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] SpaceX has launched over 700 satellites and continues to deploy its system. The Commission has also granted a blanket license for 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 order to expand its assessment of the end-to-end capabilities of its satellite system, SpaceX seeks authority to test these user terminals on seagoing platforms for a period of up to two years. Specifically, SpaceX proposes to deploy a total of ten earth stations across up to ten vessels, including two autonomous spaceport droneships used to land rocket boosters at sea on high-velocity missions that cannot carry enough fuel to allow for a return-to-launch-site landing, and support ships that accompany the droneships to the landing zone at sea.

SpaceX seeks experimental authority for operation of its user terminals aboard these vessels when they are (1) anchored in port, (2) in transit to predetermined landing zones in the Atlantic Ocean, and (3) on station at those landing zone sites.[4] 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. Such authority would enable SpaceX to obtain critical data regarding the operational performance of these user terminals and the SpaceX NGSO system more broadly.

The Commission has allocated the Ku-band uplink band (14.0-14.5 GHz) that SpaceX proposes to use for these earth stations on a primary basis only to FSS. However, certain portions of the downlink band are shared with other commercial and government services.

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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 Boosters typically land between 600 – 675 km downrange; however, the furthest droneship position was 1,239 km downrange, set during the STP-2 Falcon Heavy mission in June 2019.

SpaceX has engineered its NGSO 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.[5] 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.[6] In addition, SpaceX recognizes that its earth station operations will be subject to certain sharing conditions.[7] SpaceX is confident that the highly advanced and flexible capabilities of its NGSO system, including the earth stations proposed by SpaceX herein, will be able to comply with these limitations.

SpaceX's user terminals will communicate only with those SpaceX satellites that are visible on the horizon above a minimum elevation angle of 25 degrees. The proposed flat 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. 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. 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). For purposes of Form 442 accompanying this application, SpaceX has supplied the higher transmit power figures and lower gain figures in order to present worst-case conditions.

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[5] *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)).

[6] *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).

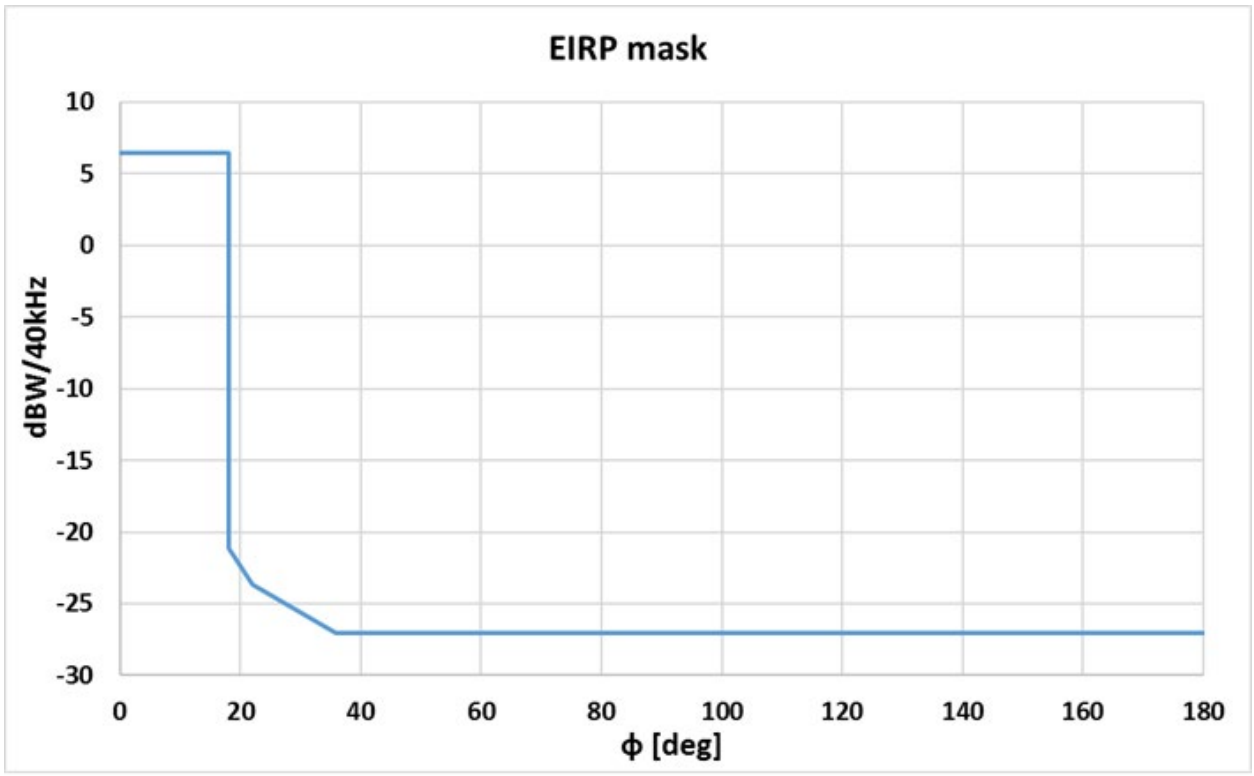
[7] *See, e.g.,* 47 C.F.R. §§ 25.115(f)(2); 25.208(o); 101.1409; 2.106 footnote 5.487A; and 2.106 footnote 342. *See also SpaceX Authorization*, ¶ 37 (requiring SpaceX to take note of NASA TDRS facilities at three locations). In addition, pursuant to Section 25.115(i), SpaceX Services hereby certifies that it is planning to use a contention protocol (TDMA/FDMA), and such protocol usage will be reasonable.

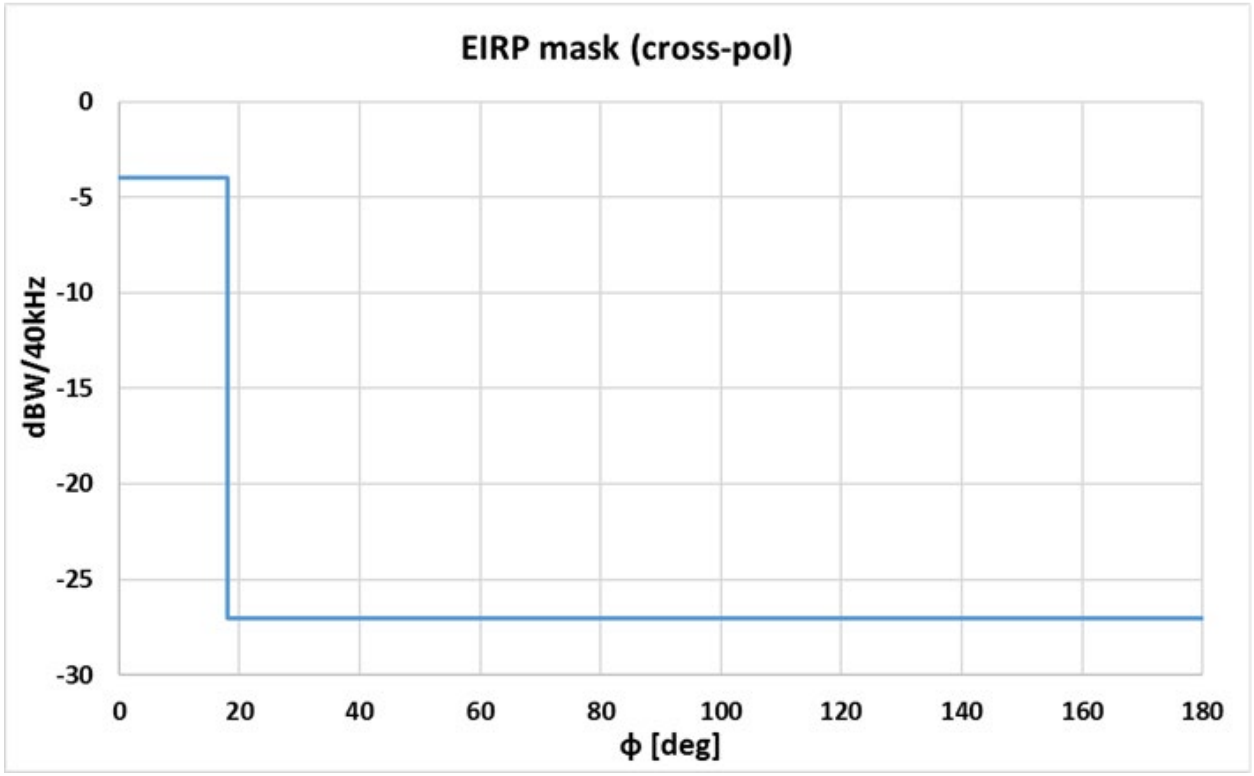
Table 1 summarizes the technical specifications of SpaceX's proposed earth station terminals.

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. Consumer Terminal Specifications

The EIRP masks for these proposed earth stations, for co-polarized and cross-polarized signals, are set forth below. In addition, SpaceX has attached hereto 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.


EIRP mask
10
5
0
-5
-10
-15
-20
-25
-30
dBW/40kHz
0
20
40
60
80
100
120
140
160
180
ϕ [deg]


EIRP mask (cross-pol)
0
-5
-10
-15
-20
-25
-30
dBW/40kHz
0
20
40
60
80
100
120
140
160
180
ϕ [deg]