

## APPLICATION FOR BLANKET-LICENSED EARTH STATIONS IN MOTION

### I. OVERVIEW

The Commission has authorized Space Exploration Holdings, LLC (“SpaceX”) to launch and operate a constellation of over 4,400 non-geostationary orbit (“NGSO”) satellites (call sign S2983/S3018) using Ku- and Ka-band spectrum.<sup>1</sup> In doing so, the Commission recognized that granting the SpaceX Authorization would “enable SpaceX to bring high-speed, reliable, and affordable broadband service to consumers in the United States and around the world, including areas underserved or currently unserved by existing networks.”<sup>2</sup> To date, SpaceX has launched over 1,100 satellites and continues to deploy its system.

The Commission has also granted a sister company, SpaceX Services, Inc. (“SpaceX Services”), a blanket license for operation of up to one million end-user customer earth stations that communicate with SpaceX’s NGSO constellation.<sup>3</sup> These user terminals employ advanced phased-array beam-forming and digital processing technologies to make highly efficient use of Ku-band spectrum resources by supporting highly directive, antenna beams that point and track the system’s low-Earth orbit satellites.

In this application, SpaceX Services seeks a blanket license authorizing operation of such 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

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<sup>1</sup> See *Space Exploration Holdings, LLC*, 33 FCC Rcd. 3391 (2018) (“*SpaceX Authorization*”); *Space Exploration Holdings, LLC*, 34 FCC Rcd. 2526 (IB 2019).

<sup>2</sup> *SpaceX Authorization* ¶ 1.

<sup>3</sup> See Radio Station Authorization, IBFS File No. SES-LIC-20190211-00151 (granted Mar. 13, 2020) (call sign E190066).

Stations in Motion (“ESIMs”)).<sup>4</sup> SpaceX Services seeks authority to deploy and operate these earth stations (1) as VMES throughout the United States and its territories, (2) as ESVs in the territorial waters of the United States and throughout international waters worldwide, and (3) as ESAAAs 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 ESIMs 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 ESIMs operating in these frequency bands.<sup>5</sup>

Below, we discuss the service to be provided by these ESIMs as well as certain spectrum sharing issues relevant to the operation of these earth stations. We then demonstrate that grant of this application 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.<sup>6</sup> To support its ambitious timetable for launching and expanding innovative satellite broadband services, SpaceX Services requests that the Commission grant the requested blanket license as expeditiously as possible.

## **II. THE ESIMs WILL EXPAND SPACEX’S INNOVATIVE BROADBAND SATELLITE SERVICE TO USERS IN MOVING VEHICLES, VESSELS, AND AIRCRAFT**

SpaceX Service’s ESIMs are electrically identical to its previously authorized consumer user terminals but have mountings that allow them to be installed on vehicles, vessels and aircraft, which are suitable for those environments. SpaceX Service’s ESIMs will communicate only with those SpaceX satellites that are visible on the horizon above a minimum elevation angle of 25

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<sup>4</sup> See 47 C.F.R. 25.103 (defining VMES, ESV, ESAA, and ESIM).

<sup>5</sup> See 47 C.F.R. § 25.115(f)(2).

<sup>6</sup> 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.

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

Being electrically identical to the previously authorized consumer user terminals, ESIM terminals have the same transmit power, gain, and EIRP. At the phased array’s equivalent of an “antenna flange,” the highest transmit power (4.06 W) occurs at maximum slant, while the lowest transmit power (0.76 W) occurs at boresight.<sup>7</sup> Similarly, the highest EIRP for all carriers (38.2 dBW) occurs at maximum slant and the lowest level (33.4 dBW) occurs at boresight. Conversely, 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).

Table 1 summarizes the technical specifications of the proposed ESIMs.<sup>8</sup>

Link Type	Frequency	Modulation	Emission Designator	Maximum EIRP	Half Power Beamwidth
Broadband Downlink (space-to-Earth)	10.7-12.7 GHz	Up to 64 QAM	240MD7W	N/A	3.5° (boresight) 5.5° (at slant)
Broadband Uplink (Earth-to-space)	14.0-14.5 GHz	Up to 64 QAM	60M0D7W	38.2 dBW	2.8° (boresight) 4.5° (at slant)

**Table 1. ESIM Terminal Specifications**

<sup>7</sup> There is no difference in transmit power between ESIMs at the center or edge of the spot or between clear sky or heavy rain conditions.

<sup>8</sup> The Commission’s rules do not require applicants to submit a maximum number of user terminals to be deployed in the Ku band because, as the Commission concluded, the number of terminals “will not significantly affect any necessary coordination.” *Comprehensive Review of Licensing and Operating Rules for Satellite Services*, 30 FCC Rcd 14713, ¶ 291 (2015). However, Form 312 Schedule B requires a number of antennas to be entered. To satisfy this technical form-validation requirement, SpaceX has entered a value of 0 on the accompanying Form 312 Schedule B. However, this is strictly to satisfy the form-validation requirements and is not intended to establish a maximum number of units that SpaceX may deploy.

The EIRP masks for these ESIMs, 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.

SpaceX Services will ensure installation of ESIM terminals on vehicles and vessels 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 vehicle and equipment. An ESIM terminal exhibiting radiation exposure levels exceeding 1.0 mW/cm 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.<sup>9</sup>

### **III. SPECTRUM SHARING**

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 FSS. Nonetheless, SpaceX recognizes that its earth station operations will be subject to certain sharing rules.<sup>10</sup> With respect to the requirements in Section 25.228(j), SpaceX Services will coordinate the operations of its ESIMs in the 14.0-14.2 GHz band within 125 km of NASA TDRSS facilities at three specified locations (for ESVs and VMESs) or within radio line of sight

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<sup>9</sup> See 47 C.F.R. § 25.228(d).

<sup>10</sup> See, e.g., 47 C.F.R. §§ 25.115(f)(2); 25.208(o); 101.1409; 2.106 footnote 5.487A; and 2.106 footnote 342. 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.

(for ESAAs); until such coordination has been completed, these ESIMs 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 that 125 km zone (for ESVs and VMESs) or within radio line of sight (for ESAAs).<sup>11</sup> In addition, SpaceX Services will not operate in the 14.47-14.5 GHz band in the vicinity of radio astronomy observatories at sixteen locations, without first completing coordination.<sup>12</sup> SpaceX Services will use Global Positioning Satellite-related or other similar position location technology to ensure compliance with this commitment.<sup>13</sup>

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.<sup>14</sup> 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 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

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<sup>11</sup> See 47 C.F.R. § 25.228(j)(1) and (2). See also *SpaceX Authorization* ¶ 37 (requiring SpaceX to take note of NASA TDRSS facilities at three locations).

<sup>12</sup> See 47 C.F.R. § 25.228(j)(3).

<sup>13</sup> See *id.* § 25.228(j)(5).

<sup>14</sup> See 47 C.F.R. § 25.228(f)(3).

allocation in this band will limit their 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 and government services. Notably, these earth stations would not transmit in those bands and thus could not cause any interference to other operators using those bands. 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. 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.<sup>15</sup> In addition, because the 12.2-12.7 GHz band is not specifically available for use by ESIMs communicating with NGSO systems,<sup>16</sup> SpaceX Services requests a waiver to authorize use of that band on a non-harmful interference, unprotected basis. This should not be controversial. Grant of this waiver will serve the public interest as operations under will not impact terrestrial uses of this band. SpaceX’s NGSO system is highly advanced, flexible, and capable of immediately ceasing operations in the unlikely event it is notified that harmful interference has occurred.

SpaceX is aware of its obligations under its Authorization to protect terrestrial and space systems in these shared bands, and hereby certifies 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 and the applicable PFD limits set forth in the Commission’s rules and Article

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<sup>15</sup> See *id.* § 25.115(f)(2).

<sup>16</sup> See *id.* § 25.202(a)(10)(ii).

21 of the ITU Radio Regulations.<sup>17</sup> The Commission has found that compliance with these EPFD and PFD limits is sufficient to protect GSO systems and terrestrial systems, respectively, against harmful interference.<sup>18</sup>

As required under the Commission’s rules, each ESIM will be self-monitoring and, should a condition occur that would cause the ESIM to exceed any emission limits included in the conditions of its license, the ESIM will automatically cease transmissions within 100 milliseconds and not resume transmissions until the condition that caused the ESIM to exceed those limits is corrected.<sup>19</sup> In addition, each ESIM will be monitored and controlled by a network control and monitoring center (“NMC”) or equivalent facility located in the United States.<sup>20</sup> Each ESIM will be designed to comply with a “disable transmission” command from the NMC within 100 milliseconds of receiving the command. In addition, the NMC will monitor the operation of each ESIM in its network, and transmit a “disable transmission” command to any ESIM that operates in such a way as to exceed any emission limits included in the conditions of its license. The NMC will not allow the ESIM(s) under its control to resume transmissions until the condition that caused the ESIM(s) to exceed the authorized emission limits is corrected.<sup>21</sup>

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<sup>17</sup> See *SpaceX Authorization* ¶¶ 40(b), (d), and (e); 47 C.F.R. § 25.115(f)(1) (incorporating certification requirement in 47 C.F.R. § 25.146(a)(2)).

<sup>18</sup> See, e.g., *Amendment 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, ¶ 77 (2000) (concluding that implementation of EPFD limits “will adequately protect GSO FSS networks”); 47 C.F.R. § 25.289 (NGSO satellite systems that comply with EPFD limits will be deemed not to cause unacceptable interference to any GSO network); *Amendment 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, ¶ 42 (2000) (observing PFD limits should protect terrestrial systems in the band).

<sup>19</sup> See 47 C.F.R. § 25.228(b).

<sup>20</sup> See *id.* §§ 25.228(e)(2) and (f). In addition, to the extent SpaceX Services uses the NMC to communicate with ESVs on vessels of foreign registry, it will maintain detailed information on each such vessel's country of registry and a point of contact for the relevant administration responsible for licensing those ESVs. *Id.* § 25.228(e)(3).

<sup>21</sup> See *id.* §§ 25.228(c) and (e)(1).

SpaceX is confident that the highly advanced and flexible capabilities of its NGSO system, including the ESIMs 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 ESIMs, SpaceX Services can be reached at its Starlink network operations center (NOC) via phone: +1 (360) 780 – 3103 or email: [satellite-operators-pager@spacex.com](mailto:satellite-operators-pager@spacex.com), which links to the pagers of appropriate technical personnel with authority and ability to cease all transmissions from these ESIMs on a 24/7 basis.

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

Granting this application would serve the public interest by authorizing a new class of ground-based components for SpaceX’s satellite system that will expand the range of broadband capabilities available to moving vehicles throughout the United States and to moving vessels and aircraft worldwide. The urgency to provide broadband service to unserved and underserved areas has never been clearer. 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 has exploded, with one report estimating that by 2022 annual global Internet protocol traffic will reach an annual run rate of 4.8 zettabytes – meaning that approximately 4,800 billion gigabytes of data would be exchanged worldwide that year.<sup>22</sup>

Moreover, consumers are interacting with broadband platforms in an increasing variety of ways. No longer are users willing to forego connectivity while on the move, whether driving a

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<sup>22</sup> See Cisco Visual Networking Index (VNI) Complete Forecast Update, 2017-2022, at 5 (Dec. 2018), [https://www.cisco.com/c/dam/m/en\\_us/network-intelligence/service-provider/digital-transformation/knowledge-network-webinars/pdfs/1213-business-services-ckn.pdf](https://www.cisco.com/c/dam/m/en_us/network-intelligence/service-provider/digital-transformation/knowledge-network-webinars/pdfs/1213-business-services-ckn.pdf).



truck across the country, moving a freighter from Europe to a U.S. port, or while on a domestic or international flight. To help meet this demand, SpaceX has deployed an innovative, cost-effective and spectrum-efficient satellite system capable of delivering robust broadband service to customers around the world, particularly in unserved and underserved areas. 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 ESIMs that will enable the extension of that network from homes and offices to vehicles, vessels, and aircraft. Operation under the requested blanket license will promote competition in the market for in-motion broadband services, to the benefit of drivers, ship operators, and 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.

Respectfully submitted,

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### Exhibit A – EIRP Mask

