

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

In the Matter of)
Kuiper Systems LLC) IBFS File No. SAT-MOD-20211207-00186
Request for Modification of the Authorization for) Call Sign: S3051
the Kuiper NGSO Satellite System)

ORDER AND AUTHORIZATION

Adopted: February 8, 2023

Released: February 8, 2023

By the Chief, International Bureau:

I. INTRODUCTION

1. In this Order and Authorization (Order), we grant, subject to conditions, the application of Kuiper Systems LLC (Kuiper) for modification of its license for a non-geostationary orbit (NGSO) satellite constellation providing fixed-satellite service (FSS) and Mobile Satellite Service (MSS) using Ka-band radio frequencies. Specifically, we grant Kuiper’s request for approval of its updated orbital debris mitigation plan, thereby satisfying a condition of our action in 2020 conditionally granting Kuiper’s request to deploy and operate its NGSO system. Our action will allow Kuiper to begin deployment of its constellation in order to bring high-speed broadband connectivity to customers around the world.

2. In granting this modification, we have considered the issues raised by interested parties in the record. These issues include, but are not limited to, collision risk, post-mission disposal reliability, completion of satellite design, and orbital separation. To address these and other issues, we require Kuiper to comply with a series of conditions, as outlined below. We adopt requirements for Kuiper to report mitigation actions taken to avoid collisions in space and to coordinate and collaborate with NASA to ensure continued availability of launch windows and on other matters.

II. BACKGROUND

3. The Commission’s July 30, 2020 Order conditionally granted Kuiper’s request for authority to operate its FSS system in the 17.7-17.8 GHz, 17.8-18.6 GHz, 18.8-19.3 GHz, 19.3-19.7 GHz, 19.7-20.2 GHz, 27.5-28.6 GHz, 28.6-29.1 GHz, 29.1-29.5 GHz, and 29.5-30.0 GHz bands, and to provide MSS, in addition to FSS, in the 19.7-20.2 GHz and 29.5-30.0 GHz bands, and to use MSS feeder

1 See Kuiper Systems LLC, Request for Modification of the Authorization for the Kuiper NGSO Satellite System, IBFS File No. SAT-MOD-20211207-00186 (filed Dec. 7, 2021). Kuiper is a wholly-owned subsidiary of Amazon.com Services (Amazon).

2 See Kuiper Systems LLC, Application for Authority to Deploy and Operate a Ka-band Non-Geostationary Satellite Orbit System, Order and Authorization, 35 FCC Rcd 8324 (2020) (Kuiper Authorization). The term Ka-band, as used in this Order, refers to the frequencies specifically identified in paragraph 3, infra.

3 Id. at 8333, para. 32.

links in the 19.4-19.6 GHz and 29.1-29.5 GHz bands, subject to certain conditions.⁴ The Commission conditioned the grant of Kuiper's application on, among other things, approval of an updated description of the orbital debris mitigation plans for the system.⁵

4. On December 7, 2021, Kuiper filed the instant modification application updating its orbital debris mitigation plans. The updated plan addresses the collision risk for the system as a whole, including consideration of the reliability of post-mission disposal and the effect of failed satellites on risk, and re-entry casualty risk.⁶ In response, Space Exploration Holdings, LLC (SpaceX) filed a letter, asking the Commission to seek additional information as to Kuiper's analysis concerning collision risk and coordination with space stations in similar orbits as the Kuiper system, Kuiper's plans and capabilities for "conjunction" events (where a close approach between two satellites is predicted), the timeline for coordination agreements with other systems, as well as further information on the system's post-mission disposal reliability and launch plans.⁷ SpaceX also questioned whether Kuiper's application, as modified, included all satellites for which Kuiper is pursuing regulatory approval.⁸

5. On May 19, 2022, the Satellite Division of the International Bureau requested that Kuiper provide additional information about its analysis of space stations in similar orbits, the reliability of the satellites' propulsion components, collision avoidance capabilities and maneuver lead-times, system deployment characteristics and timeline, fuel budgeting, and the for additional details concerning Kuiper's plans to design its satellites so that they will autonomously release stored energy, such as discharging the battery and venting propellant, after a satellite failure that results in inability to control the satellite from the ground.⁹ Kuiper responded to the Commission's inquiry on June 17, 2022.¹⁰

6. On May 27, 2022, the Kuiper Orbital Debris Modification was accepted for filing.¹¹ During the public notice period,¹² Viasat, Inc. (Viasat), SpaceX, Kepler Communications Inc. (Kepler), and the National the National Telecommunications and Information Administration (NTIA) filed comments, with NTIA filing comments on behalf of the National Aeronautics and Space Administration (NASA) and the National Science Foundation (NSF).¹³ On July 12, 2022, Kuiper responded to comments

⁴ Kuiper Authorization, 35 FCC Rcd at 8324, para. 2. This authorization does not address the Petition for Reconsideration filed by Nina Beety. See Petition for Reconsideration of Nina Beety, IBFS File No. SAT-LOA-20190704-00057 (filed Sept. 2, 2020).

⁵ Kuiper Authorization, 35 FCC Rcd at 8333, 8345, paras. 32, 64.

⁶ See Kuiper Authorization, 35 FCC Rcd at 8333, para. 32, n.74.

⁷ See Letter from David Goldman, Director of Satellite Policy, SpaceX, to Marlene H. Dortch, Secretary, FCC (filed Jan. 10, 2022).

⁸ *Id.* at 5.

⁹ Letter from Karl A. Kensinger, Chief, Satellite Division, International Bureau, FCC to C. Andrew Keisner, Lead Counsel, Kuiper Systems LLC and John L. Flynn and Camillie Landron, Jenner & Block LLP (filed May 19, 2022) at 1-3 (Commission Request Letter).

¹⁰ See Letter from Carrie Gage, Corporate Counsel, Kuiper Systems LLC to Karl A. Kensinger, Chief, Satellite Division, International Bureau, FCC (filed Jun. 17, 2022) (Kuiper Commission Response Letter).

¹¹ See Policy Branch Information, Space Stations Accepted for Filing, Public Notice, Report No SAT-01636 (IB Sat. Div. May 27, 2022).

¹² See 47 CFR §§ 25.151, 25.154.

¹³ See Comments of Viasat, Inc., IBFS File No. SAT-MOD-20211207-00186 (filed Jun. 27, 2022) (Viasat Comments); Comments of Space Exploration Holdings, LLC, IBFS File No. SAT-MOD-20211207-00186 (filed Jun. 27, 2022) (SpaceX Comments); Comments of Kepler Communications Inc., IBFS File No. SAT-MOD-20211207-00186 (filed Jun. 27, 2022) (Kepler Comments); Comments of National Telecommunications and Information Administration (NTIA) on behalf of the National Aeronautics and Space Administration (NASA), IBFS File No. SAT-MOD-20211207-00186 (filed Jun. 29, 2022) (NASA Comments); Comments of NTIA on behalf of

in a consolidated response.¹⁴ On July 22, 2022, SpaceX, Viasat, and OneWeb filed reply comments.¹⁵

7. On November 23, 2022, Kuiper submitted an additional letter addressing issues raised by commenters, specifically the concerns raised about Kuiper's strategy for post-mission disposal of satellites and the adequacy of the amount of satellite propellant Kuiper has budgeted for collision avoidance and disposal maneuvers.¹⁶ SpaceX filed a response to this letter on December 14, 2022,¹⁷ and a further *ex parte* letter on January 17, 2023 requesting, among other things, that the Commission impose certain conditions and limit authorization to a subset of Kuiper's planned system and defer consideration of the remainder of the constellation.¹⁸

III. DISCUSSION

8. After review of the record, we find Kuiper's orbital debris mitigation plan to be sufficiently developed to support deployment of its NGSO satellite system, and that granting Kuiper's request, subject to the requirements and conditions specified herein, will serve the public interest. Below, we address the outstanding issues raised by commenters on Kuiper's application. Where appropriate, we defer matters of general applicability to ongoing or potential future rulemakings.

A. Collision Avoidance

9. *Aggregate Collision Risk.* Satellites that have a failure in systems or components that result in loss of control of the satellite will present a collision risk for as long as the satellite remains in orbit. NASA's Debris Assessment Software (DAS) includes a tool for quantifying a satellite's risk of collision with large objects. Based on the single satellite risk for a satellite in the disposal failure category, and the rate of disposal failure, a relatively simple calculation can estimate the risk from disposal failure for the constellation as a whole. Kuiper has provided a worst-case single satellite large object collision risk that can be approximated as 0.0007212 and a targeted mission lifetime of seven years.¹⁹ Over a 15-year license term, and assuming replenishment on a five-year cycle, there would be the initial launch plus a replenishment cycle for the 3,236 satellites, for a total of 6,472 satellites, not counting satellites used to replace failed satellites.

10. We do not have data from Kuiper on its actual disposal failure rates, as satellites for this system have yet to be launched. For illustrative purposes, if we were to assume a 0.5% failure rate, this implies approximately 33 satellites for 6,472 satellites launched, excluding satellites used to replace failed satellites, with a corresponding risk of 0.0237996 or about 1 in 42. At a 1% failure rate, there would be approximately 65 satellite failures for 6,472 satellites launched with a corresponding cumulative collision

the National Science Foundation (NSF), IBFS File No. SAT-MOD-20211207-00186 (filed Jun. 29, 2022) (NSF Comments).

¹⁴ *Kuiper Systems LLC*, Consolidated Response of Kuiper Systems LLC, IBFS File No. SAT-MOD-20211207-00186 (filed Jul. 12, 2022) (Kuiper Consolidated Response).

¹⁵ Reply Comments of Space Exploration Holdings, LLC, IBFS File No. SAT-MOD-20211207-00186 (filed Jul. 22, 2022) (SpaceX Reply Comments); Reply Comments of Viasat, Inc., IBFS File No. SAT-MOD-20211207-00186 (filed Jul. 22, 2022) (Viasat Reply Comments); Reply Comments of WorldVu Satellites Limited, IBFS File No. SAT-MOD-20211207-00186 (filed Jul. 22, 2022) (OneWeb Reply Comments).

¹⁶ Letter from Carrie Gage, Corporate Counsel, Kuiper Systems LLC to Marlene Dortch, Secretary, FCC (filed Nov. 23, 2022).

¹⁷ Letter from David Goldman, Senior Director of Satellite Policy, SpaceX to Marlene Dortch, Secretary, FCC (filed Dec. 14, 2022).

¹⁸ See Letter from David Goldman, Senior Director of Satellite Policy, SpaceX to Marlene Dortch, Secretary, FCC, at 4 (filed Jan. 17, 2023) (SpaceX *Ex Parte* Letter). SpaceX also requests that we impose conditions on Kuiper similar to the conditions on the order authorizing in part its second-generation Starlink constellation. *Id.* at 1-4. We adopt similar conditions regarding Kuiper's system for the reasons discussed herein.

¹⁹ Kuiper Technical Appendix at 8, 14.

risk of 0.047568 (approximately 1 in 21). At a 5% failure rate, there would be 326 failed satellites for 6,472 satellites launched, with a corresponding cumulative collision risk of 0.230784 (approximately 1 in 4.3). These figures assume that all failures can be expected to occur at the regular operational altitude, when in fact failures can be expected to occur also at lower altitudes from which a satellite's orbit will decay sooner, with lower collision risk corresponding to the shorter time in orbit.

11. This type of analysis requires estimation, but it illustrates the need for Kuiper's system to maintain high disposal reliability in order to limit collision risk. Furthermore, typical spacecraft failure curves show high failure rates at the earliest and latest stages of constellation deployment. Given that high reliability will be important in maintaining low risk levels, we believe that continued monitoring of constellation reliability will be necessary. We will require semi-annual reporting concerning the number of satellites launched and disposal reliability. In addition, as a method of continuing monitoring and consistent with the approach followed in the *SpaceX Third Modification Order*,²⁰ we will require on a going forward basis that if at any time the number of satellites that have experienced a disposal failure reaches two per year, Kuiper will be required to report that fact. The two-satellite reporting threshold corresponds roughly to the estimated annual number of satellites that would exhibit a disposal failure, based on the 33 satellites for which disposal failures could be expected from a 0.5% disposal failure rate for 6,472 satellites. This is consistent with the *SpaceX Third Modification Order* where the Commission adopted a reporting threshold corresponding with a 0.5% disposal failure rate.²¹ In the event disposal failures exceed the reporting threshold, the Commission will consider whether additional license conditions or limitations on deployment and operation may be necessary, taking into account any materials submitted by Kuiper to address corrective measures.

12. In an *ex parte* letter, SpaceX requested that the Commission apply an "object-years" method to evaluate post-mission disposal that if triggered, would require Kuiper to pause deployment and reassess spacecraft reliability, as the Commission had done in the *SpaceX's Gen2 Starlink Order*.²² Under this method, the data provided in the semi-annual reports would be used to project the remaining orbital lifetime of any failed satellites and if the cumulative number of years for all failed satellites exceeds 100, Kuiper would be required to cease satellite deployment while the sources of satellite failure are reviewed to determine whether there are any adequate and reliable mitigation measures that should be undertaken before moving forward. We decline to impose such a condition at this time. When the Commission applied the 100 object-years condition in the *SpaceX's Gen2 Starlink Order*, SpaceX had already launched thousands of satellites and had data reflecting its actual satellite failures, which was used to inform the Commission's approach to satellite reliability monitoring for the Gen2 Starlink system. The Commission noted that the 100 object-years metric was new and untested, but reasoned that an incremental approach based on a clear benchmark was appropriate in the context of a planned deployment that is at a scale not previously undertaken and also untested.²³ As Kuiper has not started deploying or operating its constellation, we find it is not necessary to impose such a condition at this time. Once Kuiper begins launching and subsequently operating its constellation, we will reassess the need to add a similar condition at a later date. In any event, satellite disposal reliability remains a topic under consideration in the Commission's ongoing orbital debris proceeding and Kuiper will be subject to any rules that the Commission subsequently adopts as part of that proceeding.

²⁰ See *SpaceX Third Modification Order*, 36 FCC Rcd 7995, 8032 at para. 64.

²¹ *Id.*

²² *SpaceX Ex Parte Letter* at 2-3. We note that this specific condition is subject to Petitions for Reconsideration and Clarification at this time. See, e.g., Petition of LeoLabs, Inc. for Reconsideration, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (filed Dec. 30, 2022); Petition of Viasat, Inc. for Clarification, IBFS File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105 (filed Jan. 3, 2023). See also *Space Exploration Holdings, LLC*, Request for Orbital Deployment and Operating Authority for the SpaceX Gen2 NGSO Satellite System, Order and Authorization, FCC-22-91 (2022) at paras. 84-85 (*SpaceX Gen2 Starlink Order*).

²³ *SpaceX Gen2 Starlink Order* at para. 85.

13. In comments to the *SpaceX Gen2 Starlink Order*, NASA observed that while individual 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. In order to address NASA's concern in that proceeding, the Commission conditioned SpaceX's grant to include a reporting requirement with respect to any collision avoidance system outages or unavailability, both on a system-wide basis and 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. Given the concerns raised in the record about the effectiveness of Kuiper's collision avoidance systems, we believe that such a condition would also be relevant here, and condition this grant accordingly.

14. *Intra-system collision risk.* Viasat also raised concerns regarding Kuiper's intra-system collision risks.²⁴ Kuiper states that such a risk is "diluted by the active avoidance Kuiper [s]atellites will undertake against targets larger than 10 [centimeters]" and further mitigated because Kuiper's satellites "will be maneuverable and working in concert as part of a coordinated system."²⁵ Kuiper further notes that the Commission's adopted, though not yet effective, rules provide that "collision risk may be assumed zero for a space station during any period in which the space station will be maneuvered effectively to avoid colliding with large objects," and that such an assumption is reasonable with respect to intra-system risk because Kuiper has the ability to track and maneuver both satellites involved in any potential collision.²⁶ However, given that Kuiper's active satellites will be coordinated as part of the same system, and any failed satellites may be avoided through active collision avoidance by the other maneuverable satellites in the system, we find that Kuiper's system does not present any unique risk with respect to the potential for intra-system collisions. To the extent that Viasat's concerns are tied to a more general concern about assumptions concerning collision avoidance system reliability, we address those concerns below.

15. *Inter-system collision risk.* Viasat argues that Kuiper has failed to adequately address inter-system collision risk, stating that there is a high likelihood that thousands of additional satellites will be added to LEO in altitudes that overlap with the Kuiper system, many of which will be authorized by administrations outside of the United States.²⁷ Kuiper states that its analysis on inter-system collision risk included both foreign systems and planned systems with a pending Commission application, and that it found 36 satellites in "very similar" orbits to the Kuiper constellation, but these satellites did not create more risk or require coordination more than catalog objects currently occupying the orbital region.²⁸ Kuiper further states that it will coordinate with these and other operators whether these satellites are licensed by the Commission or a foreign jurisdiction, consistent with the Commission's rules and the Kuiper System Authorization.²⁹ Viasat's comments do not provide any specific reasoning that suggests otherwise, or specify a particular risk presented by the deployment of an identified planned system

16. In an *ex parte* letter, SpaceX argues that the Commission should limit Kuiper to deploy only 578 satellites in its 630 kilometer orbital shell, and defer action regarding the remainder of the constellation.³⁰ SpaceX argues that granting this tranche would address Kuiper's ability to coexist with other systems in and around its 590 kilometer and 610 kilometer shells, and allow for "continued

²⁴ Viasat Reply Comments at 6-7.

²⁵ Kuiper Consolidated Response at 8-9.

²⁶ *Id.* at 9. *See also* 85 Fed. Reg. at 52450 (to be codified at 47 CFR § 25.114(d)(14)(iv)(A)(1)).

²⁷ Viasat Comments at 9-10. *See also* Kuiper Technical Appendix at 9.

²⁸ Kuiper Consolidated Response at 18-19.

²⁹ *Id.* at 19.

³⁰ SpaceX *Ex Parte* Letter at 4-6.

monitoring” of deployment.³¹ To the extent that SpaceX is concerned with Kuiper demonstrating its ability to safely operate, the conditions adopted here are designed to address that point. We do not see a specific need to further limit Kuiper’s authorization.³² While SpaceX expresses concern over Kuiper’s ability to co-exist with other systems at certain altitudes, similar to Viasat, it does not specify a particular risk presented by the deployment of an identified planned system.

17. *Residual Risk.* In its Technical Appendix, Kuiper states that it will utilize onboard propulsion and will typically remediate the collision risks associated with conjunctions where the individual risk of collision with a given object is larger than 1 in 100,000.³³ Viasat has raised concerns that Kuiper failed to account for the “residual risks” that would accumulate from the predicted conjunctions that do not result in avoidance maneuvers because they are at a level of probability that do not trigger action.³⁴ Viasat, however, maintains that millions of conjunction events each with a 1 in 100,000 probability of occurring still add up to a significant risk.³⁵ The Commission has 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. In other proceedings we have declined to assess residual risk using the method utilized by Viasat.³⁶

18. Because the Commission has stated that residual risk is an area that warrants continued monitoring, we will condition this grant on Kuiper reporting, on a semi-annual basis, several indicators for this risk, including the number of collision avoidance maneuvers undertaken by its satellites. We also require Kuiper to report any collision avoidance system outages or unavailability, both on a system-wide basis and 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.³⁷ An “outage” would include any individual satellite anomaly that results in a satellite not achieving targeted risk mitigation via maneuver.

19. *Lethal, non-trackable debris.* In its comments, Viasat raises concerns as to whether Kuiper has adequately addressed all potential sources of collision risk, including risks associated from so-called lethal, non-trackable debris (LNTs), i.e., debris that is not routinely tracked primarily due to small size but that can collide with a spacecraft and damage it, potentially resulting in loss of control of the spacecraft.³⁸ Kuiper states that it will use shielding to protect key satellite components and that the satellites include backup systems, such as independent solar panels and redundant flight computers,

³¹ *Id.* at 5.

³² In terms of numbers of satellites, we observe that SpaceX’s proposed second generation Starlink constellation, which has been authorized in part, is almost ten times as large as Kuiper’s planned system.

³³ See Kuiper Technical Appendix at 7.

³⁴ Viasat Comments at 3, 10-12.

³⁵ See *Id.* at 11.

³⁶ See, e.g., Space X Gen2 Starlink Order at para. 74; see also SpaceX Third Modification Order. In comments to the *SpaceX Gen2 Starlink Order*, for example, NASA observed that while individual satellites may be deemed to have a collision risk of zero because of their propulsive capabilities with a constellation of that size, error-free systems and a collision risk of zero should not be assumed. See Letter from the National Telecommunications and Information Administration on behalf of NASA, IBFS File No. SAT-AMD-20210818-00105 at 2 (filed Feb. 08, 2022). See also Letter from Kathy Smith, Chief Counsel, NTIA to Marlene Dortch, Secretary, FCC, IBFS File No. SAT-AMD-20210818-00105, Attachment at 1 (filed Mar. 10, 2022). In order to address NASA’s concern in that proceeding, the Commission conditioned SpaceX’s grant to include a reporting requirement, and given the size of Kuiper’s planned constellation as well as concerns raised in the record about the effectiveness of Kuiper’s collision avoidance systems, we believe that such a condition would also be relevant here, and condition this grant accordingly. See SpaceX Comments at 7-8; Viasat Comments at 11-12.

³⁷ See, e.g., SpaceX Third Modification Order, 36 FCC Rcd at 8029, para. 58.

³⁸ Viasat Comments at 7.

radios, and sensors to preserve the likelihood of propulsive post-mission disposal in the event of collision.³⁹

20. As to LNTs, the Commission's rules state that applicants must assess and limit the probability of the space station becoming a source of debris by collisions with small debris or meteoroids which could cause loss of control and prevent post-mission disposal.⁴⁰ Kuiper states that it used NASA's DAS, which includes NASA's Orbital Debris Engineering Model (ORDEM) for modeling small debris, including lethal and non-lethal trackable debris, for its small debris analysis⁴¹ and will use a combination of component design and Whipple shielding to protect all components, especially the battery and the propellant tank, to better ensure that Kuiper satellites can withstand impact by small debris and remain operable.⁴² Viasat claims that these mitigation measures do not satisfy its concerns because Kuiper has not quantified the risks from lethal nontrackable debris.⁴³ Given the conditions concerning ongoing monitoring, we conclude that even if Kuiper has not sufficiently mitigated this risk, unacceptably high disposal failure rates, including those resulting from small debris collisions, will be identified and addressed.

B. Post-Mission Disposal

21. In its Technical Appendix, Kuiper states that it will remove satellites in its system from orbit at the end of their seven-year mission by lowering the perigee of the satellite to approximately 350 kilometers where the denser atmosphere will result in drag that causes the satellites to decay from orbit within one year.⁴⁴ Kuiper states that once perigee lowering is completed, remaining propellant will be used to lower apogee and to conduct collision avoidance until the remaining propellant is exhausted, or until the point in which apogee is less than the altitude of the International Space Station (ISS).⁴⁵ At that point, Kuiper satellites will then use the remaining propellant to further reduce apogee and vent any residual propellant.⁴⁶ Kuiper further states that it has allocated sufficient propellant to conduct collision avoidance maneuvers until the apogee is decreased below 400 kilometers (the altitude of the ISS).⁴⁷ Kuiper identifies the ISS in its post-mission disposal plans, but given the ongoing and persistent operations of inhabitable space stations generally, such as the Tiangong space station, we condition the authorization to require that such space stations be taken into account, i.e., Kuiper must ensure that sufficient propellant is available for its satellites to continue to maintain collision avoidance capabilities and utilize other remaining fuel to lower the apogee below any inhabitable space stations.

22. SpaceX argues that Kuiper's satellite disposal strategy will place the Kuiper satellites in an elliptical orbit that, because of the variable effects of atmospheric drag on orbit evolution, will result in large uncertainties in the predicted trajectories of the Kuiper satellites, making it difficult for other operators to assess and mitigate risk. SpaceX observes that the large covariances involved in the elliptical orbits may therefore pose a risk to SpaceX's satellites operating at the same altitudes during their orbit raising phase of operations.⁴⁸ Kuiper states in response that it will perform orbit determination using Global Positioning System (GPS) measurements on all Kuiper satellites during the deorbiting process and

³⁹ Kuiper Technical Appendix at 5.

⁴⁰ 47 CFR § 25.114(d)(14)(i).

⁴¹ Kuiper Consolidated Response at 8.

⁴² Kuiper Technical Appendix at 5.

⁴³ Viasat Comments at 7-8.

⁴⁴ Kuiper Technical Appendix at 14.

⁴⁵ *Id.* at 15.

⁴⁶ Kuiper Technical Appendix at 14-15; *see also* Kuiper Commission Response Letter at 6.

⁴⁷ Kuiper Commission Response Letter at 6.

⁴⁸ SpaceX Comments at 5-6.

share high-accuracy location information with operators on a real-time basis.⁴⁹ Given Kuiper's commitment to supplement routine tracking data with high-accuracy location information made available to other operators in order to address any issues that might arise from large covariances in the tracking data that is otherwise routinely available to other operators, we believe that the concerns raised in this instance regarding disposal strategy can be addressed and will condition this license accordingly.

23. *Maneuver Operations and Propellant Budget.* Commenters expressed concern that the Kuiper system may be required to perform more maneuver operations than Kuiper has predicted in its Modification Application,⁵⁰ or have questioned whether Kuiper has budgeted sufficient propellant to conduct all potential maneuvers.⁵¹ Kuiper states that its propellant budget accounts for risk mitigation activities during all operational phases and that it has budgeted for an ample amount of propellant in case a Kuiper satellite will need to engage in more maneuvers than originally anticipated.⁵² Kuiper further states that should it engage in more maneuvers than originally predicted that requires its satellites to consume propellant more rapidly, Kuiper will commence deorbit operations earlier in order to ensure that any affect satellites have sufficient propellant to conduct active deorbit operations. We condition this grant accordingly.⁵³

C. Other Issues

24. *Completeness of Kuiper's Satellite Design.* SpaceX and Viasat have raised concerns that Kuiper's satellite designs are not sufficiently finalized to enable review,⁵⁴ and Viasat has asked that the Commission ensure Kuiper does not make further changes to its satellite design without further authorization from the Commission.⁵⁵ Kuiper has stated that its satellite design is complete and does not expect any further material changes.⁵⁶ As a general matter, the Commission looks favorably on NGSO FSS operators improving their systems, and routinely grants modifications to encourage system refinement as technology improves. However, should Kuiper satellites materially differ from the parameters set forth in its authorization, as modified by the instant application, Kuiper must seek a modification of its license in accordance with the Commission's rules.⁵⁷

25. *Orbital Separation.* Kepler has asked the Commission to require Kuiper to maintain a ten kilometer distance from Kepler's orbits, citing Kuiper's comments in other proceedings advocating for such separation.⁵⁸ Kuiper states that it raised concerns with orbital separation on SpaceX's Gen2 constellation because of its size and specific risk factors but has not raised the same concern with respect to smaller systems that pose fewer risks.⁵⁹ We find that Kepler has not raised a substantive claim that Kuiper's satellites will pose material space safety risks to either its current or its planned systems, or, even assuming such risk, that separation requirements should be imposed solely on Kuiper. Therefore, no

⁴⁹ Kuiper Consolidated Response at 14.

⁵⁰ See Viasat Comments at 11-12; OneWeb Reply Comments at 3; SpaceX Reply Comments at 6.

⁵¹ See Viasat Comments at 12; SpaceX Reply Comments at 6; OneWeb Reply Comments at 7.

⁵² See e.g., Kuiper Nov 23 Letter at 3; Kuiper Commission Response Letter at 5; Kuiper Consolidated Response at 11, n.42.

⁵³ Kuiper Nov 23 Letter at 3-4.

⁵⁴ Viasat Comments at 13, n.31 (quoting Commission Response Letter at 5); SpaceX Comments at 2, 8.

⁵⁵ Viasat Comments at 13.

⁵⁶ See Kuiper Modification Application, Legal Narrative at 3, n.9; Kuiper Technical Appendix at 2, n.9; Kuiper Consolidated Response at 4.

⁵⁷ See 47 C.F.R. § 25.118.

⁵⁸ Kepler Comments at 2.

⁵⁹ See Kuiper Consolidated Response at 20.

such condition is adopted.

26. *Kuiper's Impact on Launch and Reentry Opportunities.* NASA raises concerns that the increase in the number of constellations could cause the loss of launch and reentry opportunities, particularly for missions requiring instantaneous or short launch windows, like planetary missions such as Europa Clipper.⁶⁰ Kuiper has acknowledged the unique nature of certain missions and their requisite need for instantaneous or short launch windows and states that it will continue its coordination with NASA to adjust spacecraft orbits in order to mitigate any impact on these unique missions.⁶¹ Given the ongoing collaboration between Kuiper and NASA, we believe this issue is best addressed through continued coordination and further condition this grant accordingly.⁶²

27. *Potential Impact on Science Missions Using Electromagnetic Spectrum.* NASA and NSF filed comments in the record regarding the potential impact of Kuiper's constellation deployment on certain science missions using radio and optical electromagnetic spectrum, including astronomy.⁶³ Kuiper states that it has engaged in productive discussions with both NASA and NSF and highlights its further plans to collaborate with both NASA and NSF to minimize impacts on government and scientific operations.⁶⁴ For example, Kuiper states that it will continue to work with NASA to "ensure that Kuiper orbital debris mitigation plans and systems are more than sufficient to protect NASA missions in LEO and other NASA assets, including the International Space Station ("ISS")" and has worked to mitigate its satellites' reflectivity, consistent with NSF's recommendations.⁶⁵ Given the similar issues raised by both agencies here and in the *SpaceX Gen2 Starlink Order*,⁶⁶ we find that it is in the public interest to condition this authorization similar to the *SpaceX Gen2 Starlink Order*, and require Kuiper 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 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 Kuiper 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 Kuiper 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.

28. We encourage Kuiper 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.⁶⁷ The conditions we adopt today will ensure that Kuiper's 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

⁶⁰ NASA Comments at 3.

⁶¹ Kuiper Consolidated Response at 25, n.95.

⁶² See NASA Comments at 3-4, Kuiper Consolidated Response at 25-26.

⁶³ See NASA Comments at 2, NSF Comments at 1. Among other issues, NASA commented that the Kuiper constellation would occupy and traverse through a congested area of LEO, potentially posing a risk to NASA missions in the region, as well as possibly impacting the availability of safe launch windows. NASA also noted potential impact to NASA's Earth observing satellites due to field of view obstruction. NSF raised similar concerns pertaining to ground-based optical, infrared and radio astronomy.

⁶⁴ Kuiper Consolidated Response at 23-26.

⁶⁵ *Id.* at 24, 26.

⁶⁶ See *SpaceX Gen2 Starlink Order* at paras. 88, 93, 98.

⁶⁷ See Kuiper Consolidated Response at 24, 26.

orbital resources.⁶⁸

IV. CONCLUSION AND ORDERING CLAUSES

29. Accordingly, IT IS ORDERED, that the Kuiper Modification Application, as amended, filed by Kuiper Systems LCC (Kuiper), is GRANTED, pursuant to section 309(a) of the Communications Act of 1934, as amended, 47 USC § 309(a).

30. IT IS FURTHER ORDERED that this authorization is subject to the following requirements and conditions:⁶⁹

31. Prior to commencing operations in the 17.8-18.6 GHz and 18.8-20.2 GHz and 27.5-30 GHz bands, Kuiper 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 the NGSO FSS processing rounds referred to in Public Notices DA 16-804, 31 FCC Rcd 7666 (IB 2016) and DA 17-525, 32 FCC Rcd 4180 (IB 2017).⁷⁰

32. Kuiper's operations must comply with spectrum sharing procedures among NGSO FSS space stations specified in 47 CFR § 25.261 with respect to any NGSO system licensed or granted U.S. market access pursuant to the March 2020 Processing Round initiated by Public Notice, DA 20-325. Spectrum sharing between Kuiper'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.

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

34. Operations in portions of the 17.8-18.6 GHz, 18.8-20.2 GHz, and 27.5-30 GHz bands, including MSS operations in the 19.7-20.2 GHz and 29.5-30 GHz bands, are authorized up to the applicable power flux-density and equivalent power-flux density limits contained in Articles 21 and 22, as well as Resolution 76 of the ITU Radio Regulations. In addition, operations must comply with the out-of-band emissions limits in 25.202(f), 47 CFR § 25.202(f).

35. Operations in the 19.3-19.4 GHz and 19.6-19.7 GHz (space-to-Earth) frequency bands are authorized up to the power flux-density limits in Article 21 of the ITU Radio Regulations that govern NGSO FSS systems in the 17.7-19.3 GHz (space-to-Earth) frequency band. Operations in the band 19.3-19.4 GHz and 19.6-19.7 GHz are on a secondary basis with respect to the GSO FSS. Blanket authorized earth stations in the 19.3-19.4 GHz and 19.6-19.7 GHz bands operate on a secondary basis with respect to the fixed service.

36. Kuiper 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

⁶⁸ *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.

⁶⁹ The conditions here replicate the full set of conditions applicable to Kuiper operations as specified in prior orders, except that paragraph 44 has been slightly modified, new conditions have been specified in paragraphs 49 through 57, and condition 64 of the original grant has been removed, as Kuiper has satisfied that specific condition through this modification application.

⁷⁰ This condition is subject to a pending modification. *See Kuiper Systems LLC*, Request for Modification of the Authorization for the Kuiper NGSO Satellite System, IBFS File No. SAT-MOD-20230201-00013 (filed Feb. 1, 2023).

Resolution 76 (WRC-03) of the ITU Radio Regulations.

37. Operations in the 17.7-17.8 GHz band are limited to service outside of the United States and must not cause harmful interference to nor claim protection from assignments in the broadcasting-satellite service operating in conformity with the Radio Regulations, pursuant to 5.517 of the U.S. Table of Frequency Allocations.

38. Operations in the 17.8-18.3 GHz frequency band are on a secondary basis with respect to the fixed service.

39. Operations in the 19.3-19.7 GHz and 29.1-29.5 GHz bands must be coordinated with any previously authorized NGSO MSS systems not included in the March 2020 Processing Round over the bands designated for use by NGSO MSS feeder links. Until any coordination agreement required is obtained, operations shall not be conducted in these frequency bands. Sharing of the 19.3-19.7 GHz and 29.1-29.5 GHz bands with other systems authorized within the March 2020 Processing Round will be subject to section 25.261.

40. MSS operations in the 19.7-20.2 GHz and 29.5-30 GHz bands shall be conducted on a non-interference, non-protected basis with respect to other FSS operations in these bands.

41. 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 47 CFR § 25.136.

42. In accordance with footnote NG62 to 47 CFR § 2.106, in the 28.5-29.1 GHz and 29.25-29.5 GHz bands, Kuiper shall not cause harmful interference to, or claim protection from, stations in the fixed service listed in that footnote.

43. Space-to-Earth operations in the 17.8-18.6 GHz, 18.8-19.3 GHz, and 19.7-20.2 GHz 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 Kuiper 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, Kuiper 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.

44. IT IS FURTHER ORDERED that prior to initiation of service, Kuiper must receive a favorable or “qualified favorable” finding in accordance with Resolution 85 with respect to its compliance with applicable EPFD limits in Article 22 of the ITU Radio Regulations as per paragraph 26 of the original grant document. Kuiper must communicate the ITU finding to the Commission and, in case of an unfavorable finding, adjust its operation to satisfy the ITU requirements. *See also* 47 CFR § 25.146(c).⁷¹

45. IT IS FURTHER ORDERED that Kuiper must make available to any requesting party the data used as input to the ITU approved validation software to demonstrate compliance with applicable EPFD limits.

46. IT IS FURTHER ORDERED that Kuiper must comply with the sharing of ephemeris data procedures described in section 25.146 of the Commission’s rules. 47 CFR § 25.146(e).

47. IT IS FURTHER ORDERED that Kuiper must coordinate physical operations of spacecraft with any operator using similar orbits, for the purpose of eliminating collision risk and minimizing operational impacts. The orbital parameters specified in this grant are subject to change based on such coordination.

⁷¹ This condition is subject to a pending modification. *See Kuiper Systems LLC*, Request for Modification of the Authorization for the Kuiper NGSO Satellite System, IBFS File No. SAT-MOD-20210806-00095 (filed Aug. 6, 2021).

48. IT IS FURTHER ORDERED that this authorization and any earth station licenses granted in the future are subject to modification to bring them into conformance with any rules or policies adopted by the Commission in the future.

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

50. Kuiper 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:

- a. The number of conjunction events identified for Kuiper 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,
- b. 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,
- c. Satellites that re-entered the atmosphere,
- d. 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
- e. 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.

51. Kuiper must also provide a report if during any continuous one-year period there are two or more satellite disposal failures. Such report shall be filed not later than 10 days following the second disposal failure, and must either state the assessed cause of the failure and remedial actions for each of the disposal failures during the period, if available, or provide a schedule for completion of a process for doing so. Based on the information reported, the license may be subject to additional terms and conditions, including additional reporting obligations, limitations on additional deployments, requirements for early removal of satellites from orbit, or any other appropriate conditions to limit collision risk.

52. Upon receipt of a conjunction warning from the 18th Space Control Squadron or other source, Kuiper 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.

53. Kuiper must communicate and collaborate with NASA to enable safe launch windows to support safety of both Kuiper and NASA assets and missions and to preserve long-term sustainable space-based communications services. Kuiper must report on the progress of its communications and collaboration efforts to the Commission in its regular reports specified in condition para. 50.

54. Kuiper 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.

55. Kuiper must monitor its satellites' propellant reserves to ensure that the Kuiper satellites are able to fully perform collision avoidance maneuvers during operations at the relevant altitudes specified in its application as well as complete maneuvers to lower the apogee to below any inhabitable space stations. Should a Kuiper satellite engage in more maneuvers than originally projected or otherwise consume propellant more rapidly than anticipated, Kuiper must initiate deorbit operations early in order to ensure that sufficient propellant remains to complete deorbit maneuvers. Kuiper must make available to other operators supplemental information, based on GPS readings or other supplemental sources, such as third-party observations, sufficient to reduce covariance of predicted trajectories to a level that facilitates collision avoidance procedures, as coordinated with other operators.

56. Kuiper must coordinate with NSF to achieve a mutually acceptable agreement to mitigate the impact of its satellites on optical ground-based astronomy. Kuiper must submit an annual report to the Commission, by January 1st each year covering the preceding year containing the following information: (1) whether it has reached a coordination agreement with NSF addressing optical astronomy; and (2) any steps Kuiper 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.

57. 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 Kuiper 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 18-818,⁷² WTB Docket 20-443,⁷³ WT docket 20-133,⁷⁴ IB docket 21-456,⁷⁵ and GN Docket 22-352.⁷⁶

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

- a. Kuiper must post a surety bond in satisfaction of 47 CFR §§ 25.165(a)(1) & (b) no later than August 30, 2020, and thereafter maintain on file a surety bond requiring payment in the event of a default in an amount, at minimum, determined according to the formula set forth in 47 CFR § 25.165(a)(1); and
- b. Kuiper 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 July 30, 2026, and Kuiper 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 July 20, 2029, 47 CFR § 25.164(b).⁷⁷

59. 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

⁷² See generally *Orbital Debris R&O & FNPRM*.

⁷³ See generally *12.2 GHz NPRM*.

⁷⁴ See generally *70/80/90 GHz Rulemaking*.

⁷⁵ See generally *Section 25.261 NPRM*.

⁷⁶ See generally *12.7 GHz Proceeding*.

⁷⁷ 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.

§ 25.164(b) may result in Kuiper'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 Kuiper's surety bond. By August 14, 2026, Kuiper 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).

FEDERAL COMMUNICATIONS COMMISSION

Thomas P. Sullivan
Chief
International Bureau