

QUESTION 7: PURPOSE OF EXPERIMENT

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.¹ As of February 2022, SpaceX has launched over 2,000 satellites and continues to deploy its system rapidly. The Commission has also granted a blanket license for operation of up to 1,000,000 end-user customer earth stations that communicate with SpaceX’s NGSO constellation.² 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.

The Commission has previously granted experimental authority to test these same user terminals at various locations within the United States.³ In addition, the Commission granted experimental authority for SpaceX to test up to five user terminals electrically identical to those covered by its blanket license when mounted on a Gulfstream jet for a period of up to two years, with a goal of expanding its assessment of the end-to-end capabilities of its satellite system.⁴

In this experimental application, SpaceX seeks to expand this testing to allow operation of terminals on a variety of fixed wing and rotary airframes to support internal, commercial, and government research projects. Such authority would enable SpaceX to obtain critical data regarding the operational performance of these experimental transceivers during all phases of flight and the SpaceX NGSO system more broadly. SpaceX seek to operate on flights over the United States (including its territories and territorial waters) subject to the following restrictions:

- Flight paths will not exceed 50,000 feet AGL
- Testing will involve at most five terminals at any one time
- SpaceX will, at all times, adhere to the EPFD, emissions masks, power limitations, and other technical restrictions described below

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

² See Radio Station Authorization, IBFS File No. SES-LIC-20190211-00151 (granted Mar. 13, 2020) (call sign E190066). The Commission’s rules specifically contemplate blanket licensing for earth stations operating in these frequency bands. See 47 C.F.R. § 25.115(f)(2). The overall height of these antennas above ground level (or above existing structures) will not exceed six meters.

³ See, e.g., Experimental Authorization, ELS File No. 0388-EX-CN-2019 (granted Aug. 27, 2019); Experimental Authorization, ELS File No. 0517-EX-CN-2019 (granted Aug. 27, 2019).

⁴ See Experimental Authorization, ELS File No. 0955-EX-CN-2020 (granted Jun. 4, 2021).

Consistent with SpaceX's space station authorization, these mobile transceivers will transmit in the 14.0-14.5 GHz band and receive in the 10.7-12.7 GHz band. These bands are available for use by earth stations in motion communicating with NGSO FSS systems.⁵

The Commission has allocated the Ku-band uplink band (14.0-14.5 GHz) that SpaceX Services proposes to use for these earth stations on a primary basis only to fixed satellite service (FSS). However, certain portions of the 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 satellite system 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.⁶ 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.⁷

In addition, SpaceX recognizes that the terminals will be subject to certain sharing conditions during experimental operations.⁸ With respect to the requirements in Section 25.228(j), SpaceX will not operate any experimental terminals in the 14.0-14.2 GHz band within radio line of sight of NASA TDRSS facilities at three locations and will not operate in the 14.47-14.5 GHz band within radio line of sight of radio astronomy observatories at sixteen locations, until it has successfully completed coordination and notified the Commission of such coordination.⁹ SpaceX will use Global Positioning Satellite-related or other similar position location technology to ensure compliance with this commitment.

An additional exhibit is attached that provides further information on interference protection considerations for earth-station in motion ("ESIM").

⁵ See 47 C.F.R. § 25.202(a)(10)(ii).

⁶ 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)).

⁷ 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). 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.

⁸ 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.

⁹ See 47 C.F.R. § 25.228(j)(1) and (3). See also SpaceX Authorization, ¶ 37 (requiring SpaceX to take note of NASA TDRS facilities at three locations).

SpaceX is confident that the highly advanced and flexible capabilities of its NGSO system 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 terminals during their experimental use, SpaceX will take all reasonable steps to eliminate the interference. Should an issue arise, SpaceX can be reached at isp.noc@spacex.com, which links to the pagers of appropriate technical personnel 24/7.

The experimental, mobile terminals will communicate only with those SpaceX satellites that are visible on the horizon above a minimum elevation angle of 25 degrees. The terminals will track SpaceX's NGSO satellites passing within its field of view. As the terminals steer their transmitting beams, they will automatically change the power to maintain a constant level at the receiving antenna of its target satellite, compensating for variations in antenna gain, path loss, and steering angle resulting from aircraft maneuvers. At a phased array's equivalent of an "antenna flange," the highest transmit power will occur at maximum slant, while the lowest transmit power occurs at boresight. Similarly, the highest EIRP for all carriers occurs at maximum slant and the lowest level occurs at boresight. Conversely, the antenna gain is highest at boresight and lowest at maximum slant. For purposes of Form 442 accompanying this application, SpaceX has supplied the following worst-case characteristics:

- Lower transmit frequency: 14.0 GHz
- Upper transmit frequency: 14.5 GHz
- Lower receive frequency: 10.7 GHz
- Upper receive frequency: 12.7 GHz
- Power (maximum, peak): 12 dBW
- ERP (maximum, peak): 46.5 dBW
- Frequency tolerance (worst-case): +/- 1 ppm
- Necessary Bandwidth (maximum): 62.5 MHz
- Modulating signal types: BPSK, QPSK, 8 PSK, 16 QAM, 32 QAM, 64 QAM
- Emission: D7W
- Maximum Permissible Exposure (MPE) limit: < 1 mW/cm² averaged over 30-minutes

The EIRP masks for these proposed transceivers, for co-polarized and cross-polarized signals, are set forth below. In addition, SpaceX has attached a radiation hazard analysis to demonstrate that these earth stations are compliant with and will not result in exposure levels exceeding the applicable radiation hazards limits established by the Commission.

