

SPACEX GEN2 MOBILE-SATELLITE SYSTEM

ATTACHMENT A

Technical Information to Supplement Schedule S

A.1 Scope and Purpose

This attachment contains information describing SpaceX's non-geostationary orbit ("NGSO") satellite system and use of the 1610-1617.775 MHz and 2483.5-2500 MHz bands (together, the "1.6/2.4 GHz band"), the 2000-2020 MHz and 2180-2200 MHz bands (together, the "2 GHz band"), and the 2020-2025 MHz band for Mobile-Satellite Service ("MSS"), as required under Part 25 of the Commission's rules.¹ Because portions of the technical information included below cannot be fully captured by the Schedule S software, SpaceX provides this attachment as a supplement. The accompanying Schedule S generally reflects the system as it will operate once modified and fully deployed.

A.2 Overall Descriptions

Constellation information is generally available in Attachment A ("Technical Information to Supplement Schedule S") to the previous applications related to SpaceX's second-generation NGSO Fixed-Satellite Service ("FSS") system ("Gen2 system").² Under the modification proposed herein, SpaceX requests adding an MSS payload operating in the 1.6/2.4 GHz, 2 GHz and 2020-2025 MHz bands (collectively, the "SpaceX MSS system") to satellites in the Gen2 system, as part of its current authorization.³

¹ 47 C.F.R. § 25.117.

² See Application for Approval of Orbital Deployment and Operating Authority for the SpaceX Gen2 NGSO Satellite System, IBFS File No. SAT-LOA-20200526-00055 (filed May 26, 2020); Amendment, IBFS File No. SAT-AMD-20210818-00105 (filed, Aug. 18, 2021) (collectively, "Previous Applications"); see also *Space Exploration Holdings, LLC*, FCC 22-91 (rel. Dec. 1, 2022) ("Gen2 Authorization").

³ See *Gen2 Authorization* ¶¶ 6-8.

Orbital Parameters

The SpaceX MSS system is an NGSO satellite system that will consist of a payload deployed on satellites in SpaceX's Gen2 system, subject to the conditions set forth in the *Gen2 authorization* initially granting SpaceX authority to launch and operate 7,500 satellites.⁴ The SpaceX MSS system will initially be deployed on up to 7,500 satellites within the orbital shells at 525 km, 530 km, and 535 km altitudes. Thus, SpaceX's Gen2 system will remain as described in the Previous Applications, which are incorporated by reference, and as granted in the *Gen2 Authorization*.⁵ Operation of the SpaceX MSS system payload will have no effect on the orbital characteristics of these already licensed satellites.

Technology and Operations

The SpaceX MSS system will utilize advanced phased array beam-forming and digital processing technologies onboard each satellite payload to efficiently utilize spectrum resources and promote spectrum sharing with other space-based and terrestrial-licensed users. The SpaceX MSS service will be available for residential, commercial, institutional, and governmental users in the United States.

SpaceX seeks to leverage its existing space resources to provide ubiquitous connectivity options to Americans throughout the country. To expand into mobile service, SpaceX acquired Swarm Technologies, Inc. ("Swarm"), a company authorized to deploy and operate 150 small NGSO MSS satellites designed to provide narrowband services in the very-high frequency ("VHF") 137-138 MHz and 148-150.5 MSS bands.⁶ Swarm has already launched most of its

⁴ *Id.* ¶¶ 1-2, 18-19.

⁵ *Id.* ¶ 7.

⁶ *See* Public Notice, 36 FCC Rcd. 14264 (IB 2021) (confirming authority for Swarm transfer of control to SpaceX).

authorized satellites and is offering services to customers in the agriculture, maritime, energy, environmental, and transportation sectors, among others in need of global satellite connectivity for Internet-of-Things devices. The combination of SpaceX's proposed MSS operations, in conjunctions with Swarm's Internet-of-Things connectivity solutions, will truly encompass all ranges of data rates and power levels for devices around the world.

Spectrum

The frequency plan and satellite downlink parameters are provided in the Schedule S. Satellites carrying the SpaceX MSS system payload will transmit with right-hand circular polarization ("RHCP") and left-hand circular polarization ("LHCP"). As discussed below, SpaceX will operate the SpaceX MSS system without causing harmful interference to any other service duly licensed in the 1.6/2.4 GHz band, the 2 GHz band, and the 2020-2025 MHz band (collectively, the "MSS bands").

A.3 Predicted Space Station Antenna Gain Contours

All MSS downlink spot beams on each SpaceX satellite are independently steerable. The antenna gain contours for the transmit and receive beams for a representative SpaceX MSS payload operating at 525 km, 530 km, and 535 km are embedded in the associated Schedule S, as required by Section 25.114(c)(4)(vi)(B). Figure A.3-1 shows a typical contour plot. Information on Telemetry, Tracking and Command ("TT&C") beam contours is available in Attachment A to the Previous Applications and incorporated by reference.

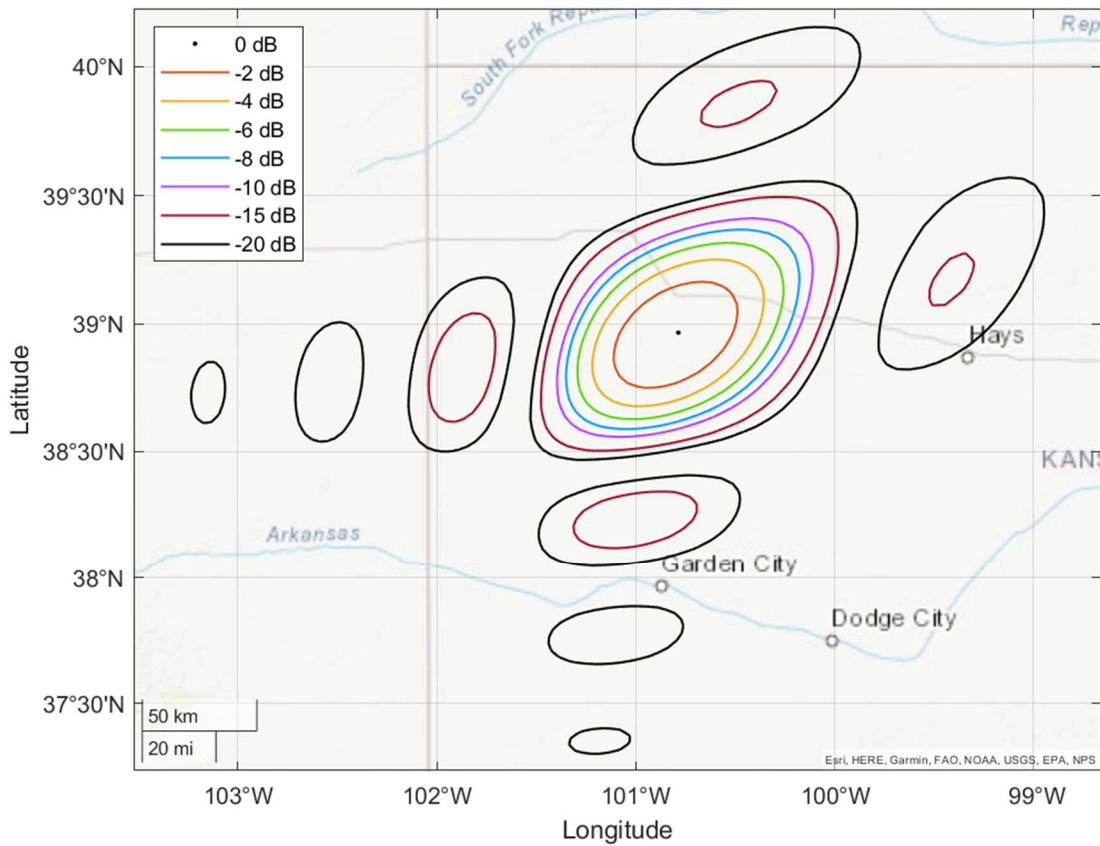


Figure A.3-1: Notional Beam Contours for a 35 Degree Off-Nadir Scan Angle Beam

A.4 TT&C Characteristics

SpaceX will use the existing TT&C subsystem on its Gen2 system for communications with the spacecraft during pre-launch, transfer orbit, and on-station operations, as well as during spacecraft emergencies, consistent with the *Gen2 Authorization*. A description of the SpaceX TT&C subsystem is provided in the Previous Applications and incorporated by reference.⁷

A.5 Backhaul Operations

The SpaceX MSS system backhaul will use the gateway links authorized in Ka-band spectrum for the Gen2 system, as well as future E-band links, which remain pending. As discussed

⁷ See also *Gen2 Authorization* ¶ 90 (citing Previous Applications).

in the Previous Applications, the SpaceX Gen2 system will utilize high-gain steered beams to simultaneously communicate with multiple satellites from a single gateway site. SpaceX has also deployed optical inter-satellite links to provide seamless network management and continuity of service while minimizing the spectrum footprint of the system overall and facilitating spectrum sharing with other space-based and terrestrial systems. All backhaul will be consistent with the Gen2 system parameters. A description of the SpaceX TT&C subsystem is provided in the Previous Applications and incorporated by reference.⁸

A.6 Geographic Coverage

As stated in the narrative, SpaceX seeks a waiver to deploy and operate an MSS payload operating in 1.6/2.4 GHz and 2 GHz bands on the initial 7,500 satellites within the Gen2 system while it awaits authorization for the remainder of its proposed constellation. With this initial deployment, SpaceX's MSS system will continuously cover all but the northernmost portion of the United States and will still provide coverage to these northernmost latitudes during parts of the day. At full deployment, the SpaceX MSS system will be capable of providing complete and continuous global coverage, including all locations as far north as 70° North latitude and as far south as 55° South latitude for at least 75% of every 24-hour period; and throughout the continental United States, Alaska, Hawaii, Puerto Rico, and the U.S. Virgin Islands, as required by Section 25.143(b)(2) of the Commission's rules.

A.7 Cessation of Emissions

Each active satellite transmission chain can be individually turned on and off by ground telecommand, thereby causing cessation of emissions from the satellite, as required by Section

⁸ *Id.*

25.207 of the Commission's rules.

A.8 Frequency Tolerance

The carrier frequency of each space station transmitter shall be maintained within 0.002 percent of the reference frequency, as required by Section 25.202(e) of the Commission's rules.

A.9 Mean Power of Emissions

The mean power of emissions will comply with the limits required by Section 25.202(f) of the Commission's rules.

A.10 Interference Analyses

The Commission has recognized that a proposed modification to an NGSO authorization should be granted where it “does not present any significant interference problems and is otherwise consistent with Commission policies.”⁹ As discussed in greater detail below, the advanced capabilities of SpaceX's MSS system, as proposed, will enable effective and efficient spectrum sharing with other licensed users of the bands. Although SpaceX has filed a range of values in the Schedule S to demonstrate the technical capabilities of the system, it anticipates operating within limits set as discussed in the sections below.

SpaceX is confident that the modern communication technologies, sophisticated phased arrays, and advanced beam scheduling protocols included in its MSS system payload will allow it to capably co-exist with other systems without causing harmful interference into any modern, capable, and well-designed satellite or terrestrial system.

⁹ *Teledesic LLC*, 14 FCC Rcd. 2261, ¶ 5 (1999).

MSS Downlink (2483.5-2500 MHz)

The SpaceX MSS system will comply with all relevant power-flux density (“PFD”) limits in Section 25.208(v) for the 2496-2500 MHz band. Between 2483.5 and 2496 MHz, SpaceX requests the authority to operate up to an agreed-upon PFD limit established in good faith coordination with co-frequency MSS operators and in line with the Commission’s original intent to have multiple operators in the band.¹⁰

In addition, SpaceX requests authority to operate up to any future PFD limit, should it be increased through a rulemaking proceeding, processing round, license application, or modification of another MSS operator’s license in the band, or for any other reason.

MSS Uplink (1610-1617.775 MHz)

The SpaceX MSS system will operate up to an agreed upon EIRP limit established in good faith coordination with co-frequency MSS operators and in line with the Commission’s original intent to have multiple operators in this band.¹¹

In addition, SpaceX requests authority to operate up to any future EIRP limit, should it be increased through a rulemaking proceeding, processing round, license application, or modification of another MSS operator’s license in this band, or for any other reason.

MSS Downlink (2180-2200 MHz)

The SpaceX MSS system will operate up to any agreed-upon power-flux density (“PFD”) limits established in good faith coordination with co-frequency MSS operators and in line with the

¹⁰ See *Spectrum and Service Rules for Ancillary Terrestrial Components in the 1.6/2.4 GHz Big Leo Bands/Review of the Spectrum Sharing Plan Among Non-Geostationary Satellite Orbit Mobile Satellite Service Systems in the 1.6/2.4 GHz Bands*, 22 FCC Rcd. 19733, ¶ 4 (2007).

¹¹ *Id.*

Commission's original intent to have multiple operators in the band.¹² SpaceX will also facilitate good faith coordination with other services within the band, including terrestrial operators providing AWS-4 service. In doing so, SpaceX notes that, as required by Section 27.1136 of the Commission's rules, an AWS-4 terrestrial licensee must accept any interference received from authorized MSS systems, and must protect MSS operations in the band from harmful interference.

In addition, SpaceX requests authority to operate up to any future PFD limit should it be increased through a rulemaking proceeding, processing round, license application, or modification of another MSS operator in the band, or for any other reason.

MSS Uplink (2000-2020 MHz)

The SpaceX MSS system will operate up to an agreed upon EIRP limit between co-frequency MSS operators based on good faith coordination and the Commission's original intent to have multiple MSS operators in this band.¹³ SpaceX will also facilitate good faith coordination with other services within the band, including terrestrial operators providing AWS-4 service. In doing so, SpaceX notes that, as required by Section 27.1136 of the Commission's rules, an AWS-4 terrestrial licensee must accept any interference received from authorized MSS systems, and must protect MSS operations in the band from harmful interference.

In addition, SpaceX requests authority to operate up to any future EIRP limit should it be increased through a rulemaking proceeding, processing round, license application, or modification of another MSS operator's license in this band, or for any other reason.

¹² See *Service Rules for Advanced Wireless Services in the 2000-2020 MHz and 2180-2200 MHz Bands*, 27 FCC Rcd. 16102, ¶ 6 (2012).

¹³ *Id.*

MSS Uplink (2020-2025 MHz)

As stated in the narrative, SpaceX seeks a waiver to operate an MSS uplink in the 2020-2025 MHz range consistent with the Kepler/Spire Petition.¹⁴ SpaceX will coordinate its operations with Spire, Kepler, and any other duly authorize operator to ensure harmonized operations in this band and can cease operations should a report of harmful interference occur.

A.11 Coordination with U.S. Government Networks

To the extent necessary, SpaceX will coordinate with the National Telecommunications and Information Administration (“NTIA”) to protect any Federal operations in the MSS bands from harmful interference and to ensure that SpaceX’s operations in these bands are compatible with federal uses.

A.12 ITU Filings for SpaceX

SpaceX has not yet submitted system information for ITU publication. SpaceX will submit this information at the appropriate time to the Commission for filing through the United States and will unconditionally accept all consequent ITU cost-recovery responsibility for the filing.

A.13 Orbital Debris Mitigation

SpaceX hereby incorporates by reference the orbital debris mitigation discussion from its Gen2 system application and authorization, and the SpaceX MSS system will comply with any conditions on the Gen2 system relating to orbital debris mitigation.

¹⁴ SPIRE GLOBAL, INC. & KEPLER COMMUNICATIONS INC., *Petition to Revise Sections 2.106 and 25.142 of the Commission's Rules to Expand Spectrum Availability for Small Satellites by adding Mobile-Satellite Service Allocation in the Frequency Band 2020-2025 MHz*, RM-11869 (filed Oct. 30, 2020) (pending).

ENGINEERING CERTIFICATION

I hereby certify that I am the technically qualified person responsible for preparation of the engineering information contained in this application, that I am familiar with Part 25 of the Commission's rules, that I have either prepared or reviewed the engineering information submitted in this application, and that it is complete and accurate to the best of my knowledge and belief.

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Date