## NARRATIVE DESCRIPTION: STA APPLICATION NO. 2057-EX-ST-2022

This STA application is identical to the application previously filed and granted under ELS File No. 1169-EX-ST-2022 but extends the launch window period beyond February 1, 2023.

### STARSHIP-SUPER HEAVY TEST FLIGHT

SpaceX's Starship spacecraft and Super Heavy booster represent a fully reusable transportation system designed to carry both crew and cargo to Earth orbit, the Moon, Mars, and beyond. SpaceX intends to mount Starlink satellite terminals on the Super Heavy booster and orbital Starship for Starship-Super Heavy's first test flight and use these terminals to communicate with SpaceX's satellite constellation.

### OBJECTIVES

SpaceX intends to demonstrate high-data-rate communications with the Starship spacecraft and the Super Heavy booster on the ground at the launch site in Starbase, TX, during launch, in-flight operations, booster recovery, and spacecraft entry. SpaceX's satellite constellation can provide unprecedented volumes of telemetry and enable communications during atmospheric entry when ionized plasma around the spacecraft inhibits conventional telemetry frequencies. These tests will demonstrate its ability to improve the efficiency and safety of future orbital spaceflight missions.

### FLIGHT PROFILE

The Starship-Super Heavy test flight will originate from Starbase, TX. The booster stage will separate and will then perform a partial return and land in the Gulf of Mexico or return to Starbase and be caught by the launch tower. The orbital Starship spacecraft will continue on its path to an altitude of approximately 250 km before performing a powered, targeted landing in the Pacific Ocean.

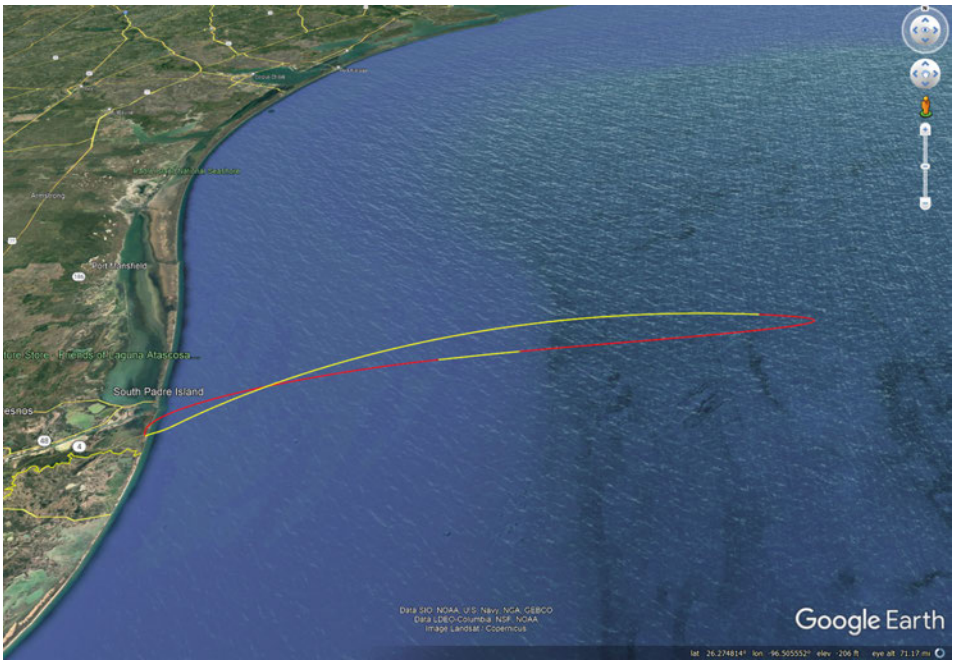



Figure 1: Super Heavy Booster Launch Profile


Figure 2: Orbital Starship Launch Profile

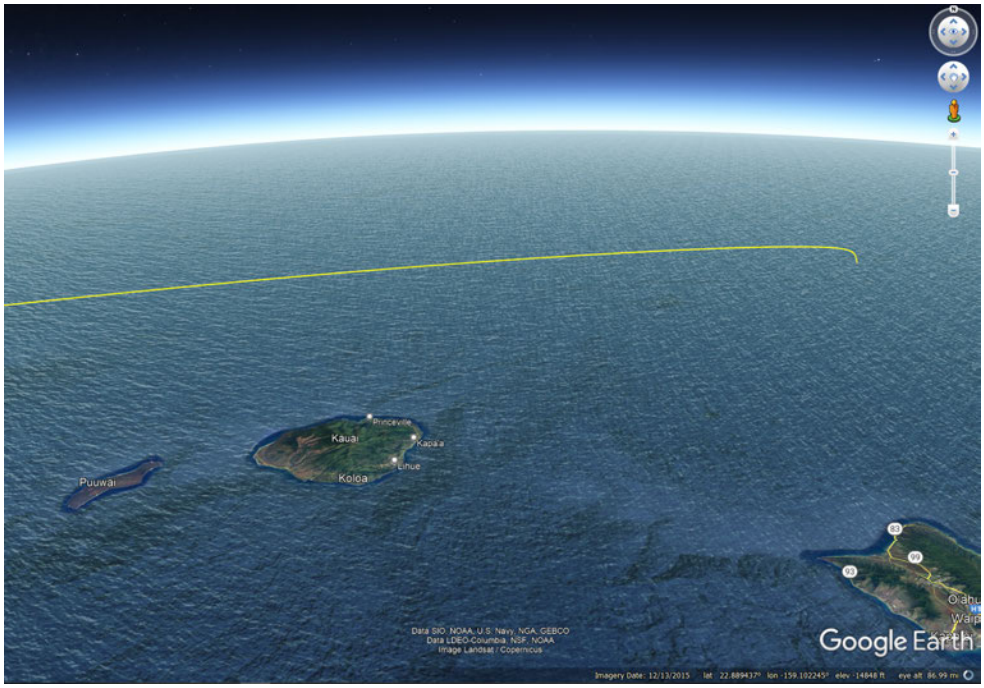


Figure 3: Orbital Starship Entry Profile

## STARLINK TERMINALS

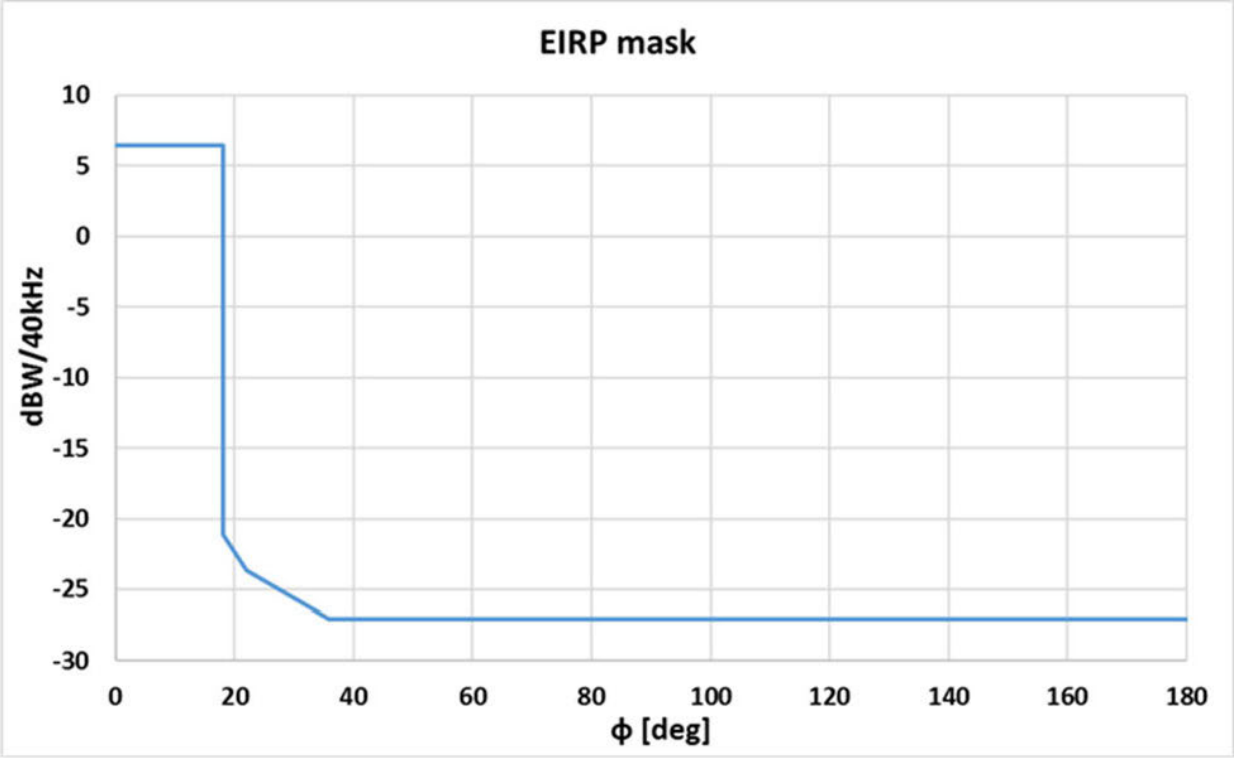
Multiple Starlink terminals will be fitted to each vehicle to ensure a clear view of the SpaceX satellite constellation through the Starship flight profile. The terminals will use the same antenna and communications electronics as SpaceX's previously authorized consumer terminals but with a revised enclosure and mounting that is suitable for the mission profile.

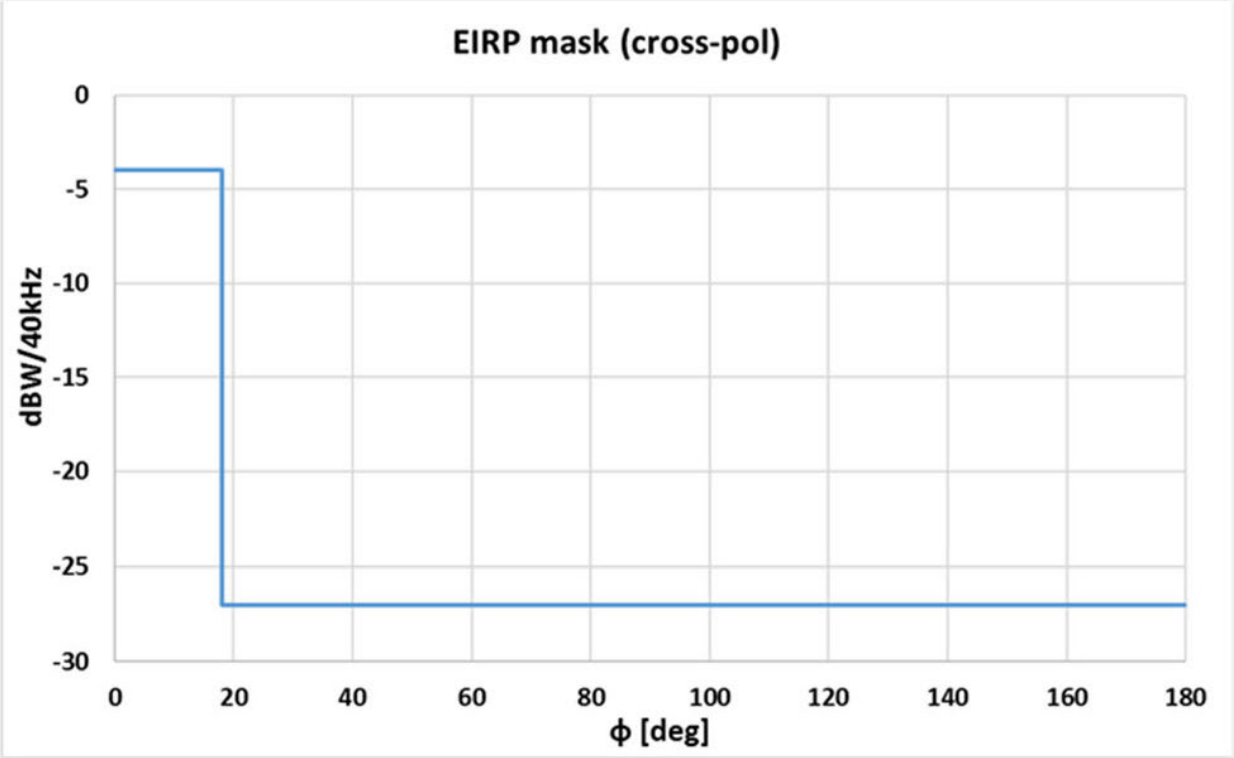
Each user terminal will communicate only with those SpaceX satellites that are visible on the horizon above a minimum elevation angle and that observe the appropriate angular separation from the Geostationary Orbital ("GSO") arc. The phased array user terminals will track SpaceX's NGSO satellites passing within their 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 possible, 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 is 4.06 W and 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). For purposes of the STA Form accompanying this application, SpaceX has supplied the highest transmit power figures and lowest gain figures. Table 1 summarizes the technical specifications of SpaceX's proposed earth station terminals.

| 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 | 38.2 dBW |

Table1: Starlink Terminal Characteristics

The EIRP masks for these proposed earth stations, for co-polarized and cross-polarized signals, are set forth below.


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]

## INTERFERENCE PROTECTION

The Commission has allocated the Ku-band that SpaceX proposes to use for uplink communications (14.0-14.5 GHz) on a primary basis only to FSS. Certain portions of the 10.7-12.7 GHz downlink band are shared with other commercial and government services. Notably, the proposed earth stations would not transmit in those bands and thus could not cause any interference to other operators using those bands.

SpaceX has been licensed to operate a network of ESIM's in the 14.0-14.5 GHz (uplink) and 10.7-12.7 GHz (downlink) bands.[1] The operations requested herein would be similar to those already permitted under that authorization and would protect other spectrum users in similar ways.

### Geostationary Satellite Orbit Systems

The proposed operations will protect GSO systems from harmful interference by operating within the ITU EPFD limits that apply to the SpaceX user-terminal network as a whole, which the Commission has concluded "will adequately protect GSO FSS networks."[2] Here, the applicable ITU EPFD limits are provided in Article 22 and Resolution 76 of the ITU Radio Regulations, which require the assessment of a satellite system as a whole to demonstrate that the probability of emissions exceeding certain levels remain within specified regulatory limits.

As discussed in SpaceX's ESIM applications and others, SpaceX has confirmed that its user-terminal network as a whole will comply with these EPFD limits.[3] The user terminals SpaceX seeks to operate in this application will likewise operate within that previously authorized user-terminal network within those EPFD limits and will not exceed the on- or off-axis EIRP levels of those devices.[4] Like other SpaceX ESIMs, these terminals will limit EPFD by observing

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[1] *See* SpaceX Services, Inc., Radio Station Authorization, IBFS File No. SES-LIC-20210803-01360 (granted June 30, 2022) (call sign E210309) ("Next Gen. ESIM Application"); SpaceX Services, Inc., Radio Station Authorization, IBFS File No. SES-LIC-20210803-01361 (granted June 30, 2022) (call sign E210310) ("HP ESIM Application").

[2] *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"). *See also* 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.).

[3] *See* Next Gen. ESIM Application; HP ESIM Application; SpaceX Services, Inc., Radio Station Authorization, IBFS File No. SES-LIC-20190211-00151 (granted Mar. 13, 2020) (call sign E190066).

[4] *Id*. Notably, the Commission does not require the submission of antenna patterns for blanket-licensed NGSO earth stations, as the EIRP mask is sufficient to verify compliance with EPFD limits and other interference-protection benchmarks. SpaceX's Part 25 blanket user-terminal authorization was granted on this basis. NGSO user terminals are also not required to comply with

minimum elevation and GSO avoidance angles. In addition, the EIRP mask limits the sidelobe power spectral density of transmissions from the terminal toward GSO satellites.

Accordingly, by complying with the appropriate EPFD limits, the proposed operations will satisfy the GSO interference-protection requirements that the Commission has adopted for NGSO systems in this band.

In addition, the proposed operations will comply with the FCC's requirements for NGSO Earth Stations in Motion ("ESIMs") in these bands to ensure that motion of the user-terminal will not cause it to inadvertently exceed interference protection limits. In particular, these earth stations will be self-monitoring and, should a condition occur that causes it to exceed EIRP, EIRP density or off-axis EIRP mask limits included in the licensing conditions for the FSS NGSO network that it is using as a point of communication in the 14.0-14.5 GHz band, the terminal will automatically cease transmissions within 100 milliseconds and not resume transmissions until the condition that caused the experimental terminal to exceed those limits is corrected.[5]

The protection of GSO systems is not meaningfully affected by the altitude of the terminal for the proposed test flights. At a maximum altitude of 250 km, the proposed terminals are less than 0.7% closer to the satellites in the GSO, so power reduction of only 0.06 dB is required to maintain the same power flux density at the GSO.

**Fixed-Service Systems**

Similar to protection of GSO systems, the ITU has adopted PFD limits (codified in Article 21 of the ITU Radio Regulations) that limit the energy of satellite downlink transmissions to protect terrestrial services. The Commission has concluded that compliance with these PFD limits is sufficient to protect terrestrial fixed-service operators from harmful interference.[6]

Nothing about the operation of the proposed earth stations will affect that. As mentioned above, the 14.0-14.5 GHz band in which these earth stations transmit is allocated on a primary basis solely to FSS. The protection of fixed-service operators is enhanced by the higher altitude of the terminal for the proposed test flights. For example, at a maximum altitude of 250 km, the proposed terminals are 20 times further away from the ground than the previously authorized 12.5 km, which will reduce the PFD of their transmissions at the ground by 26 dB.

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the antenna-gain limitations in Section 25.209. The Commission has granted other blanket user-terminal authorizations as well that have not included antenna patterns and which have correctly asserted that "the Commission's antenna performance standards contained in Section 25.209 of the Commission's rules are not applicable to NGSO user terminals." *See* WorldVu Satellites Limited, Radio Station Authorization, IBFS File No. SES-LIC-20190930-01217 (granted Apr. 27, 2021) (call sign E190727).

[5] *See* 47 C.F.R. § 25.228(c).

[6] *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).

With respect to the 12 GHz band, SpaceX reiterates that, the proposed earth stations will only *receive* in this band, and thus cannot cause any interference to other authorized users. Use of the 12 GHz band is also consistent with SpaceX's existing ESIM authorizations.[7]

**NGSO Systems**

The SpaceX NGSO FSS system, including operations under the authorization requested herein, will at all times comply with Section 25.261(c) which governs spectrum sharing between NGSO operators. Beyond the requirements of Section 25.261, the SpaceX system uses steerable and shapable beams as well as satellite diversity, which will often allow SpaceX to choose from multiple satellites capable of serving any one point on the ground. These advanced capabilities will allow SpaceX to minimize the potential for in-line events involving these or any other SpaceX earth stations. The SpaceX terminals described in this application include these same capabilities and flying at higher altitudes does not affect how these capabilities work.

**TDRSS and Radio Astronomy**

SpaceX will comply with its obligations, pursuant to conditions placed on its blanket user-terminal authorizations, to avoid and/or coordinate with NASA TDRSS and radio astronomy facilities as necessary to avoid harmful interference to these services.[8]

[7] *See supra* note 2.

[8] Section 25.228(j) covers operation with TDRSS and Radio Astronomy. For these experimental operations, SpaceX will not operate within radio line of sight of the listed facilities unless SpaceX has coordinated its operations.