

AMENDMENT

SpaceX Services, Inc. (“SpaceX”), pursuant to Section 25.116 of the Commission’s rules, hereby amends its pending application for authority to operate a Ka-band gateway with eight technically identical 1.5-meter antennas in Greenville, Pennsylvania (the “Greenville Gateway”).¹ SpaceX originally applied for authority to transmit in the 28.35-29.1 GHz and 29.5-30.0 GHz bands and receive in the 17.8-18.6 GHz and 18.8-19.3 GHz bands. However, it deferred in requesting authority to operate this earth station in the 27.5-28.35 GHz band designated for use by the Upper Microwave Flexible Use Service (“UMFUS”) on a primary basis, with a secondary designation for FSS.²

SpaceX has now completed its analysis of the Greenville Gateway site so that it can demonstrate compliance with the requirements of Section 25.136(a)(4) of the Commission’s rules such that its earth station may operate without providing additional interference protection to terrestrial UMFUS systems operating in the band.³ Technical Appendix A hereto demonstrates that the Greenville Gateway will satisfy the criteria set forth in Section 25.136(a)(4). Accordingly, SpaceX is amending its application in order to request authority to transmit in the 27.5-28.35 GHz band pursuant to that rule.

SpaceX also submits with this amendment updated antenna performance information for its gateway operations. SpaceX will comply with a mask similar to the one in Section 25.209(a)(3) applicable to earth station antennas operating in the 24.75-25.25 GHz and 28.35-30.0 GHz bands with geostationary satellites but will improve that pattern to -3 dBi (rather than 0 dBi) beyond 25 degrees off-axis. The mask can be stated as follows:

¹ See Narrative, IBFS File No. SES-LIC-20190906-01170 (filed Sep. 5, 2019).

² See *id.* at 1 and n.3.

³ See 47 C.F.R. § 25.146(a)(4).

$29-25\log_{10}\theta$	dBi	for $2^\circ \leq \theta \leq 7^\circ$.
8	dBi	for $7^\circ < \theta \leq 9.2^\circ$.
$32-25\log_{10}\theta$	dBi	for $9.2^\circ < \theta \leq 25^\circ$.
-3	dBi	for $25^\circ < \theta \leq 180^\circ$.

Consistent with Section 25.209(a)(3), “[t]his envelope may be exceeded by up to 3 dB in 10% of the range of θ angles from ± 7 - 180° , and by up to 6 dB in the region of main reflector spillover energy.”⁴

All other aspects of the original application, including the public interest showing, remain unchanged.

⁴ *Id.* § 25.209(a)(3).

TECHNICAL APPENDIX A: SECTION 25.136(A)(4) UMFUS COORDINATION

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 proposed Greenville Gateway satisfies these criteria, and the Commission should authorize this earth station without requiring additional protection for future UMFUS systems.

1. Section 25.136(a)(4)(i)

The Greenville Gateway complies with this section of the Commission's rules because there are no other earth stations authorized in the 27.5-28.35 GHz band operating in Mercer County, Pennsylvania.

2. 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 earth station's PFD contour that is equal to or exceeds $-77.6 \text{ dBm/m}^2/\text{MHz}$. The Greenville Gateway is located in Mercer County, which has a population of approximately 110,680 people.² As demonstrated below, the Greenville Gateway's PFD contour contains far fewer than 450 people.

In order to conduct a technical analysis to determine the region around the Greenville Gateway site that would fall within the PFD contour defined by Section 25.136(a)(4), SpaceX used

¹ See 47 C.F.R. § 25.146(a)(4).

² See QuickFacts Mercer County, PA, United States Census Bureau, <https://www.census.gov/quickfacts/fact/table/mercercountypennsylvania,US/PST045218>.

the Visualyse Professional software tool created by Transfinite Systems Ltd., which implements the standard ITU-R Rec. P.452.16 propagation model.³ Because each of the eight antennas of the Greenville Gateway would track a different SpaceX satellite, SpaceX first determined the worst-case aggregate EIRP density toward the horizon to be -13.7 dBW/MHz without shielding, or -28.7 dBW/MHz after installing site shielding capable of 15 dB of attenuation.⁴ Next, SpaceX defined a reference antenna at 10 meters height above ground with 50.24 dBi gain pointed toward the Greenville Gateway. This is necessary because Visualyse performs its calculations using receive power density rather than 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.⁵ SpaceX also loaded information on the surrounding terrain at a 1-arc second resolution (approximately 30 meters by 30 meters) from NASA's SRTM Digital Terrain Elevation Data profile, and ran the analysis both with and without including the effect of the 15 dB of radiofrequency shielding that SpaceX will install surrounding the site. Table 1 below summarizes the Greenville Gateway parameters used for the analysis.

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

⁴ This value is based on eight earth station antennas with -3 dBi gain toward the horizon, each operating at -22.7 dBW/MHz EIRP density toward the horizon, based on -19.7 dBW/MHz input power density. SpaceX notes that the earth station input power spectral density used for this calculation is 3.9 dB lower than the maximum provided in the application since the latter includes maximum uplink power control for rain events.

⁵ This is the gain of a meter square antenna at 27.5 GHz ($G = 10 \cdot \log_{10}(4\pi/\lambda^2)$), where $\lambda=1.09$ 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.

Table 1: Greenville Gateway Parameters	
Site address	1020 Methodist Rd, Greenville, PA 16125
County	Mercer County, PA
Antenna coordinates	41.433580°N, 80.333676°W
Simulation Frequency	27.5 GHz
Number of active antennas	8
Antenna sidelobe level toward horizon	-3 dBi
Extra site shielding	15 dB
Worst-case aggregate EIRP	-13.7 dBW/MHz (without site shielding) -28.7 dBW/MHz (after adding site shielding)

With these inputs 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 antennas) PFD contour with a threshold of $-107.6 \text{ dBW/m}^2/\text{MHz}^6$ at 10 meters above ground, as required under Section 25.136. It does so by moving the reference antenna in small steps all around the area surrounding the Greenville Gateway to measure the value of received power at each location step. The resulting contour can be exported as a .kml file for viewing with a range of GIS mapping software. Figure 1 below shows the PFD contour as calculated by Visualyse superimposed on Google Maps, both with shielding (blue) and without (yellow).⁷

⁶ This is equivalent to the $-77.6 \text{ dBm/m}^2/\text{MHz}$ value used in Section 25.136(a)(4).

⁷ Because SpaceX intends to surround the gateway site with 15 dB shielding, the shielded contour is used in determining population coverage.

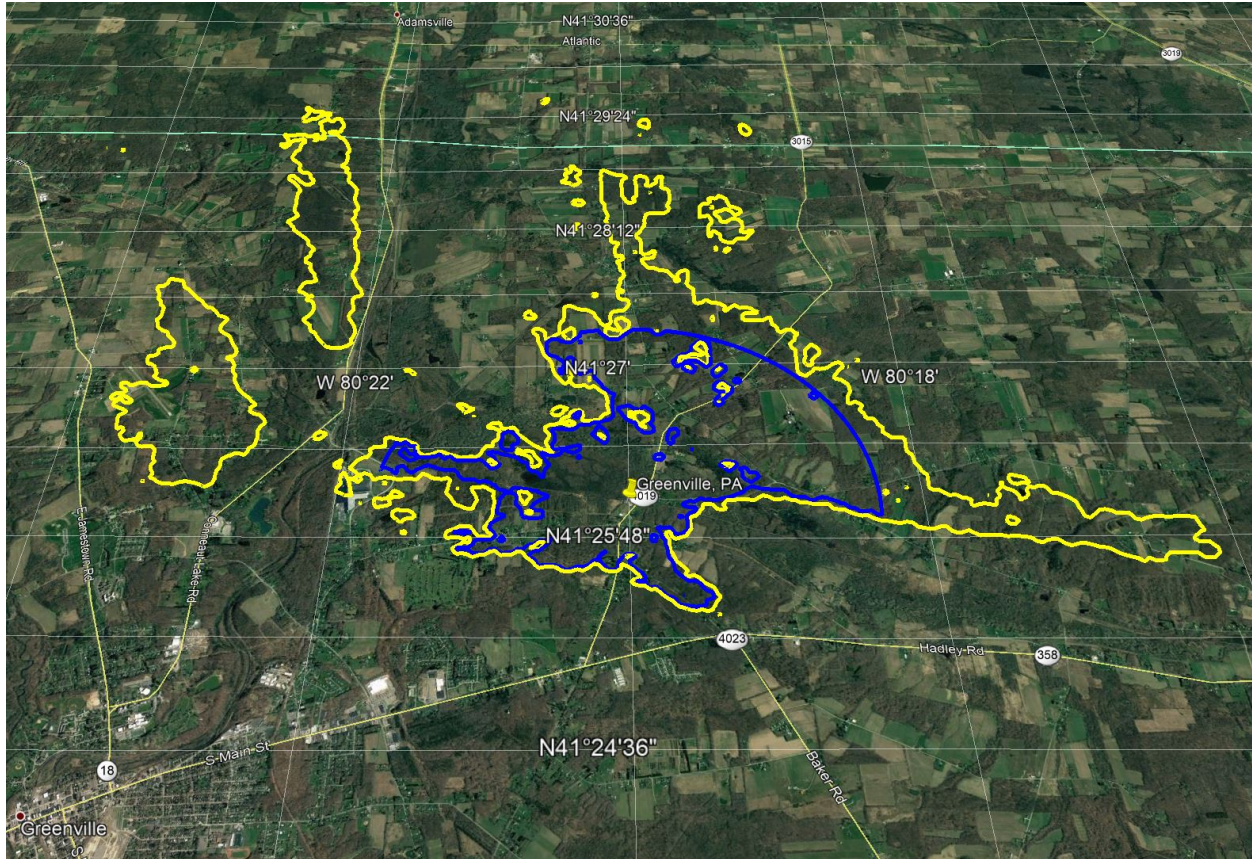


Figure 1. PFD Contours for Greenville Gateway

This PFD contour can also be used with other data sources to determine the population that falls within the contour. For this purpose, SpaceX used two sources for input data. First, it used the most recent version of NASA’s Socioeconomic Data and Applications Center Gridded Population of the World (“GPWv4”).⁸ The GPWv4 data is based on population counts collected at the most detailed spatial resolution available from the results of the 2010 U.S. Census, which is also extrapolated to produce population estimates for 2020. By superimposing the PFD contour on the GPWv4 population distribution grid in Figure 2 below, SpaceX was able to integrate the population contained within the contour using projected 2020 total population with 30 arc-second resolution.

⁸ See NASA Socioeconomic Data and Applications Center, *Gridded Population of the World: Version 4*, <http://sedac.ciesin.columbia.edu/data/collection/gpw-v4/maps/services>.

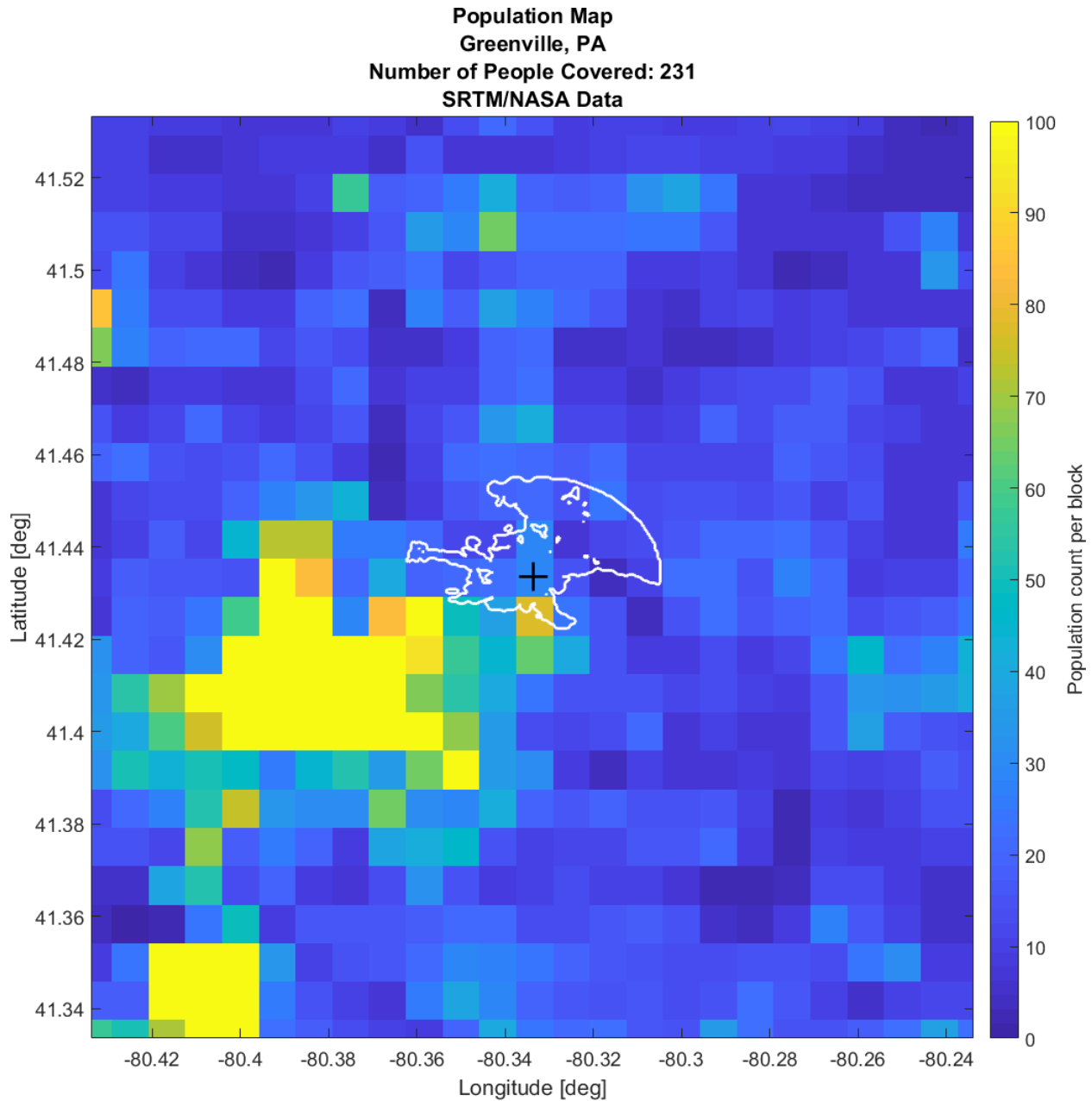


Figure 2. PFD Contour Projected Onto GPWv4 Population Grid

Using this tool, the estimated population within the PFD contour is 231 people – much less than the 450-person limit established in Section 25.136(a)(4)(ii).

Second, SpaceX used data from the 2010 U.S. Census in order to confirm the analysis based on the NASA data above. Here again, SpaceX was able to project the PFD contour onto a map of census blocks as shown in Figure 3 to determine which ones fall partially or totally within

the contour, and then integrate the share of the population covered in each block to reach an aggregate figure.⁹

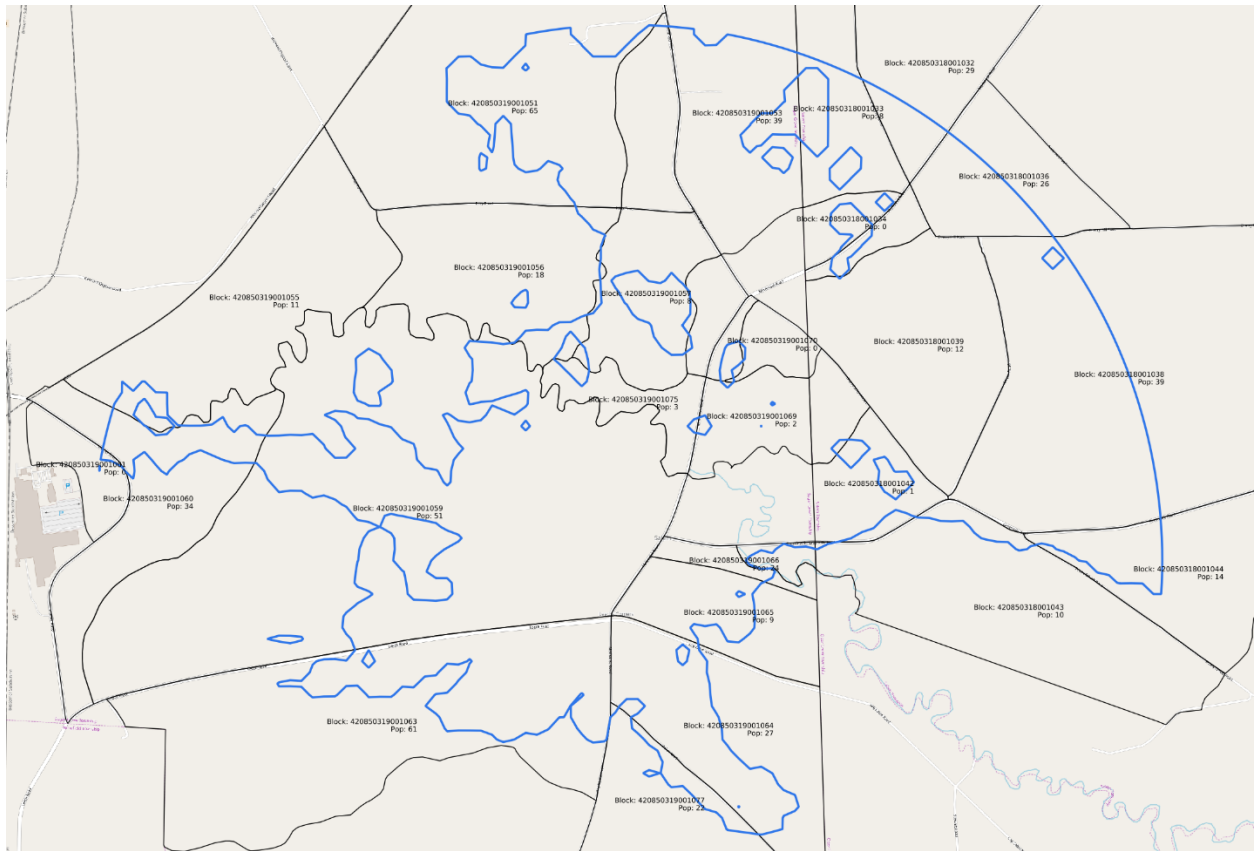


Figure 3. PFD Contour Projected Onto Census Blocks and Population

Using this approach, the estimated population within the PFD contour is 357 people – confirming compliance with the 450-person limit.

⁹ The following census block IDs fall partially or entirely within the PFD contour: 420850318001032; 420850318001033; 420850318001034; 420850318001035; 420850318001036; 420850318001038; 420850318001039; 420850318001040; 420850318001041; 420850318001042; 420850318001043; 420850318001044; 420850318001056; 420850318001057; 420850318001074; 420850319001051; 420850319001053; 420850319001054; 420850319001055; 420850319001056; 420850319001057; 420850319001058; 420850319001059; 420850319001060; 420850319001061; 420850319001063; 420850319001064; 420850319001065; 420850319001066; 420850319001067; 420850319001068; 420850319001069; 420850319001070; 420850319001071; 420850319001072; 420850319001073; 420850319001074; 420850319001075; 420850319001077; 420850319001078; and 420850319001079.

3. Section 25.136(a)(4)(iii)

Based on a search in Google Maps, there are no major event venues, urban mass transit routes, passenger railroads, or cruise ship ports within the Greenville Gateway's PFD contour. Accordingly, the Greenville Gateway complies with the requirements of this subsection.

4. Section 25.136(a)(4)(iv)

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