

APPLICATION FOR BLANKET LICENSED EARTH STATIONS

I. OVERVIEW

The Commission has authorized Space Exploration Holdings, LLC (“SpaceX”) to launch and operate a constellation of 4,425 non-geostationary orbit (“NGSO”) satellites (call sign S2983/S3018) using Ku- and Ka-band spectrum.¹ 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.”² SpaceX intends to begin launching satellites to populate its constellation in 2019.

In this application, a sister company, SpaceX Services, Inc. (“SpaceX Services”) seeks a blanket license authorizing operation of up to 1,000,000 earth stations that end-user customers will utilize to communicate with SpaceX’s NGSO constellation. 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, steered antenna beams that track the system’s low-Earth orbit satellites. Consistent with SpaceX’s space station authorization, these earth stations 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 frequency bands.³ SpaceX Services seeks authority to deploy and operate these

¹ See *Space Exploration Holdings, LLC*, 33 FCC Rcd. 148 (2018) (“SpaceX Authorization”). SpaceX recently filed a modification application in which it proposes to relocate 1,584 satellites previously authorized to operate at an altitude of 1,150 km to an altitude of 550 km, and to make related changes to the operations of the satellites in this new lower shell of the constellation. See Application, IBFS File No. SAT-MOD-20181108-00083 (Nov. 8, 2018).

² SpaceX Authorization, ¶ 1.

³ See 47 C.F.R. § 25.115(f)(2).

earth stations throughout the contiguous United States, Alaska, Hawaii, Puerto Rico, and the U.S. Virgin Islands.

Below, we discuss 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 on Form 312. To support its ambitious timetable for launching satellites and deploying broadband services, SpaceX Services requests that the Commission grant the requested blanket license as expeditiously as possible.

II. SPECTRUM SHARING ISSUES

The Commission has allocated the Ku-band uplink band (14.0-14.5 GHz) that SpaceX Services proposes to use for these blanket-licensed earth stations on a primary basis only to FSS. However, certain portions of the downlink band are shared with other commercial and government services. 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 is aware of its obligations under its Authorization to protect terrestrial and space systems in these shared bands, particularly the applicable equivalent power flux-density (“EPFD”) limits set forth in Article 22 and Resolution 76 of the ITU Radio Regulations and the applicable power flux-density (“PFD”) limits set forth in the Commission’s rules and Article 21 of the ITU Radio Regulations.⁴ The Commission has found that compliance with these EPFD and PFD limits is sufficient to protect GSO systems and terrestrial systems, respectively, against harmful

⁴ 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)).

interference.⁵ In addition, SpaceX Services recognizes that its earth station operations will be subject to certain sharing conditions.⁶ SpaceX is confident that the highly advanced and flexible capabilities of its NGSO system, including the earth stations proposed by SpaceX Services herein, will be able to comply with these limitations.

III. GRANT OF THIS APPLICATION WOULD SERVE THE PUBLIC INTEREST

Granting this application would serve the public interest by helping to speed broadband deployment throughout the United States by authorizing the ground-based component of SpaceX's satellite system. 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 annual global Internet protocol traffic reached 1.5 zettabytes in 2017 – meaning that approximately 1,500 billion gigabytes of data were exchanged worldwide last year.⁷

Yet, as the Commission has recognized, many communities across the United States and the world still lack access to reliable broadband connectivity, preventing them from fully participating in economic, social, and civic activities.⁸ To help close this digital divide, SpaceX is

⁵ 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).

⁶ 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. See also SpaceX Authorization, ¶ 37 (requiring SpaceX to take note of NASA TDRS facilities at three locations). 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.

⁷ See Cisco Visual Networking Index: Forecast and Methodology, 2017-2022, at 1 (Nov. 26, 2018), available at <https://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/white-paper-c11-741490.html>.

⁸ See, e.g., *Inquiry Concerning the Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion*, 33 FCC Rcd. 1660, ¶ 50 (2018) (noting that “over 24 million Americans still

designing, constructing, and deploying 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 the end-user customers' earth stations that incorporate advanced technologies to enable highly efficient use of the spectrum and enhance the customer's broadband experience. Accordingly, an expeditious grant of this application would serve the public interest.

Respectfully submitted,

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lack fixed terrestrial broadband at speeds of 25 Mbps/3 Mbps,” and that “the gap in rural and Tribal America remains notable: 30.7 percent of Americans in rural areas and 35.4 percent of Americans in Tribal lands lack access to fixed terrestrial 25 Mbps/3 Mbps broadband”). Internationally, the disparities between broadband access and absence are even greater, with 4.2 billion people (or 57% of the world’s population) offline. *See* BROADBAND COMMISSION FOR SUSTAINABLE DEVELOPMENT, “Open Statement from the Broadband Commission for Sustainable Development to the UN High-Level Political Forum (HLPF)” (July 11, 2016), *available at* <http://broadbandcommission.org/Documents/publications/HLPF-July2016.pdf>. *See also* BROADBAND COMMISSION FOR SUSTAINABLE DEVELOPMENT, “The State of Broadband 2015,” at 8 (Sep. 2015), *available at* <http://www.broadbandcommission.org/Documents/reports/bb-annualreport2015.pdf> (“A large body of evidence has now been amassed that affordable and effective broadband connectivity is a vital enabler of economic growth, social inclusion and environmental protection.” (footnotes omitted)).

TECHNICAL ANNEX

In this Technical Annex, SpaceX Services provides additional information on the proposed operations of its blanket-licensed earth stations to supplement the data provided in Schedule B to Form 312 filed with this narrative application.¹

A. Minimum Elevation Angle

SpaceX Service's user terminals will communicate only with those SpaceX satellites that are visible on the horizon above a minimum elevation angle. In the very early phases of constellation deployment and as SpaceX first initiates service, this angle may be as low as 25 degrees,² but this will return to 40 degrees as the constellation is deployed more fully and more satellites are in view of a given end-user. For purposes of this application, SpaceX Services has supplied the lower angle in order to capture the full potential range of service.

B. Power and Gain Figures

The proposed user terminal is a flat phased array capable of steering its beams to track SpaceX's NGSO satellites passing within its field of view. As the terminal steers the transmitting beam, it also adjusts 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. 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.³ Similarly, the highest EIRP for all carriers (38.2 dBW) occurs at maximum slant and the lowest

¹ 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, and SAT-MOD-20181108-00083.

² Operation at elevation angles below 40 degrees is achieved by tilting the antenna.

³ There is no difference in transmit power between CP terminals at the center or edge of the spot or between clear sky or heavy rain conditions.

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). For purposes of Form 312 accompanying this application, SpaceX Services has supplied the higher transmit power figures and lower gain figures in order to present worst-case conditions.

C. Antenna Patterns

Section 25.209 of the Commission's rules imposes reference antenna pattern requirements for certain satellite earth stations. Most of these relate to earth stations communicating with GSO systems, as the rule was developed to facilitate GSO-to-GSO sharing where a constant level of interference is present.⁴ Over the last two decades, the Commission has repeatedly declined to adopt similar antenna reference pattern for use in licensing NGSO user terminals. In doing so, it has "recognize[d] that there are physical limitations on the amount of sidelobe suppression achievable in small earth station antennas," and concluded that "[w]e do not see a need at this time to specify an NGSO FSS customer premises earth station reference antenna pattern."⁵ Moreover, it has expressed its concern "that imposing an antenna reference pattern will increase the cost for NGSO FSS user terminals and create additional regulatory burdens,"⁶ and found "little evidence that imposing such an antenna reference pattern on NGSO FSS user Earth stations would significantly improve [spectrum] sharing."⁷ The Commission recently confirmed that it "has not

⁴ See *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, ¶ 81 (2000) ("Ku-Band NGSO Order"). But see 47 C.F.R. § 25.209(h) (specifying performance standards for transmitting gateway earth stations operating with Ku-band NGSO systems).

⁵ See, e.g., *Ku-Band NGSO Order*, ¶ 240.

⁶ *Establishment of Policies and Rules for the Non-Geostationary Satellite Orbit, Fixed Satellite Service in the Ku-Band*, 16 FCC Rcd. 9680, ¶ 48 (2001).

⁷ *Establishment of Policies and Rules for the Non-Geostationary Satellite Orbit, Fixed Satellite Service in the Ku-Band*, 17 FCC Rcd. 7841, ¶ 60 (2002).

yet determined what off-axis gain envelopes might be appropriate for earth stations operating with NGSO FSS space stations, either to facilitate NGSO-to-NGSO or NGSO-to-GSO interference protection.”⁸

Accordingly, the Commission’s earth station licensing rules that are predicated on antenna performance standards do not apply to this application. For example, Section 25.132 of the Commission’s rules provides that applications for transmitting FSS earth stations must include a certification that the applicant has reviewed the results of a series of radiation pattern tests performed on representative equipment in representative configurations, and the test results demonstrate that the equipment meets relevant off-axis gain standards in Section 25.209. Since no such standards apply to the user terminals in this application, no such certification is required.⁹

Although no antenna performance requirements apply, SpaceX Services provides the half power beamwidth for its proposed earth stations in Table 1 below.

Function	At Boresight	At Slant
Receive (11.7 GHz)	3.5°	5.5°
Transmit (14.25 GHz)	2.8°	4.5°

Table 1. Half Power Beamwidth

In addition, the EIRP mask for its proposed earth stations, for both co-polarized and cross-polarized signals, are as follows:

⁸ *Comprehensive Review of Licensing and Operating Rules for Satellite Services*, 30 FCC Rcd. 14713, ¶ 213 (2015). See also *Update to Parts 2 and 25 Concerning Non-Geostationary, Fixed-Satellite Service Systems and Related Matters*, 32 FCC Rcd. 7809, ¶¶ 54-55 and n.121 (2017) (declining to adopt NGSO earth station antenna performance standards).

⁹ Nonetheless, in response to Item E16 on Schedule B to Form 312, SpaceX Services has responded “no” to the question of whether its earth stations will comply with the antenna gain patterns specified in Section 25.209 – even though those patterns are inapplicable.

