



January 25, 2022

BY ELECTRONIC FILING

Kerry E. Murray
Federal Communications Commission
45 L Street, N.E.
Washington, DC 20554

Re: *IBFS File No. SES-LIC-20210311-00469*

Dear Ms. Murray:

SpaceX Services, Inc. ("SpaceX Services") has filed the above-referenced license application for authority to operate a gateway earth station in Lawrence, KS in the 17.8-18.6 GHz, 18.8-19.3 GHz, 28.35-29.1 GHz, and 29.5-30.0 GHz bands. Authority to operate was granted on 7/19/21.

The 27.5-28.35 GHz band has been designated for use by the Upper Microwave Flexible Use Service ("UMFUS") on a primary basis, with a secondary designation for FSS. The Technical Appendix in this document demonstrates that the Lawrence Gateway will satisfy the criteria set forth in Section 25.136(a)(4) of the Commission's rules, such that it may operate in this band without providing additional interference protection to terrestrial UMFUS systems operating in the band.

SpaceX requests that the above-referenced gateway authorization be modified to permit operation in the 27.5-28.35 GHz frequency band. Apart from the addition of the 27.5-28.35 GHz frequency band, all other technical details previously submitted with this license application remain unchanged. The grant of this modification would improve the quality and quantity of SpaceX's services, which would increase the rate of broadband deployment throughout the United States. Accordingly, an expeditious grant of this application would serve the public interest.

Sincerely,

A handwritten signature in cursive script that reads "David Liptsyn".

David Liptsyn
Starlink Infrastructure Lead

SPACE EXPLORATION TECHNOLOGIES CORP.
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Technical Appendix

Section 25.136(a)(4) of the Commission's rules defines four elements that, if met, permit an earth station licensee to operate without providing additional interference protection to terrestrial systems in the Upper Microwave Flexible Use Service ("UMFUS") operating in the 27.5-28.35 GHz band.¹ As demonstrated below, the Lawrence Gateway satisfies these criteria, and the Commission should authorize this earth station modification without requiring additional protection for future UMFUS systems.

Section 25.136(a)(4)(i)

The Lawrence Gateway complies with this section of the Commission's rules because there are no other earth stations authorized nor pending authorization in the 27.5-28.35 GHz band via CFR 25.136(a) in Leavenworth County, KS.

Section 25.136(a)(4)(ii)

Section 25.136(a)(4)(ii) provides that an earth station operator need not provide interference protection to future UMFUS systems if, in a UMFUS license area with a population between 6,000 and 450,000 people, no more than 450 people will be within the aggregate PFD contour that is equal to or exceeds -77.6 dBm/m²/MHz of all earth stations that are authorized per Section 25.136(a) in that UMFUS license area. The Lawrence Gateway is located in Leavenworth County, which has a population of approximately 81,881 people.² As demonstrated below, the Lawrence Gateway's PFD contour contains fewer than 450 people.

In order to conduct a technical analysis to determine the region around the Lawrence Gateway site that would fall within the PFD contour defined by Section 25.136(a)(4), SpaceX used the Visualyse Professional software tool created by Transfinite Systems Ltd., which implements the standard ITU-R Rec. P.452.16 propagation model.³ SpaceX accounted for clutter using the ITU-R P.452 model, as recommended by the Commission.⁴ The ITU P.452 clutter category used in the analysis for this earth station was found to be the most appropriate category based on satellite and street view imagery in Google Earth, as well as in-person surveys at the proposed earth station location. Details on the clutter category and related assumptions can be found in Table 1 below. Because each of the eight antennas of the Lawrence Gateway would track a different SpaceX satellite, SpaceX first determined the worst-case aggregate EIRP density toward the horizon to be -18.7 dBW/MHz.⁵ Next, SpaceX defined a reference antenna at 10 meters height above ground with 50.24 dBi gain pointed toward the Lawrence Gateway. This is necessary because Visualyse performs its calculations using receive power density rather than

¹ See 47 C.F.R. § 25.146(a)(4).

² See QuickFacts Leavenworth County, KS, United States Census Bureau, <https://www.census.gov/quickfacts/fact/table/leavenworthcountykansas/PST045221>.

³ Information on this software can be found at <https://www.transfinite.com/content/professional>.

⁴ See Report No. SPB-281 (<https://docs.fcc.gov/public/attachments/DA-20-631A1.pdf>).

⁵ This value is based on eight earth station antennas with -8 dBi gain toward the horizon, each operating at -20.7 dBW/MHz EIRP density toward the horizon, based on -19.7 dBW/MHz input power density.

PFD. The 50.24 dBi gain effectively converts the receive power density value to a PFD value so that Visualyse can display the results in terms of PFD.⁶ SpaceX also loaded information on the surrounding terrain at a 3-arc second resolution (approximately 90 meters by 90 meters) from NASA's SRTM Digital Terrain Elevation Data profile, and ran the analysis with the effect of the 11 dB of radiofrequency shielding that SpaceX will install surrounding the site. Table 1 below summarizes the Lawrence Gateway parameters used for the analysis.

With the inputs listed in Table 1 and an omni-directional pattern centered at the gateway site, SpaceX ran the Visualyse software implementing the ITU propagation model to develop a composite (eight-antenna) PFD contour with a threshold of $-107.6 \text{ dBW/m}^2/\text{MHz}$ ⁷ at 10 meters above ground, as required under Section 25.136. The simulation works by moving the reference antenna in small steps all around the area surrounding the Lawrence Gateway to measure the value of received power at each location step. Figure 1 and 2 show the PFD contour as calculated by Visualyse, superimposed on Google satellite imagery.

The PFD contour can also be used with other data sources to determine the population that falls within the contour. SpaceX used 2010 US Census data, and projected the PFD contour onto a map of census blocks. Then SpaceX integrated the share of the population covered by the PFD contour in each block to reach an aggregate figure. Using this approach, the estimated population within the PFD contour is 1.91 people – confirming compliance with the 450-person limit.

⁶ This is the gain of a meter square antenna at 27.5 GHz ($G = 10 \cdot \log_{10}(4\pi/\lambda^2)$), where $\lambda = 1.09 \text{ cm}$ at 27.5 GHz). This is a physical quantity corresponding to an antenna with one-meter square effective area, necessary to convert Visualyse's calculation in terms of receive power density into power flux density.

⁷ This is equivalent to the $-77.6 \text{ dBm/m}^2/\text{MHz}$ value used in Section 25.136(a)(4).

Table 1: Lawrence Gateway Parameters	
Site location	Lawrence, KS
County	Leavenworth County, KS
Site coordinates	39°0'50.0" N, 95°8'57.8" W
Simulation frequency	27.5 GHz
Antenna sidelobe level toward horizon ⁸	-8 dBi
Input power density ⁹	-19.7 dBW/MHz
Number of active antennas	8
Height to midline of antenna	1.7m
ITU P.452 clutter category	Deciduous trees (irregularly spaced)
Nominal Height clutter assumption	15 meters
Nominal Distance clutter assumption	50 meters
Extra site shielding ¹⁰	11 dB
Worst-case aggregate EIRP	-18.7 dBW/MHz

Section 25.136(a)(4)(iii)

The Lawrence Gateway complies with this section of the Commission's rules because its PFD contour does not contain any "major event venue, urban mass transit route, passenger railroad, or cruise ship port." In addition, the PFD contour does not cross any roadways classified as "Other Freeways and Expressways or Other Principal Arterials."

To make the certification regarding roadways, SpaceX uses QGIS software to conduct an analysis of a comprehensive dataset of roadways obtained from the 2017 release of the HPMS¹¹ ARNOLD¹² dataset, belonging to the Federal Highway Administration of the Department of Transportation. To ensure compliance with 47 CFR § 25.136(a)(4)(iii), SpaceX analysis considers the following categories within the dataset: "Interstate," "Principal Arterial – Other Freeways and Expressways," and "Principal Arterial – Other". SpaceX uses QGIS and the

⁸ There have been changes over time in the antenna sidelobe level toward the horizon used in SpaceX's earth station applications. The changes are due to improvements in SpaceX earth station antenna design over time.

⁹ For this application, SpaceX conservatively uses worst-case input power density and does not change maximum power during rain fade conditions. Clear-sky maximum power is the same as during rain fade for this application.

¹⁰ Most ground-based SpaceX earth stations in the US are surrounded with a solid metal panel fence, which is 8 feet in height and is set 11 feet and 6 inches from the centerline of the outermost antennas. Each earth station is analyzed independently to determine the shielding value required to comply with 47 CFR § 25.136(a)(4)(ii) and 47 CFR § 25.136(a)(4)(iii), based on PFD contours. The independent nature of the analysis explains the variation in shielding values between applications. SpaceX installs shielding at all sites with effectiveness equal to or greater than the value required to remain in compliance with 47 CFR § 25.136(a)(4)(ii) and 47 CFR § 25.136(a)(4)(iii).

¹¹ Highway Performance Monitoring System.

¹² All Road Network of Linear Referenced Data.

comprehensive dataset of roadways to ensure that the PFD contour does not cross any roads classified as “Other Freeways and Expressways or Other Principal Arterials.” According to the website from which the dataset is obtained¹³: “[the dataset] derives and is collected from State DOT road data. ARNOLD consists of locations of all roads in the U.S.”

Section 25.136(a)(4)(iv)

The Comsearch Report submitted demonstrates that SpaceX completed coordination in compliance with the Commission’s rules.

¹³ Source: <https://www.bts.gov/geography/geospatial-portal/NTAD-direct-download>.

Figure 1. Wide-area View showing Census Block and County Boundaries

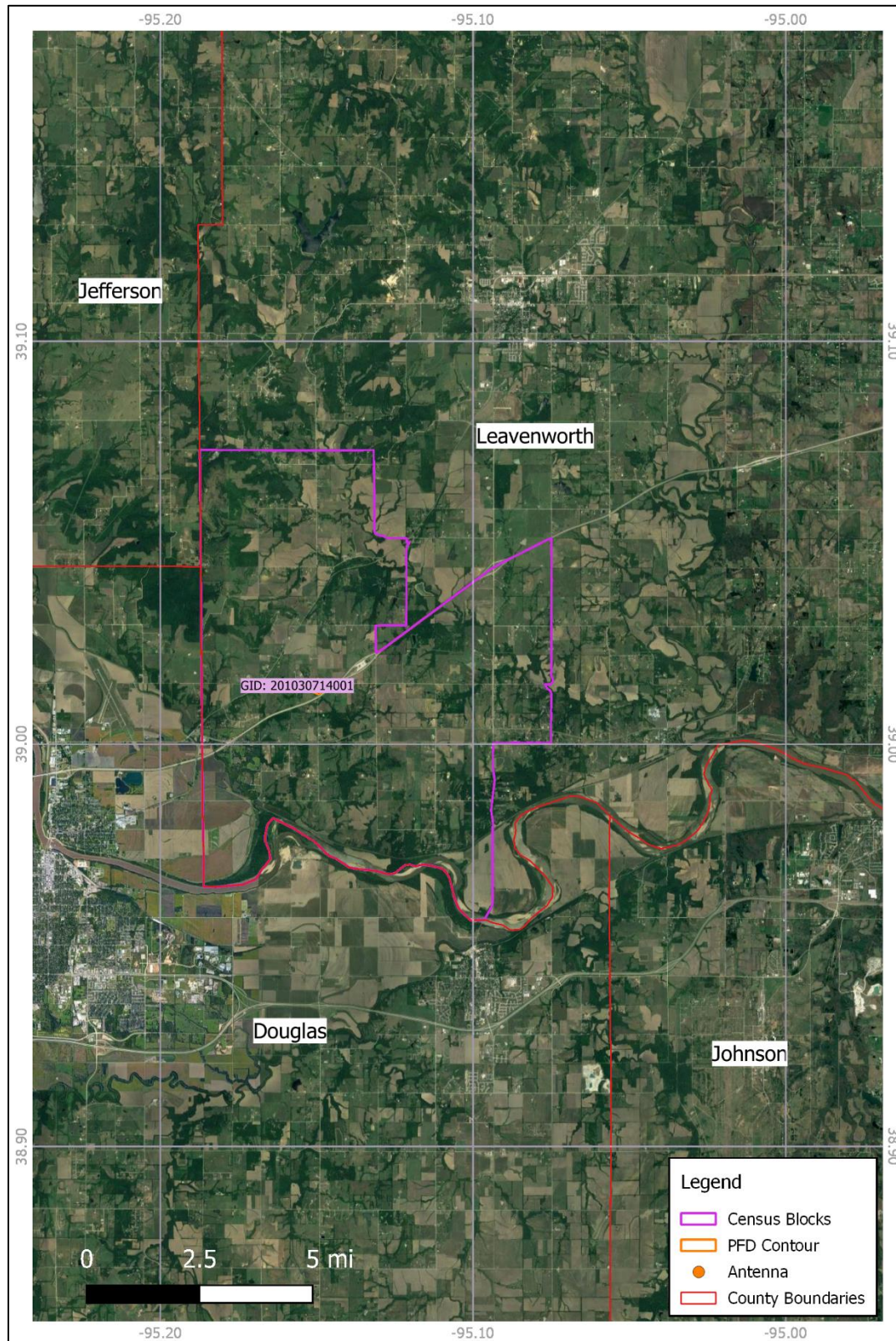


Figure 2. PFD Contour and Population Coverage

