SpaceX's request for waiver of section 25.208(e) of the Commission's rules, 47 CFR § 25.208(e), is DISMISSED.

140. IT IS FURTHER ORDERED that SpaceX's request for waiver of section 25.146(a)(1) of the Commission's rules, 47 CFR § 25.146(a)(1), is GRANTED.

141. IT IS FURTHER ORDERED that the request for waiver of the requirement that under 47 CFR § 25.146(a) that 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 prior to commencing operations is GRANTED, subject to the conditions set forth above.

142. IT IS FURTHER ORDERED that SpaceX's request for waiver of section 25.146(a)(1) of the Commission's rules, 47 CFR § 25.146(a)(1), is GRANTED.

143. IT IS FURTHER ORDERED that SpaceX's request for waiver of the Commission's rules due to various limitations in the Schedule S software is GRANTED.

144. IT IS FURTHER ORDERED that the Petition to Defer and Condition of SES Americom and O3b Limited is GRANTED-IN-PART and DENIED-IN-PART to the extent set forth above.

145. IT IS FURTHER ORDERED that the Petition to Deny or Defer in Part of RS Access LLC. is GRANTED-IN-PART and DENIED-IN-PART to the extent set forth above.

146. IT IS FURTHER ORDERED that the Petition to Deny or Hold in Abeyance of Viasat, Inc. is GRANTED-IN-PART and DENIED-IN-PART to the extent set forth above.

147. IT IS FURTHER ORDERED that the Petition to Dismiss or Deny in Part of DISH Network Corporation is DENIED.

148. IT IS FURTHER ORDERED that the Opposition and Motion to Await Conclusion of Pending Directly Intertwined Litigation, Motion for Consultation with Affected Agencies, Motion for Disclosure, Motion for Certification of Suitably Comprehensive Insurance Coverage, Motion for Certification of Indemnity, and Motion to Suspend or Revoke Licenses of The Balance Group is

[513] 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.

DISMISSED.

149. IT IS FURTHER ORDERED that the Motion for Abeyance of DISH Network Corporation is DISMISSED.

FEDERAL COMMUNICATIONS COMMISSION

Marlene H. Dortch
Secretary