AMENDMENT TO APPLICATION FOR BLANKET LICENSED EARTH STATIONS IN MOTION

I. OVERVIEW

SpaceX Services, Inc. ("SpaceX Services") has filed an application seeking a blanket license authorizing operation of end-user earth stations for deployment as Vehicle-Mounted Earth Stations ("VMESs"), Earth Stations on Vessels ("ESVs"), and Earth Stations Aboard Aircraft ("ESAAs") (collectively, Earth Stations in Motion ("ESIMs")).[1] These user terminals employ advanced phased-array beam-forming and digital processing technologies to make very efficient use of Ku-band spectrum resources by supporting highly directive antenna beams that point and track the non-geostationary orbit ("NGSO") satellites operated by a sister company, Space Exploration Holdings, LLC ("SpaceX").[2] In May 2019, SpaceX began launching satellites to populate its constellation, and has launched more than 1,700 satellites in orbit.

By this application, SpaceX Services hereby amends its pending application to scale back its request in two ways. First, it seeks a blanket license authorizing operation of only up to 500 of these end-user earth stations. Second, it seeks authorization only as ESAAs, which would be deployed on U.S.-registered aircraft operating worldwide and non-U.S.-registered aircraft operating in U.S. airspace. Consistent with SpaceX's space station authorization, these ESAAs will transmit in the 14.0-14.5 GHz band and receive in the 10.7-12.7 GHz band. The Commission's rules specifically contemplate blanket licensing for earth stations operating in these

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1 *See* Application for Blanket-Licensed Earth Stations In Motion, IBFS File No. SES-LIC-20210309-00698 (filed Mar. 9, 2021) ("ESIM Application").

2 *See Space Exploration Holdings, LLC*, 33 FCC Rcd. 3391 (2018) ("*SpaceX Authorization*"). The Commission recently granted a request to modify SpaceX's license. *See Space Exploration Holdings, LLC*, FCC 21-48 (rel. Apr. 27, 2021) ("*SpaceX Modification*"). These authorizations anticipate that Ku-band spectrum would be used for communications with subscribers.

frequency bands.[3] However, the 12.2-12.7 GHz band is not specifically available for use by ESAAs communicating with NGSO systems,[4] so below SpaceX Services requests a waiver to authorize use of that band on an unprotected basis.

Below, we discuss the service to be provided by these ESAAs as well as certain spectrum sharing issues relevant to their operation. We then demonstrate that grant of this application, including the requested waiver, would serve the public interest. Lastly, we provide technical information to supplement the information provided in Schedule B to Form 312 filed with this narrative application.[5] To support its ambitious timetable for offering ever more diverse and innovative satellite broadband services, SpaceX Services requests that the Commission grant the requested blanket license as expeditiously as possible.

II. THE ESAAS WILL EXPAND SPACEX'S INNOVATIVE BROADBAND SATELLITE SERVICE TO USERS IN MOVING AIRCRAFT

SpaceX Service's ESAAs will be electrically identical with the 1,000,000 fixed user terminals the Commission has already authorized[6] from a radiofrequency perspective but have mountings that allow them to be installed on aircraft. These ESAAs will communicate only with those SpaceX satellites that are visible on the horizon above a minimum elevation angle of 25 degrees. The proposed phased array user terminal will track SpaceX's NGSO satellites passing within its field of view. As the terminal steers the transmitting beam, it automatically changes the power to maintain a constant level at the receiving antenna of its target satellite to the extent

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3 *See* 47 C.F.R. § 25.115(f)(2).

4 *See id.* § 25.202(a)(10)(ii).

5 To the extent relevant, SpaceX Services hereby incorporates the technical information submitted with SpaceX's space station applications. *See* IBFS File Nos. SAT-LOA-20161115-00118, SAT-LOA-20170726-00110, SAT-MOD-20181108-00083, and SAT-MOD-20200417-00037.

6 *See* Radio Station Authorization, Call Sign E190066 (issued Mar. 13, 2020). SpaceX Services has filed for modification to increase this authorization to five million user terminals, which remains pending. *See* Application for Modification, IBFS File No. SES-MOD-20200731-00807 (July 31, 2020).

possible, compensating for variations in antenna gain and path loss associated with the steering angle.

Being electrically identical to the previously authorized fixed consumer user terminals, the ESAA terminals have the same transmit power, gain, and EIRP. At the phased array's equivalent of an "antenna flange," the highest transmit power is 4.06 W[7] while the highest EIRP for all carriers is 38.2 dBW. The antenna gain is highest at boresight (33.2 dBi and 34.6 dBi for the receive and transmit antennas, respectively) and lowest at maximum slant (30.6 dBi and 32.0 dBi for the receive and transmit antennas, respectively).[8]

Table 1 summarizes the technical specifications of the proposed ESAAs.

Link Type	Frequency	Modulation	Emission Designator	Maximum EIRP
Broadband Downlink (space-to-Earth)	10.7-12.7 GHz	Up to 64 QAM	240MD7W	N/A
Broadband Uplink (Earth-to-space)	14.0-14.5 GHz	Up to 64 QAM	60M0D7W	38.2dBW

Table 1. ESAA Terminal Specifications

The EIRP masks for these ESAAs, for co-polarized and cross-polarized signals, are set forth in Exhibit A hereto, and are identical to those for the previously authorized consumer user terminals. In addition, SpaceX Services has submitted with this application a radiation hazard analysis to demonstrate that these earth stations are compliant with and will not result in exposure levels exceeding the applicable radiation hazard limits established by the Commission.

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[7] There is no difference in transmit power between ESAAs at the center or edge of the spot or between clear sky or heavy rain conditions.

[8] For purposes of Form 312 accompanying this application, SpaceX Services has supplied the highest transmit power and EIRP figures to present worst-case conditions.

SpaceX Services will ensure installation of ESAA terminals on aircraft by qualified installers who have an understanding of the antenna's radiation environment and the measures best suited to maximize protection of the general public and persons operating the aircraft and equipment. An ESAA terminal exhibiting radiation exposure levels exceeding 1.0 mW/cm^2 in accessible areas, such as at the exterior surface of the radome, will have a label attached to the surface of the terminal warning about the radiation hazard and will include thereon a diagram showing the regions around the terminal where the radiation levels could exceed the maximum radiation exposure limit specified in 47 C.F.R. § 1.1310 Table 1.[9]

III. SPECTRUM SHARING ISSUES

The Commission has allocated the Ku-band that SpaceX Services proposes to use for uplink communications (14.0-14.5 GHz) from these blanket-licensed earth stations on a primary basis only to the fixed-satellite service ("FSS"). Nonetheless, SpaceX Services recognizes that its earth station operations will be subject to certain sharing conditions.[10] With respect to the requirements in Section 25.228(j), SpaceX Services will coordinate the operations of its ESAAs in the 14.0-14.2 GHz band within radio line of site of NASA TDRSS facilities at three specified locations; until such coordination has been completed, these ESAAs will not exceed an EIRP spectral density towards the horizon of 12.5 dBW/MHz and will not exceed an EIRP towards the horizon of 16.3 dBW when operating within radio line of site of these TDRSS facilities.[11] In addition, SpaceX Services will not operate these earth stations in the 14.47-14.5 GHz band in the

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9 *See* 47 C.F.R. § 25.228(d).

10 *See, e.g.*, 47 C.F.R. §§ 25.115(f)(2), 25.208(o), 101.1409, 2.106 nn.5.487A & US342. In addition, pursuant to Section 25.115(i), SpaceX Services hereby certifies that it is planning to use a contention protocol (TDMA/FDMA), and such protocol usage will be reasonable.

11 *See id.* § 25.228(j)(1), (2). *See also SpaceX Authorization* ¶ 37 (requiring SpaceX to take note of NASA TDRSS facilities at three locations).

vicinity of radio astronomy observatories at sixteen locations, without first completing coordination.[12] SpaceX Services will use Global Positioning Satellite-related or other similar position location technology to ensure compliance with this commitment.[13]

Prior to operations of its ESAAs on U.S.-registered aircraft within a foreign nation's airspace, SpaceX Services will ascertain whether the relevant administration has operations that could be affected by ESAA terminals and determine whether that administration has adopted specific requirements concerning ESAA operations. When the ESAA-equipped aircraft enters foreign airspace, the ESAA terminal will operate under the Commission's rules, or those of the foreign administration, whichever is more constraining.[14] To the extent that all relevant administrations have identified geographic areas from which ESAA operations would not affect their radio operations, SpaceX Services will operate within those identified areas without further action. To the extent that the foreign administration has not adopted requirements regarding ESAA operations, SpaceX Services will coordinate its operations with any potentially affected operations.

SpaceX Services ESAA transmissions in the 14.0-14.5 GHz band from international airspace within line-of-sight of the territory of a foreign administration, where fixed service networks have primary allocation in this band, will be limited to a maximum power flux-density ("PFD") produced at the surface of the Earth by emissions from a single aircraft to not exceed the values provided in Section 25.228(i) of the Commission's rules, unless the foreign administration has imposed other conditions for protecting its fixed service stations.

Certain portions of the 10.7-12.7 GHz downlink band are shared with other commercial

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12 *See* 47 C.F.R. § 25.228(j)(3).

13 *See id.* § 25.228(j)(5).

14 *See id.* § 25.228(g)(3).

and government services. Notably, the proposed SpaceX Services ESAAs will not transmit in those bands and thus could not cause any interference to other operators using those bands. Moreover, SpaceX has engineered its NGSO system design to achieve a high degree of flexibility to facilitate spectrum sharing with other authorized satellite and terrestrial systems. In addition, its system is capable of immediately ceasing operations in the unlikely event it is notified that harmful interference has occurred. SpaceX Services understands that its operations in the 10.7-11.7 GHz band would be authorized on an unprotected basis with respect to current and future systems operating in the fixed service.[15] In addition, as mentioned above, SpaceX Services seeks a waiver for its ESAAs to receive on an unprotected basis in the 12.2-12.7 GHz band.

SpaceX is aware of its obligations under its authorization to protect terrestrial and space systems in these shared bands, and has certified that it will comply with the applicable equivalent power flux-density ("EPFD") limits set forth in Article 22 and Resolution 76 of the ITU Radio Regulations.[16] SpaceX has also demonstrated that it will comply with the applicable PFD limits in the Ku-band set forth in the Commission's rules and Article 21 of the ITU Radio Regulations.[17] The Commission has found that compliance with these EPFD and PFD limits is sufficient to protect GSO systems and terrestrial systems, respectively, against unacceptable interference.[18]

As required under the Commission's rules, each ESAA will be self-monitoring and, should a condition occur that would cause the ESAA to exceed any emission limits included in the

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15 *See id.* § 25.115(f)(2).

16 *See* Application for Modification of Authorization for the SpaceX NGSO Satellite System, IBFS File No. SAT-MOD-20200417-00037, Technical Attachment at 15 (Apr. 17, 2020) ("Modification Application"); 47 C.F.R. § 25.115(f)(1) (incorporating certification requirement in 47 C.F.R. § 25.146(a)(2)).

17 *See* Modification Application, Technical Attachment at 10-12.

18 *See, e.g.*, *Updates to Parts 2 and 25 Concerning Non-Geostationary, Fixed-Satellite Service Systems and Related Matters*, 32 FCC Rcd. 7809, ¶ 32 (2017) ("*NGSO Update Order*") ("Any NGSO FSS system operating in compliance with these [EPFD] 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."); 47 C.F.R. § 25.289 (same); *Amendment of Parts 2 and 25 of the Commission's Rules to Permit Operation of NGSO FSS Systems Co-*

conditions of its license, the ESAA will automatically cease transmissions within 100 milliseconds and not resume transmissions until the condition that caused the ESAA to exceed those limits is corrected.[19] In addition, each ESAA will be monitored and controlled by a network control and monitoring center ("NCMC") or equivalent facility located in the United States.[20] Each ESAA will be designed to comply with a "disable transmission" command from the NCMC within 100 milliseconds of receiving the command. In addition, the NCMC will monitor the operation of each ESAA in its network and transmit a "disable transmission" command to any ESAA that operates in such a way as to exceed any emission limits included in the conditions of its license. The NCMC will not allow the ESAA(s) under its control to resume transmissions until the condition that caused the ESAA(s) to exceed the authorized emission limits is corrected.[21]

SpaceX is confident that the highly advanced and flexible capabilities of its NGSO system, including the ESAAs proposed by SpaceX Services herein, will be able to comply with the limitations discussed above. Nonetheless, in the extremely unlikely event that harmful interference should occur due to transmissions to or from its ESAAs, SpaceX Services can be reached at its Starlink network operations center via phone at (360) 780-3103 or email at satellite-operators-pager@spacex.com, which links to the pagers of appropriate technical personnel with authority and ability to cease all transmissions from these ESAAs on a 24/7 basis.

Frequency with GSO and Terrestrial Systems in the Ku-Band Frequency Range, 16 FCC Rcd. 4096, ¶ 42 (2000) (observing PFD limits should protect terrestrial systems in the band).

19 *See* 47 C.F.R. § 25.228(b).

20 *See id.* § 25.228(e)(2), (f).

21 *See id.* § 25.228(c), (e)(1).

IV. GRANTING A WAIVER TO ALLOW THESE ESAAS TO USE THE 12 GHZ BAND WOULD PROVIDE REQUIRED OPERATIONAL FLEXIBILITY WITHOUT AFFECTING OTHER AUTHORIZED USERS OF THE BAND

The 12.2-12.7 GHz band (the "12 GHz band") has been allocated domestically and internationally for use by NGSO FSS systems on a co-primary basis.[22] As discussed above, however, while the Commission's rules provide for blanket licensing of NGSO earth stations operating in the 12 GHz band, this spectrum is not specifically listed among the bands available for operations of NGSO ESIMs, including ESAAs—although the rule specifically contemplates that other frequencies "may be assigned on a case-by-case basis to space systems under this part in conformance with" the allocation table.[23] Indeed, the Commission did not affirmatively prohibit NGSO ESIM operations in this band—though it did so with respect to other spectrum.[24] Rather, the omission of this band from the list of available ESIM spectrum is largely a result of the way the rules were promulgated. The Commission adopted rules for GSO ESIMs first and then proposed an analogous approach for NGSO ESIMs. With respect to the spectrum available for ESIM use, the *NGSO ESIMs NPRM* makes clear that the Commission initiated the proceeding to enable "ESIMs to communicate with NGSO FSS systems in the Ku- and Ka-bands where the Commission's rules allow ESIM communications with GSO FSS space stations."[25] Unfortunately, because GSO systems (other than Direct Broadcast Satellite ("DBS")) are not allowed to operate in the 12 GHz band, that band had not been contemplated for use by GSO ESIMs—and thus, it was omitted from the list considered for NGSO ESIMs. After several commenters in the proceeding argued for extension of the rules to include the 12 GHz band, the Commission

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22 *See id.* § 2.106; ITU Radio Regs. 5.487A.

23 *See* 47 C.F.R. § 25.202(a)(10)(ii), b.

24 *See id.* § 25.115(f)(2) (prohibiting ESIM operations in the 28.35-28.4 GHz band).

25 *Facilitating the Communications of Earth Stations in Motion with Non-Geostationary Orbit Space Stations*, 33 FCC Rcd. 11416, ¶ 8 (2018) ("*NGSO ESIMs NPRM*").

concluded only that the record was not sufficient at that point to include the band, not that ESIM operation would cause any technical impediment to other authorized uses in the band.[26]

Accordingly, SpaceX Services seeks a waiver to allow its ESAAs to use the 12 GHz band on a non-protected basis, notwithstanding the fact that this spectrum is not listed as available for NGSO ESIM operations in Section 25.202(a)(10)(ii). The Commission may waive its rules for good cause shown.[27] "Waiver is appropriate if special circumstances warrant a deviation from the general rule and such deviation would better serve the public interest than would strict adherence to the general rule," including "more effective implementation of overall policy."[28] In considering requests for non-conforming spectrum uses, the Commission has indicated that it would generally grant such waivers "when there is little potential for interference into any service authorized under the Table of Frequency Allocations and when the non-conforming operator accepts any interference from authorized services."[29] As shown below, there is good cause for the Commission to grant a waiver to allow SpaceX Systems ESAAs to receive signals in the 12 GHz band.

The proposed ESAAs will only receive in the 12 GHz band. Moreover, because SpaceX will operate its satellites in compliance with the EPFD and PFD limits that the Commission has found sufficient to protect GSO and terrestrial systems, they present no risk of interference to other authorized spectrum users. On the other hand, granting SpaceX Services access to this band is necessary to provide robust broadband service to American consumers. The 12 GHz band

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[26] *Amendment to Parts 2 and 25 of the Commission's Rules to Facilitate the Use of Earth Stations in Motion Communicating with Geostationary Orbit Space Stations in Frequency Bands Allocated to the Fixed Satellite Service*, 35 FCC Rcd. 5137, ¶¶ 45-46 (2020).

[27] 47 C.F.R. § 1.3. *See also WAIT Radio v. FCC*, 418 F.2d 1153 (D.C. Cir. 1969); *NE. Cellular Tel. Co. v. FCC*, 897 F.2d 1164 (D.C. Cir. 1990).

[28] *GE American Communications, Inc.*, 16 FCC Rcd. 11038, ¶ 9 (IB 2001) (quoting *WAIT Radio*, 418 F.2d at 1159).

[29] *Fugro-Chance, Inc.*, 10 FCC Rcd. 2860, ¶ 2 (IB 1995) (authorizing non-conforming MSS in the C-band); *See also Motorola Satellite Communications, Inc.*, 11 FCC Rcd. 13952, ¶ 11 (IB 1996) (authorizing service to fixed terminals in bands allocated to the mobile-satellite service).

represents 500 MHz of the potential spectrum authorized for downlinks from SpaceX satellites to customer user terminals. SpaceX must share all the spectrum for which it is authorized with other NGSO operators, must operate on a secondary basis with respect to fixed systems in half this spectrum (10.7-11.7 GHz), and must avoid 250 MHz at the bottom of the band (10.7-10.95 GHz) in order to protect radio astronomy operations in the adjacent band. Accordingly, the 12 GHz band constitutes a large portion of the spectrum available for communications with user terminals and gives SpaceX needed flexibility to accommodate sharing with other spectrum users in these bands while still providing robust broadband service to underserved and unserved American consumers.

SpaceX recognizes that its non-conforming use of the 12 GHz band would be authorized on a non-protected basis. That means that its ESAAs would have to accept interference from both DBS (which it was already required to do) and MVDDS (without the protection of coordination rules applicable to fixed earth stations).[30] However, the Commission has recognized that allowing satellite operators to make opportunistic use of spectrum on an unprotected basis provides operational flexibility and more intensive use of spectrum without compromising service to customers. For example, although earth stations would have to operate on an unprotected basis in the 10.7-11.2 GHz band used by SpaceX, the Commission found such use would serve the public interest because "[i]n the event of harmful interference, operators could switch to alternative spectrum not shared with the fixed service, such as the adjacent 11.7-12.2 GHz band. In addition, any operations that require certainty of protection may be individually coordinated and licensed."[31]

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[30] SpaceX recognizes that the Commission has initiated a rulemaking to explore whether to "continu[e] with the current framework" for NGSO/MVDDS sharing or "increase[e] terrestrial use of the shared band." *Expanding Flexible Use of the 12.2-12.7 GHz Band*, 36 FCC Rcd. 606, ¶ 19 (2021). However, the Commission has expressly restricted that proceeding—at the very outset—to only those changes it could make "without causing harmful interference to incumbent licensees," such as SpaceX. *Id.* ¶ 2. In any event, the unprotected operation of SpaceX Services ESIMs in this band would not preclude Commission action consistent with this premise in this rulemaking.

[31] *NGSO Update Order* ¶ 25.

Accordingly, granting a waiver would serve the public interest by enhancing SpaceX Service's ability to make productive use of valuable spectrum resources to provide high-speed, low-latency service to customers on moving aircraft. Moreover, it would do so without any offsetting interference or customer service concerns.

V. GRANT OF THIS APPLICATION WOULD SERVE THE PUBLIC INTEREST AND PROVIDE SERVICE TO AIRCRAFT OPERATING IN AREAS OTHERWISE UNSERVED OR UNDERSERVED BY HIGH-THROUGHPUT, LOW-LATENCY BROADBAND

Over the last two years, SpaceX has deployed over 1,700 satellites, sufficient to support introduction of its high-capacity, low-latency broadband services in portions of the United States and other countries. This system is now on the brink of delivering this service across the globe—including to the most remote corners and Polar Regions that too often get left behind. The demand for more broadband is surging and the need for connections has never been more important. Granting this application would serve the public interest by authorizing a new class of ground-based component for SpaceX's satellite system that will expand the range of broadband capabilities available to moving aircraft worldwide. U.S. and worldwide demand for broadband services and Internet connectivity continues to increase with escalating requirements for speed, capacity, and reliability and ongoing adaptations for usage. The volume of traffic flowing over the world's networks continues to grow, with one report estimating more traffic in 2022 alone than in the 32 years combined since the Internet started, and more than six out of ten people in the world being online.[32] Another report estimates that annual global Internet protocol traffic will grow from 1.5 zettabytes in 2017 to 4.8 zettabytes in 2022.[33] Similarly, the average Internet user will generate

[32] *See Cisco Predicts More IP Traffic in the Next Five Years Than in the History of the Internet*, CISCO (Nov. 27, 2018), https://newsroom.cisco.com/press-release-content?type=webcontent&articleId=1955935.

[33] *See VNI Complete Forecast Highlights*, CISCO, 1 (2018), https://www.cisco.com/c/dam/m/en_us/solutions/service-provider/vni-forecast-highlights/pdf/Global_2022_Forecast_Highlights.pdf.

84.6 gigabytes of Internet traffic per month by 2022, compared to 28.8 gigabytes in 2017.[34]

Moreover, consumers are interacting with broadband platforms in an increasing variety of ways. Users now require connectivity while on the move, including on domestic and international flights. In many cases, these users lack any true high-throughput, low-latency options. To close this gap, SpaceX has deployed an innovative, cost-effective, and spectrum-efficient satellite system capable of delivering robust broadband service to customers around the world. SpaceX has already secured U.S. authority for the space station components of its NGSO system. This application takes the next step by seeking authority for ESAAs that will enable the extension of that network from homes and offices to moving aircraft. Operation under the requested blanket license will provide the first option for some and promote competition for others in the market for in-motion broadband services, to the benefit of air travelers in the United States and abroad. These services will enhance the security of mobile platforms and allow operators and passengers to access services that enable increased productivity. Accordingly, an expeditious grant of this application would serve the public interest.

[34] *Id.* at 5.

Respectfully submitted,

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