Section 25.136 Protection Criteria Compliance

SpaceX Services, Inc. ("SpaceX") hereby demonstrates compliance with Sections 25.136(a)-(e) for the proposed earth station gateway site's Ka- and V-band operations, and the Commission should authorize this earth station without requiring additional protection for stations in the Upper Microwave Flexible Use Service ("UMFUS").[1] While the analysis below demonstrates compliance with these rules, recent test data reinforces the Commission's finding that terrestrial UMFUS deployments remain limited and sparse, confined largely to short-range, street-level deployments in dense urban canyons and large indoor venues, where obstructions from the built and natural environment minimize or eliminate interference risk from gateway earth stations.[2] Consequently, SpaceX does not anticipate any meaningful risk of harmful interference from its proposed earth station operations into UMFUS terrestrial operations.

SpaceX has successfully completed frequency coordination for the proposed 27.5-28.35, 37.5-40.0, 47.2-48.2, and 50.4-51.4 GHz band operations in accordance with the Commission's rules.[3] The coordination results can be found in the attachments to this application. Additionally, a search of the International Communications Filing System shows that there are no more than two other authorized earth stations (1) operating in the 27.5-28.35, 37.5-40.0, 47.2-48.2, and 50.4-51.4 GHz bands at the county level and no more than 14 earth stations operating in these frequencies at the Partial Economic Area (PEA) level, and (2) that meet the criteria contained in Sections 25.136(a), (c), (d), and (e).[4]

Analysis Methodology: Ka-band

In accordance with Section 25.136(a), SpaceX conducted a technical analysis and simulation to demonstrate that SpaceX's proposed gateway site will not interfere with UMFUS stations and should be authorized to conduct its Ka-band uplink operations (27.5-28.35 GHz) without providing additional interference protection to UMFUS stations. The site will have up to 40 antennas, each tracking a different SpaceX satellite. For this analysis, SpaceX used the Visualyse Professional software tool created by Transfinite Systems Ltd., which implements the standard ITU-R Rec. P.452.16 propagation and clutter models,[5] consistent with guidance issued by the Commission.[6] The ITU P.452 clutter category used in the analysis for this gateway site 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. SpaceX used the Time-Variant Gain (TVG) method from ITU RR Appendix 7, which calculates the area in which the PFD limit is not exceeded for a certain percentage of time.[7] As each of the 40 antennas at the gateway site would track a different SpaceX satellite, SpaceX determined the aggregate 99th

[1] *See* 47 C.F.R. § 25.136.
[2] *See Mike Dano, A Return to mmWave* 5G, OOKLA (Apr. 13, 2026), https://www.ookla.com/articles/a-return-to-mmwave-5g.
[3] *See* 47 C.F.R. §§ 25.136(a)(4)(iv), (c)(4), (d)(4)(iv), (e)(4)(iv); 101.103(d).
[4] *See id.* at §§ 25.136(a)(4)(i), (c)(1), (d)(4)(i), (e)(4)(i).
[5] Information on this software can be found at https://www.transfinite.com/content/professional.
[6] *See International Bureau Issues Guidance on Siting Methodologies for Earth Station Seeking to Operate in the 24.75-25.25 GHz, 27.5–28.35 GHz, 37.5–40 GHz, 47.2-48.2 GHZ, and 50.4-51.4 GHz Frequency Bands to Demonstrate Compliance with Section 25.136*, Public Notice, 35 FCC Rcd. 6347 (IB 2020) ("UMFUS Guidance").
[7] The TVG method has previously been approved by FCC for SES-LIC-20180727-02075; SpaceX has elected to use a conservative value of 99% for this percentage.

percentile EIRP density for the given azimuth angle between the SpaceX site and the incumbent receiver. Next, SpaceX defined a reference antenna at 10 meters above ground with 50.24 dBi gain pointed toward the gateway site. This is necessary because SpaceX proprietary software 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 results can be displayed in terms of PFD.[8] 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. Table 1 below summarizes the parameters used for this analysis.

Table 1. Gateway Parameters: Ka-band	
Site Coordinates	39.555065, -94.564923
Simulation Frequency	27.5 GHz
Number of Active Antennas	40
Reference Antenna Gain	50.24 dBi
Power Flux Density (PFD) Threshold	-107.6 dBW/m^2/MHz
Aggregate Effective Isotropic Radiated Power (EIRP) Towards the Horizon	-7.9 dBW/MHz
Clutter Model (ITU P.452)	Deciduous

Using the parameters above and an omni-directional pattern centered at the gateway site, and in accordance with Section 25.136(a), SpaceX generated a composite PFD contour with a threshold of -107.6 dBW/m^2/MHz[9] at 10 meters above ground level, as shown below in Figure 1 and Tables 2 and 3. The simulation works by moving the reference antenna in small steps all around the area surrounding the gateway site to measure the value of received power at each location step.

Then, using 2020 U.S. Census county population data[10] and the actual area method,[11] SpaceX estimated the aggregate population that falls within the PFD contour of the gateway site and compared that estimate to the values provided in Section 25.136(a)(4)(ii). As shown in Tables 2 and 3 below, the PFD contour contains approximately 126.1 people or 0.6% of the total county population, which is under the threshold of 450 people in Clinton County, MO. This threshold is based on a population of 21,184 people in Clinton County. Additionally, SpaceX used the HEPGIS National Highway System Map and comprehensive data sets of state roadways and maps to confirm that the PFD contour does not contain any "major event venue, urban mass transit route, passenger railroad, or cruise ship port," or cross any roadways classified as "Other Freeways and Expressways or Other Principal Arterials," as required under Section 25.136(a)(4)(iii).[12]

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[8] This is the gain of a meter square antenna at 27.5 GHz (G = 10*log10(4π/λ^2)), where λ=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 receive power density into power flux density.

[9] This is equivalent to the -77.6 dBm/m^2/MHz value used in Sections 25.136(a)(4), (d)(4), and (e)(4).

[10] U.S. Census 2020 county population data retrieved from the U.S. Census Bureau's "QuickFacts" database. *See QuickFacts: United States*, U.S. CENSUS BUREAU, https://www.census.gov/quickfacts/fact/table/US/.

[11] *See* UMFUS Guidance at 4.

[12] *See National Highway System Map*, FEDERAL HIGHWAY ADMINISTRATION, https://hepgis-usdot.hub.arcgis.com/pages/852f56ef5f624811bc231aed6da8d718; *MO MoDOT Functional Classes*, MISSOURI DEPARTMENT OF TRANSPORTATION, https://data-msdis.opendata.arcgis.com/datasets/9e9b20e04bfe4a41b41c832a3e6e6375_0/explore?location=39.619278%2C-94.596063%2C18 (last accessed August 3, 2026).

Figure 1. PFD Contour for the Gateway: Ka-band

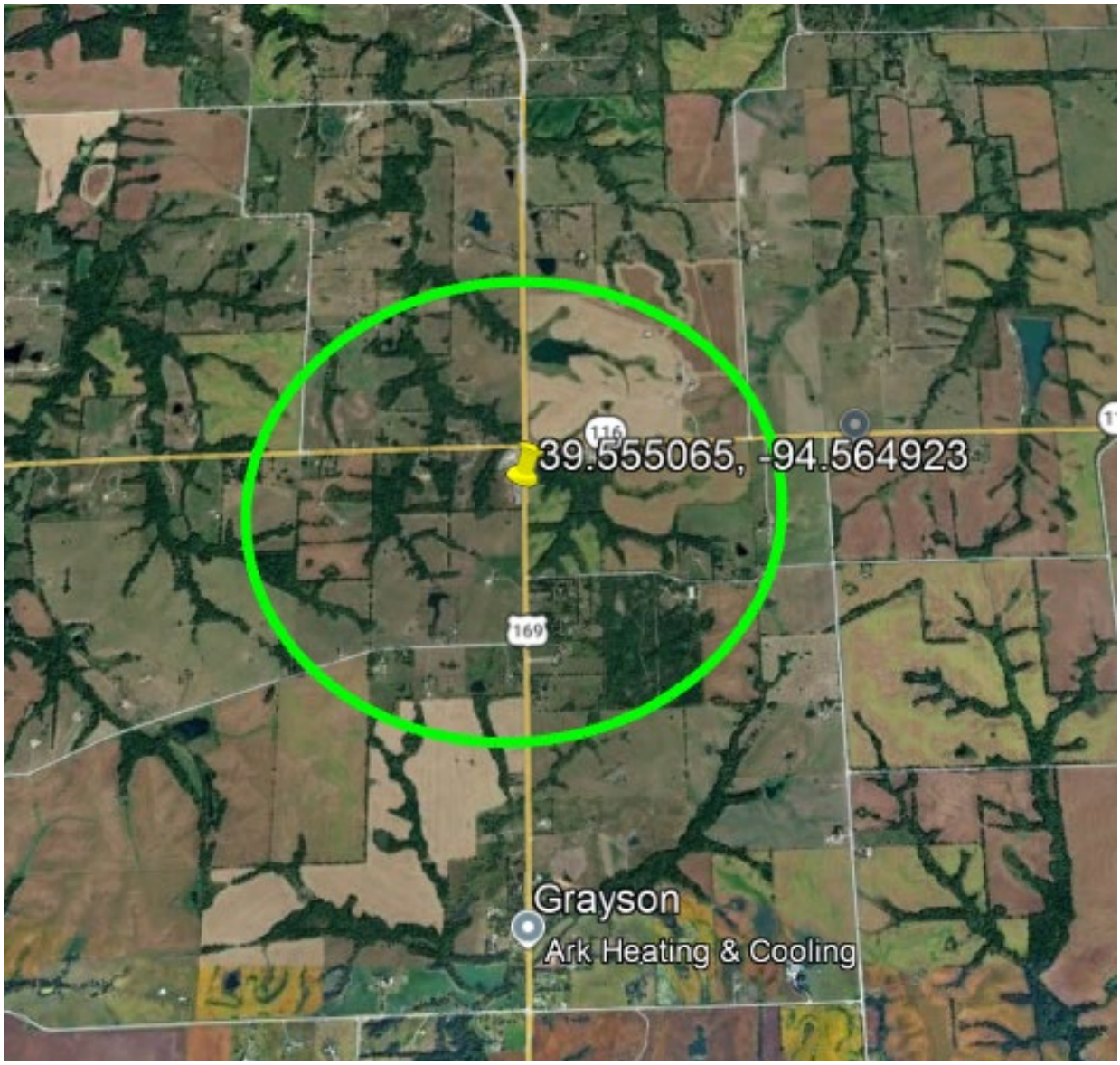

Table 2. PFD Contour Summary: Ka-band	
PFD contour area covered	6.531 km^2
Does PFD contour overlap with Section 25.136(a) infrastructure?	No
Aggregate population within PFD contour	126.1 people

Table 3. PFD Contour Population Coverage: Ka-band

Area	Area ID	Area Population	Aggregate population within PFD contour	Compliant with Section 25.136(a)
County	Clinton County, MO	21,184	126.1 people	True

V-band Protection Zone:

In accordance with Sections 25.136(b) and (c), SpaceX generated a zone using reasonable engineering methods within which the earth station will require protection from transmissions of UMFUS licensees by simulating an UMFUS base station in the 37.5-40.0 GHz band using the parameters in Table 4. For this analysis, SpaceX used the Visualyse Professional software tool created by Transfinite Systems Ltd., which implements the standard ITU-R Rec. P.452.16 propagation and clutter models,[13] consistent with guidance issued by the Commission.[14] The ITU P.452 clutter category used in the analysis for this gateway site 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. 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. To generate the protection zone, first, SpaceX defined a grid with the earth station gateway site located at the grid center. Then, SpaceX defined a reference UMFUS base station transmitter with a base station EIRP value of -1.9 dBW/MHz. The simulation works by moving the reference UMFUS base station transmitter in small steps all around the grid surrounding the gateway site to measure the interference-to-noise ratio ("I/N") at each location step. SpaceX compared the measured I/N to an acceptable I/N threshold to determine the distance needed to generate the protection zone around the earth station gateway site. Table 4 below summarizes the parameters used for this analysis.

Table 4. Protection Zone Parameters	
Base Station EIRP	-1.9 dBW/MHz
Gateway Receive Gain Toward Horizon	0 dBi
Gateway TSYS	300 K
Acceptable I/N	-6.0 dB
Terrain	NASA SRTM
Clutter Model (ITU P.452)	Deciduous

Using the parameters above, and in accordance with Section 25.136(c), SpaceX generated a protection zone with an acceptable I/N threshold of -6.0 dB, as shown below in Figure 2 and Tables 5 and 6.

Then, using 2020 U.S. Census county population data,[15] the Commission's Partial Economic Areas (PEA)[16], and the actual area method,[17] SpaceX estimated the aggregate population that falls within the protection zone and compared that estimate to the values provided in Section 25.136(c)(2). As shown in Tables 5 and 6 below, the protection zone contains

[13] Information on this software can be found at https://www.transfinite.com/content/professional.

[14] *See International Bureau Issues Guidance on Siting Methodologies for Earth Station Seeking to Operate in the 24.75-25.25 GHz, 27.5–28.35 GHz, 37.5–40 GHz, 47.2-48.2 GHZ, and 50.4-51.4 GHz Frequency Bands to Demonstrate Compliance with Section 25.136*, Public Notice, 35 FCC Rcd. 6347 (IB 2020) ("UMFUS Guidance").

[15] U.S. Census 2020 population data retrieved from the U.S. Census Bureau's "QuickFacts" database. *See QuickFacts: United States*, U.S. CENSUS BUREAU, https://www.census.gov/quickfacts/fact/table/US/.

[16] To estimate the 2020 PEA population, SpaceX aggregated the U.S. Census 2020 county population data of each county within the PEA. *See FCC Areas*, FEDERAL COMMUNICATIONS COMMISSION, https://www.fcc.gov/oet/maps/areas.

[17] *See* UMFUS Guidance at 4.

approximately 17.7 people or 0.01% of the population in PEA 299 Kirksville, MO, which is under the threshold of 2,250 people in PEA 299. This threshold is based on a population of 137,783 people in PEA 299 Kirksville, MO. Additionally, SpaceX confirmed that the protection zone does not contain any "major event venue, urban mass transit route, passenger railroad, or cruise ship port," or cross any roadways classified as "Other Freeways and Expressways or Other Principal Arterials," as required under Section 25.136(c)(3), using the same methodology described above for its Ka-band analysis.

Figure 2. Protection Zone Contour

Table 5. Protection Zone Summary	
Protection zone area covered	2.418 km^2
Does protection zone overlap with Section 25.136(c) infrastructure?	No
Aggregate population within protection zone	17.7 people or 0.01%

Table 6. Protection Zone Contour Population Coverage: V-band				
Area	**Area ID**	**Area Population**	**Aggregate population within protection zone**	**Compliant with Sections 25.136(b), (c)**
Partial Economic Area (PEA)	PEA 299 Kirksville, MO	137,783	17.7 people or 0.01%	True

Analysis Methodology: V-band

In accordance with Sections 25.136(d) and (e), SpaceX conducted a technical analysis and simulation to demonstrate that SpaceX's proposed gateway site will not interfere with UMFUS stations and should be authorized to conduct its V-band uplink operations (47.2-48.2 and 50.4-51.4 GHz) without providing additional interference protection to UMFUS stations. SpaceX used the same methodology described above for its Ka-band analysis with the revised parameters shown below in Table 7.

Table 7. Gateway Parameters: V-band	
Site Coordinates	39.555065, -94.564923
Simulation Frequency	47.2 GHz, 50.4 GHz
Number of Active Antennas	40
Reference Antenna Gain[18]	54.93 dBi, 55.50 dBi
Power Flux Density (PFD) Threshold	-107.6 dBW/m^2/MHz
Aggregate Effective Isotropic Radiated Power (EIRP) Towards the Horizon	-12.6 dBW/MHz
Clutter Model (ITU P.452)	Deciduous

Using the parameters above and an omni-directional pattern centered at the gateway site, and in accordance with Sections 25.136(d) and (e), SpaceX generated PFD contours for the listed frequencies with a threshold of -107.6 dBW/m^2/MHz at 10 meters above ground level, as shown below in Figures 3 and 4, and Tables 8, 9, and 10.

Then, SpaceX estimated the aggregate PEA and county populations that fall within the PFD contours of the gateway site using the same methodologies described above and compared the estimated PEA and county populations to the values provided in Sections 25.136(d)(4)(ii) and (e)(4)(ii), respectively. As shown in Tables 8 and 10 below, the 47.2 GHz PFD contour contains approximately 17.4 people or 0.01% of the total PEA population, which is under the threshold of 2,250 people in PEA 299 Kirksville, MO. This threshold is based on a population of 137,783 people in PEA 299. Additionally, the 50.4 GHz PFD contour contains approximately 44.5 people or 0.2% of the total county population (*see* Tables 9 and 10), which is under the threshold of 450 people in Clinton County, MO. This threshold is based on a population of 21,184 people in Clinton County. Additionally, SpaceX confirmed that these PFD contours do not contain any "major event venue, urban mass transit route, passenger railroad, or cruise ship port," or cross any roadways classified as "Other Freeways and Expressways or Other Principal Arterials," as required under Sections 25.136(d)(4)(iii) and (e)(4)(iii), using the same methodology described above for its Ka-band analysis.

[18] These values are the gain of a meter square antenna at 47.2 GHz and 50.4 GHz ($G = 10*\log10(4\pi/\lambda^2)$), where λ=0.635 cm at 47.2 GHz and λ=0.595 cm at 50.4 GHz. This is a physical quantity corresponding to an antenna with one-meter square effective area, necessary to convert receive power density into power flux density.

Figure 3. PFD Contour for the Gateway: V-band (47.2 GHz)

Table 8. PFD Contour Summary: V-band (47.2 GHz)

PFD contour area covered	2.369 km^2
Does PFD contour overlap with Section 25.136(d) infrastructure?	No
Aggregate population within PFD contour – PEA	17.4 people or 0.01%

Figure 4. PFD Contour for the Gateway: V-band (50.4 GHz)

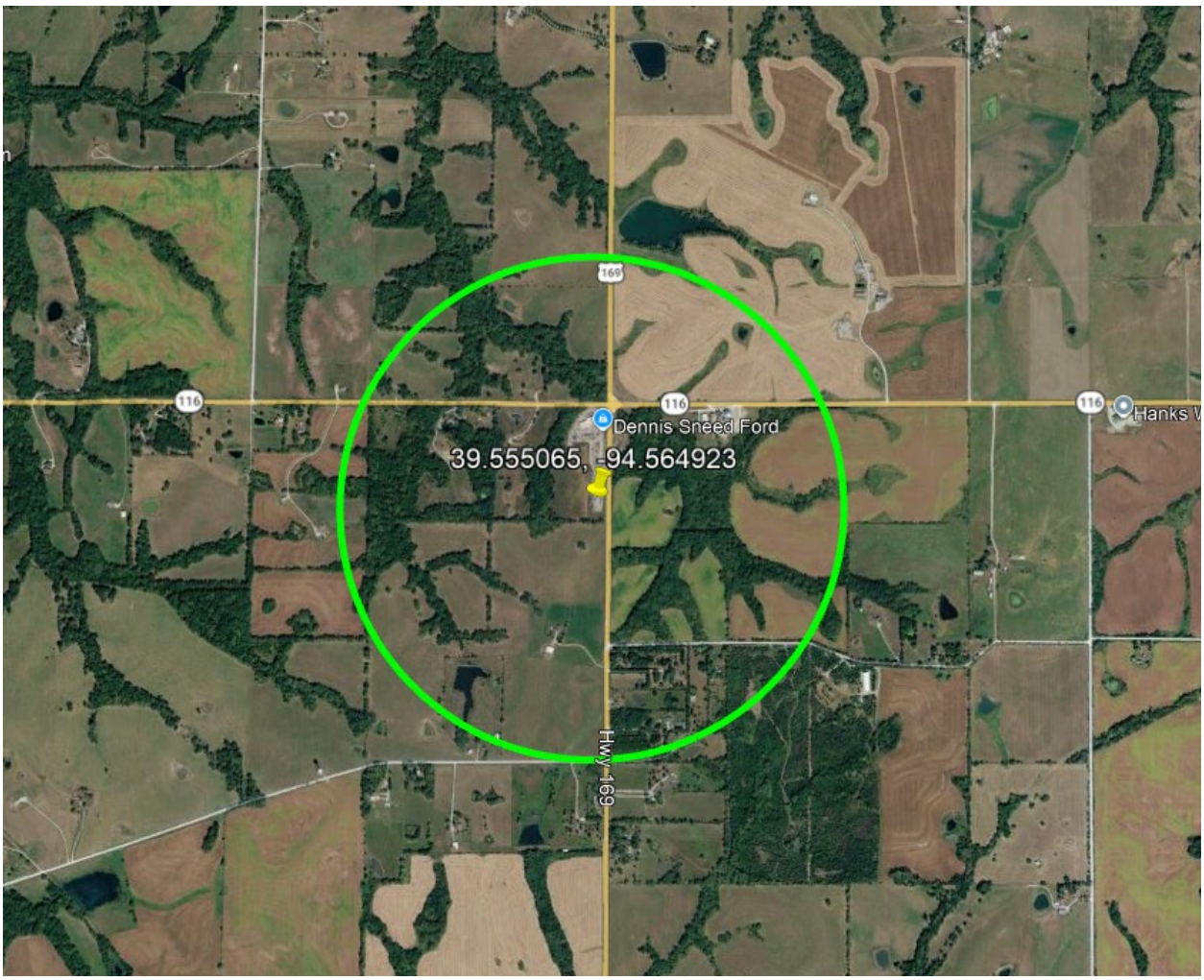

Table 9. PFD Contour Summary: V-band (50.4 GHz)

PFD contour area covered	2.306 km^2
Does PFD contour overlap with Section 25.136(e) infrastructure?	No
Aggregate population within PFD contour - County	44.5 people or 0.2%

Table 10. PFD Contour Population Coverage: V-band

Relevant Frequency	Area	Area ID	Area Population	Aggregate population within PFD contour	Compliant with Sections 25.136(d), (e)
47.2 GHz	Partial Economic Area (PEA)	PEA 299 Kirksville, MO	137,783	17.4 people or 0.01%	True
50.4 GHz	County	Clinton County, MO	21,184	44.5 people or 0.2%	True