

Interference Analysis for the “Meshbed” Satellite

Updated for STA 1560-EX-ST-2019

Mission Summary

The Meshbed satellite is a 3U CubeSat architecture and will be launched on an Indian Space Research Organization (ISRO) Polar Services Launch Vehicle (PSLV) tail number C47. The mission is for Meshbed to act as an on-orbit RF test and technology demonstration platform. Meshbed has two independent RF subsystems: a dipole UHF tape spring antenna connected to the primary radio used for tracking, telemetry and control (TT&C) at 401.3 MHz communicating with the ground station in Windham, NY, and a wideband Active Electronically Scanned Array (AESA) antenna connected to a wideband software defined radio to be operated at 2.4225 GHz, 5.295 GHz and 5.515 GHz during test campaign operations to the ground station in Bedford, MA.

Summary of Spacecraft Orbit and RF Details

- Launch Date: NET October 30, 2019
- Altitude: 505 km \pm 20 km (3-sigma tolerance)
- Inclination: 97.48 degrees \pm 0.2 degrees (3-sigma tolerance)
- Local Time of Descending Node: 10:30 -0/+15 min (3-sigma tolerance)

Table 1 - Space to Earth transmission details

Beam Name	Lower Frequency (MHz)	Center Frequency (MHz)	Upper Frequency (MHz)	Bandwidth (kHz)
TT&C	401.275	401.3	401.325	25
S-Band	2395	2422.5	2450	55,000
C-Band 1	5270	5295	5320	50,000
C-Band 2	5490	5515	5540	50,000

Summary of Analysis

This report analyzes each of Meshbed’s four transmission beams to determine their potential for causing interference to national and international radio operations. This report includes the noise falloff, transmit power, and geographic analysis for all four beams. The resulting noise and power signature for each of the beams defines the range of potential interference stakeholders.

For our TT&C beam, we identified and coordinated with the closest interference stakeholder. After finding there would be no interference with them, we concluded that stakeholders further away would similarly experience no interference.

The S-Band beam and the two C-Band beams create worst-case noise footprints closely constrained to central New England, providing clear parameters for stakeholder search. The S-Band FCC database search revealed several stakeholders within the reasonable noise footprint. After communicating with each stakeholder, we completed coordination of our operations and determined no interference. For the C-Band search, we found no interference stakeholders within the footprint area. The closest C-Band interference stakeholder identified operates nearly 240 km away from the outermost edge of the beam, and so we conclude there will be no interference.

Timeouts and Deployment

Clearance of Meshbed to Integrate and Launch

Pursuant to the launch provider flight requirements document signed and dated March 13, 2019 by both ASI and the provider, Spaceflight, Inc. (SFI), the Meshbed spacecraft frequencies described herein have been supplied to SFI for analysis and cross reference against other payloads on the flight. Given the frequencies and powers provided, Meshbed has been cleared to launch and deploy with all other primary and secondary payloads upon the ISRO PSLV C47 launch. Deployment cadence of secondary payloads and exact separation timing are not shared with ASI. A detailed separation report will be provided within 90 minutes of separation from the launch vehicle and insertion into the mission orbit.

Separation Timing and Early Operations

Meshbed is designed to delay for no less than 30 minutes after separation from the launch vehicle before transmitting or receiving on the TT&C link. The TT&C link is low power at 0.543 dBW ERP, and based on the following analysis is not anticipated to interfere with Earth based operations.

The S-Band, C-Band 1, and C-Band 2 links shall remain unpowered until the early orbit checkout mission phase is completed. This checkout phase will consist of spacecraft on orbit verification testing and attitude control calibration and will occupy the first two to four weeks of the mission. These verification and calibration tests must be executed prior to the use of the S and C-Band links in order to ensure proper body and antenna pointing control, given the highly directional and high gain nature of the S and C-Band links.

Transmit Description - TT&C Link

Transmit frequency: 401.30 MHz

Transmitter bandwidth: 25 kHz

Maximum ERP: 31 dBm

Adjacent channel power (using GFSK and 25 kHz spacing) is typically -50 dBc, with a maximum adjacent power of -45 dBc.

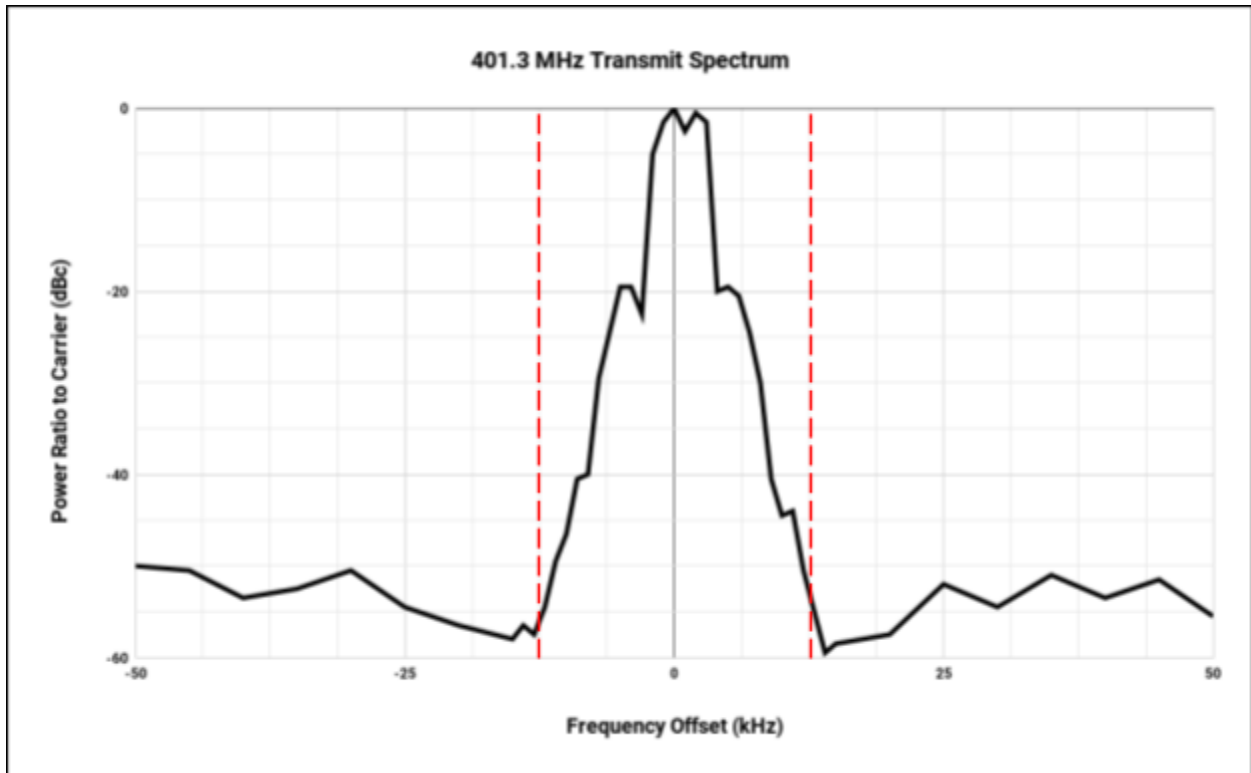


Figure 1 - Meshbed transmit spectrum efficiency. Red lines denote the 25 kHz bandwidth designation around 401.3 MHz.

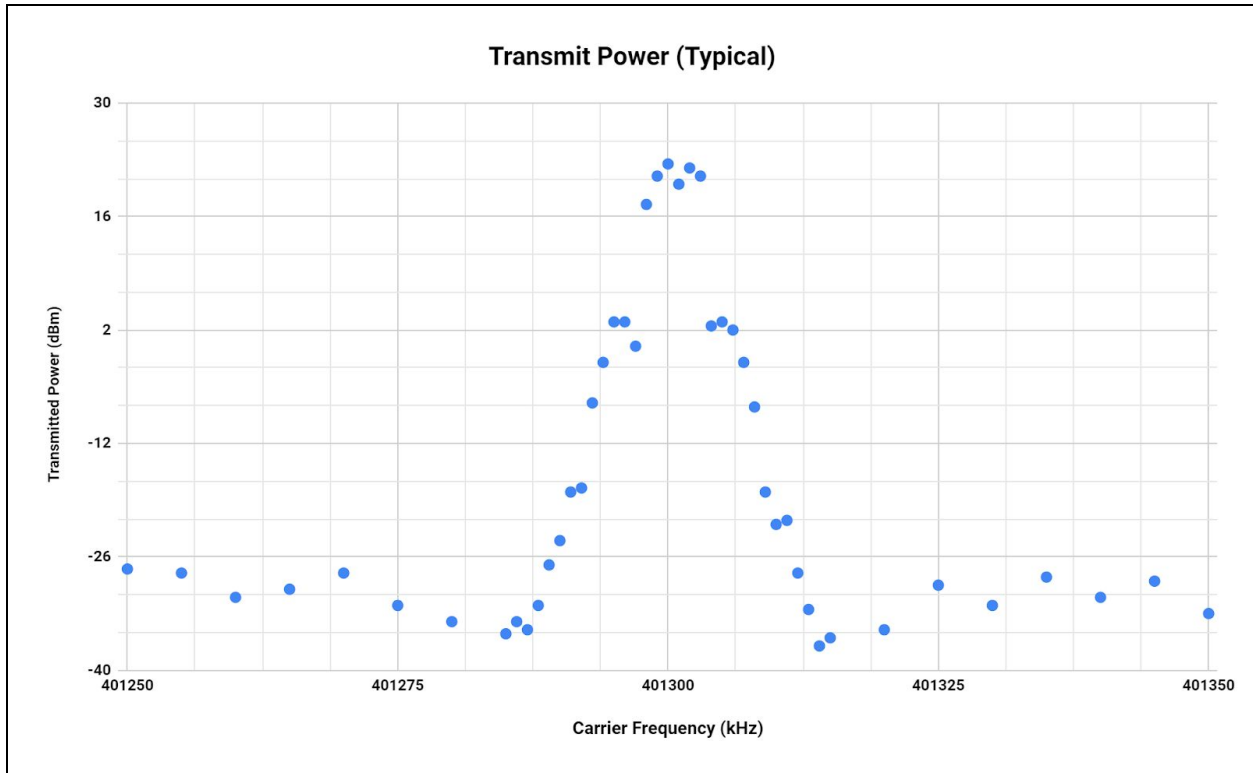


Figure 2 - Meshbed transmit power near 401.3 MHz.

Relevant Power and Power Flux Density Metrics

Transmit power at the antenna outside of the specified transmission band is at or below -27 dBm for all other frequencies. Furthermore, at the mission orbital altitude, all frequencies outside of the transmission band will be at or below a power flux density of -182 dB W/m² at Earth's surface when the spacecraft is directly overhead.

Domestic Operator Search

Relative to the primary ASI-use ground station in Windham, NY, the nearest ground station licensed to operate within the frequency of concern is located at Dublin, Ohio (see FCC file number SES-AMD-20181219-03513 and call sign E181423). At nearly 800 km separation distance, the power flux density will be at or below -112.9 dBm within the frequency band of concern when communication space-to-Earth or Earth-to-space at Windham. After coordinating with that operator, we conclude that this operation does not involve an earth-based receiver in this frequency range, and therefore expect no interference. The next closest ground stations operating in the frequency are in Louisiana and North Dakota, 1,800 km away.

International Operator Search

The TT&C 401.3 MHz downlink beam can bleed over national borders into Canada. We carried out a broad search to find stations to coordinate with.

ITU Radiocommunication

Space Network Systems Online

Special Query System: List of earth stations operating with geostationary and non-geostationary satellites in the frequency range from 401 MHz to 402 MHz and longitude range from -60 to -110 (for geostationary satellites)

beams: emission&reception

?

Export result of the query to:

[MSACCESS](#) [EXCEL 3.0](#)

table/worksheet:
freqrange_earth

STATION NAME	LONGITUDE	LATITUDE	SATELLITE NAME	POSITION	ADM	CATEGORY
TOTAL: 0						

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Revised: 21 March 2019

International Telecommunication Union, 1996-2008

Figure 3 - Search criteria for international ground stations and results.

After a frequency search for all ITU registered ground stations in Canada over the Space Network Systems database, there are no Earth based operators in Canada licensed for 401.3 MHz, and we therefore conclude there will be no interference.

Transmit Description - S-Band Link

Transmit center frequency: 2.4225 GHz

Transmitter allotted bandwidth: 55 MHz

Maximum ERP: 40 dBm

Modulation type: Binary CPFSK

Figure 4 below shows output measured from the Meshbed SDR for a typical waveform representative of the S-Band beam, centered here at 2.45 GHz.

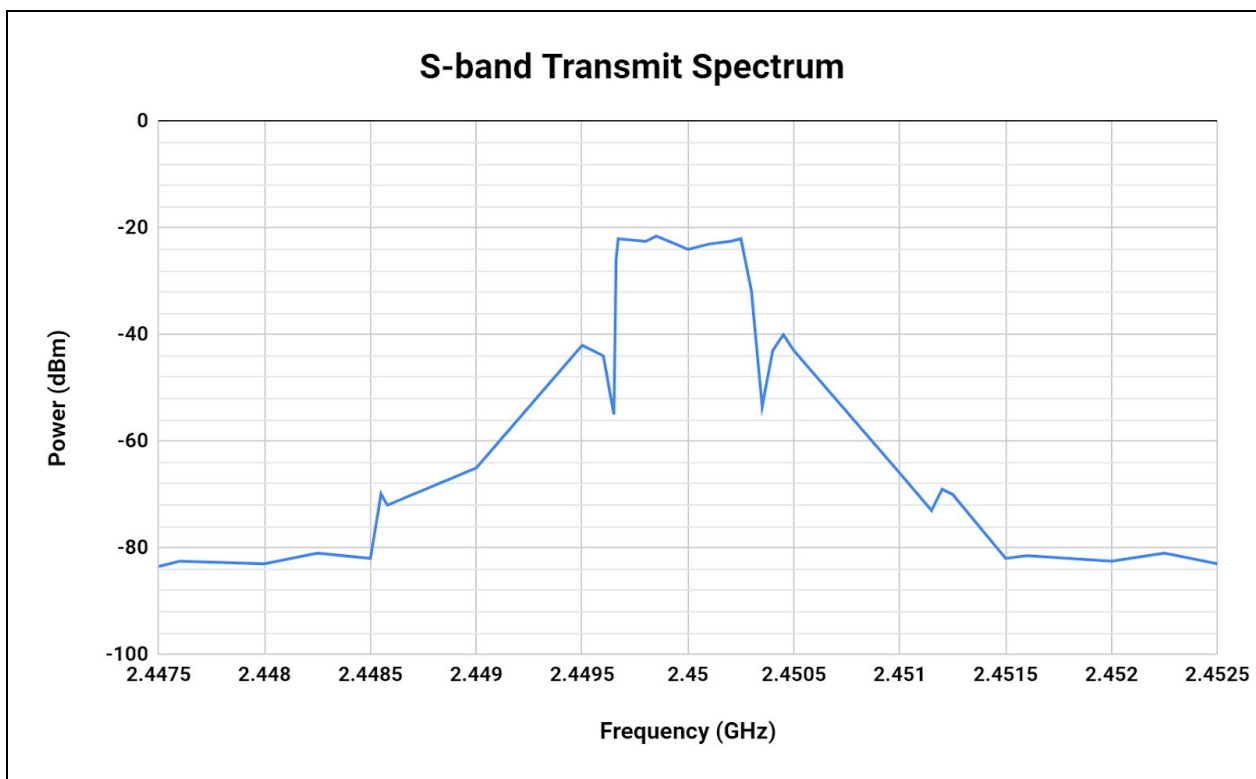


Figure 4 - SDR sample output power, centered at 2.45 GHz, prior to amplification and gain.

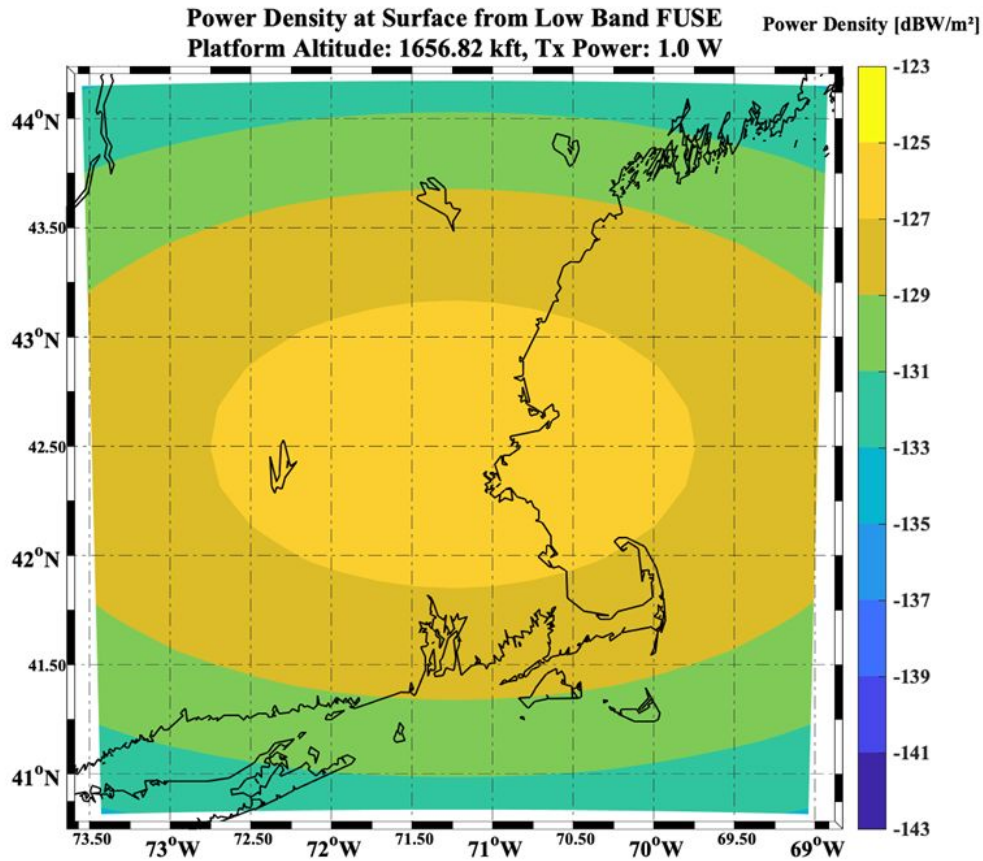


Figure 5 - Footprint overlay analysis for the S-Band beam with power density.

The worst-case interference footprint of the S-Band (2.4 GHz) beam can be represented as an ellipse bounded by latitudes ~41.30°N and ~43.60°N and longitudes ~68.50°W and ~74.00°W, outside of which the power density is less than -130 dBW/m².

Domestic Operator Search

The FCC database search revealed several licensed operators within the potential interference area: BAE systems Callsign: WH2XZR, Collision Communications Callsign: WJ2XFF, MIT Lincoln Laboratory Callsign: WK2XIW, Raytheon Callsigns WF2XLB and WH2XPR, and Sony Mobile Communications Callsign: WO9XZQ. We have communicated and exchanged operational parameters with each of these operators, and have mutually concluded that there will be no interference between our operations.

International Operator Search

Since the S-Band footprint does not bleed over national borders, we conclude that there are no international interference stakeholders.

Transmit Description - C-Band Link

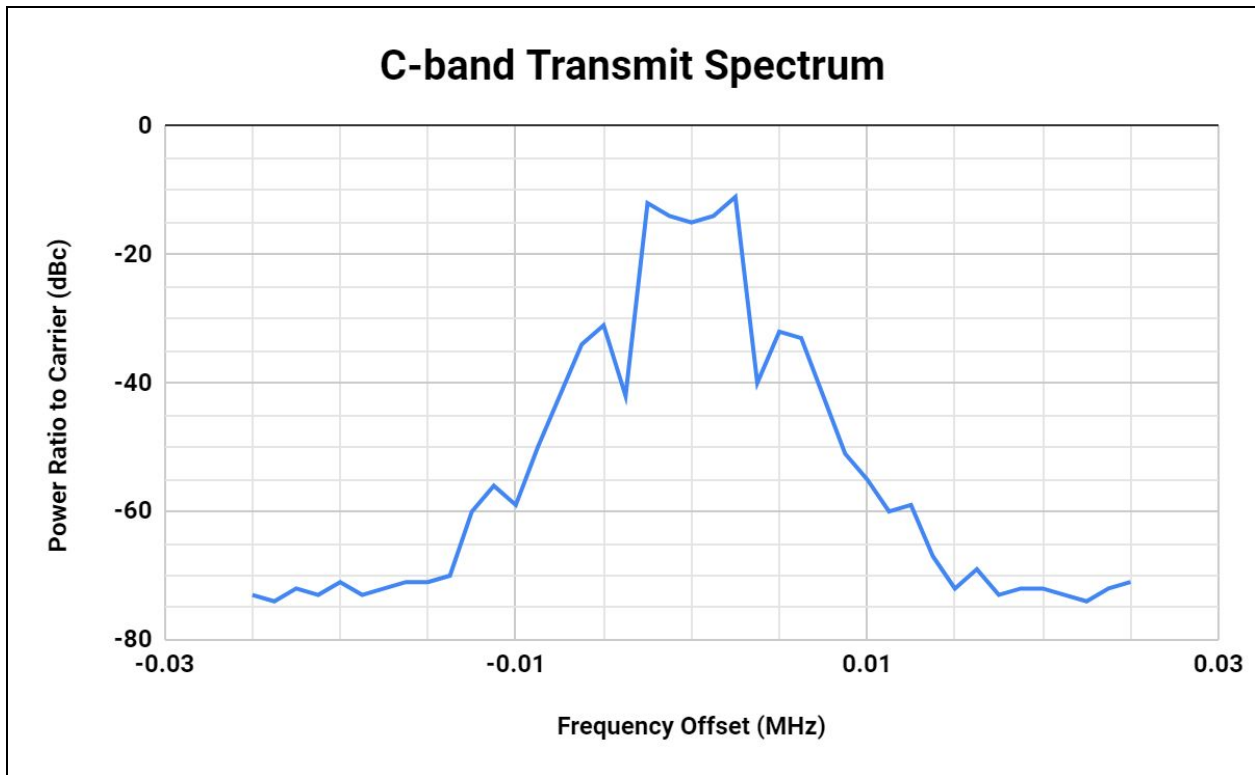


Figure 6 - General C-Band output power ratio from satellite SDR, centered at 5 GHz.

Figure 6 above represents the general transmit power efficiency of the spacecraft SDR for the two C-Band beams. Although the C-Bands differ from each other in center frequency, they are nearly identical in terms of transmit power efficiency and bandwidth. Following is the analysis for each C-Band individually.

Transmit Description - C-Band 1

Transmit frequency: 5.295 GHz
Transmitter allotted bandwidth: 50 MHz
Maximum ERP: 41 dBm
Modulation type: Binary CPFSK

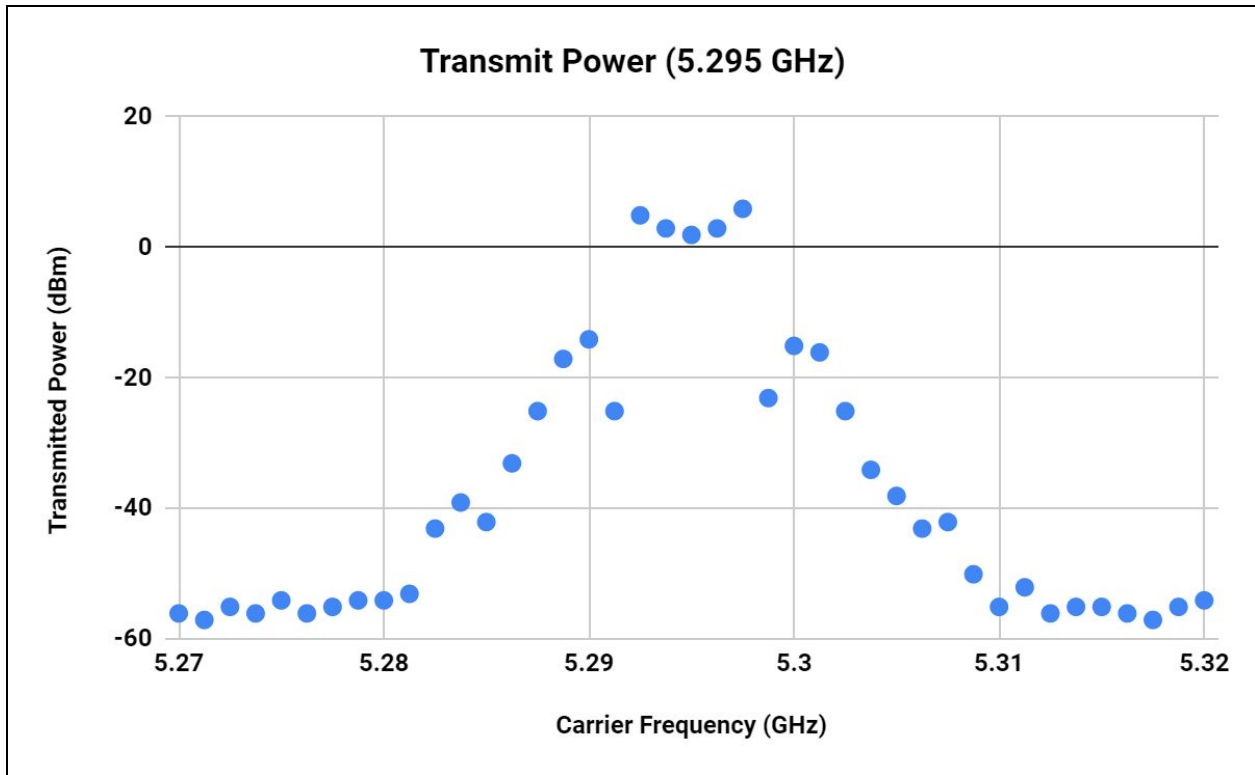


Figure 7 - Specific Meshbed C-Band 1 output power from satellite with typical realized gain from powered antenna.

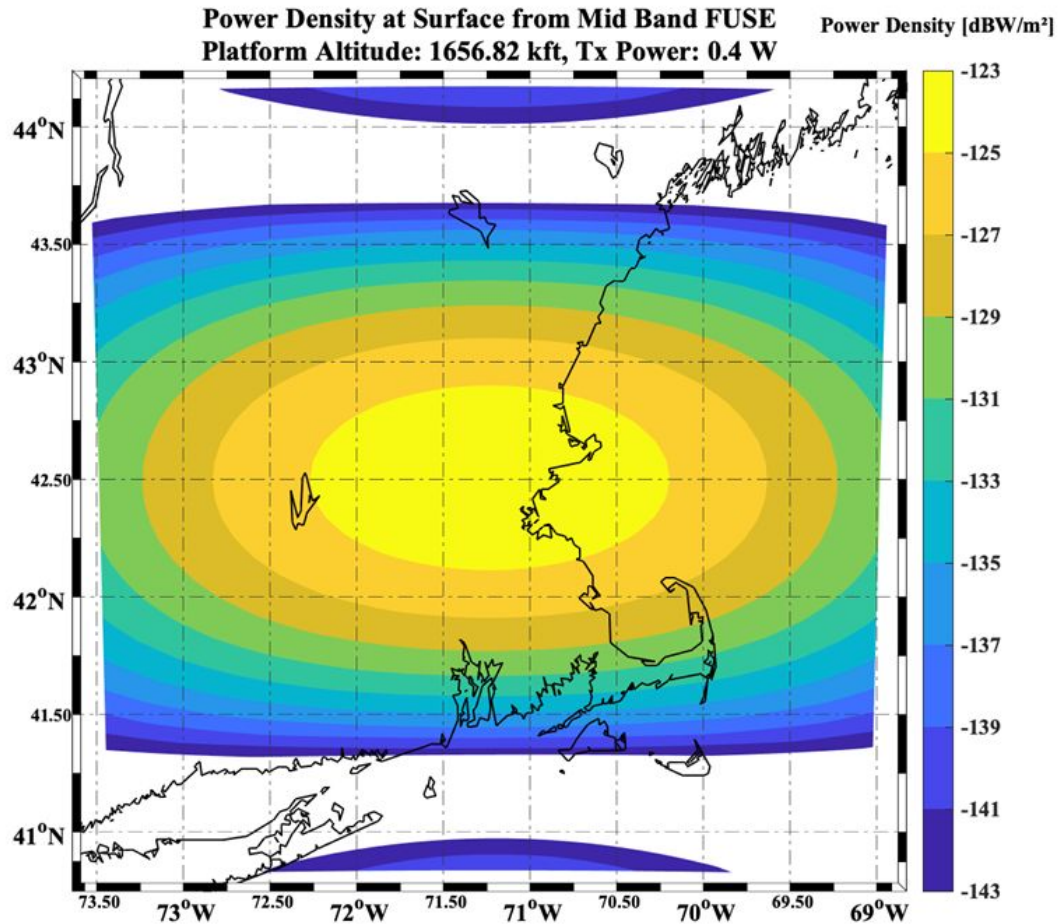


Figure 8 - Footprint overlay analysis for the C-Band 1 beam with power density.

The worst-case interference footprint of the C-Band 1 (5.295 GHz) beam can be represented as an ellipse bounded by latitudes $\sim 41.50^\circ\text{N}$ and $\sim 43.40^\circ\text{N}$ and longitudes $\sim 69.25^\circ\text{W}$ and $\sim 73.25^\circ\text{W}$, outside of which the power density is less than -130 dBW/m^2 .

Domestic Operator Search

Besides our receiving ground station in MA, there are no FCC licensed ground station operators within the beam footprint of C-Band 1 besides the ground station servicing our satellite, WO9XCW. The nearest ground station that also uses this frequency resides in Philadelphia, PA (see FCC file number 0204-EX-CR-2017 and call sign WH2XTI). The station in Philadelphia is a mobile station using 5.3-8.9 GHz with an authorized power of 0.01 W (ERP), within 1.6km of $39^\circ 51' 32''\text{ N } 75^\circ 19' 11''\text{ W}$. This ground station is nearly 450km away, far outside of our Massachusetts footprint, and we do not anticipate any interference with their operations.

International Operator Search

Since the C-Band 1 footprint does not bleed over national borders, we conclude that there are no international interference stakeholders.

Transmit Description - C-Band 2

Transmit frequency: 5.515 GHz

Transmitter allotted bandwidth: 50 MHz

Maximum ERP: 38 dBm

Modulation type: Binary CPFSK

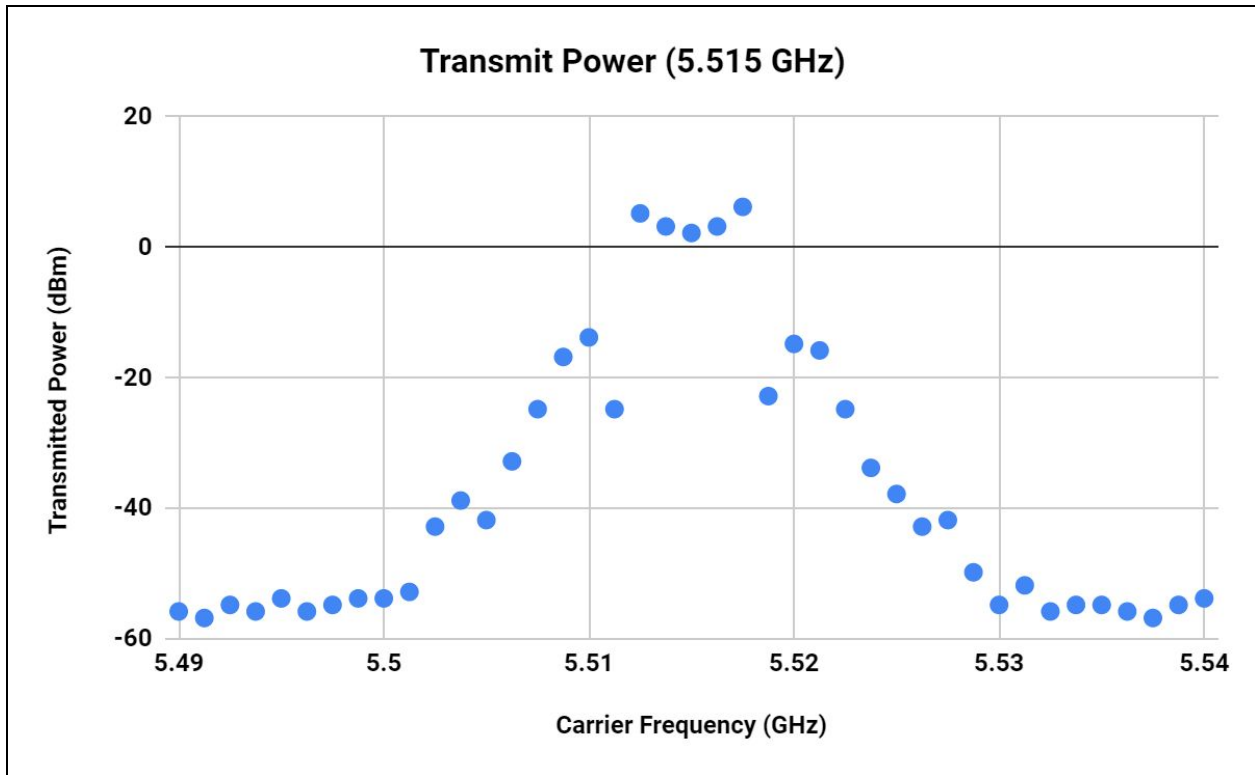


Figure 9 - Specific Meshbed C-Band 2 output power from satellite with typical realized gain from powered antenna.

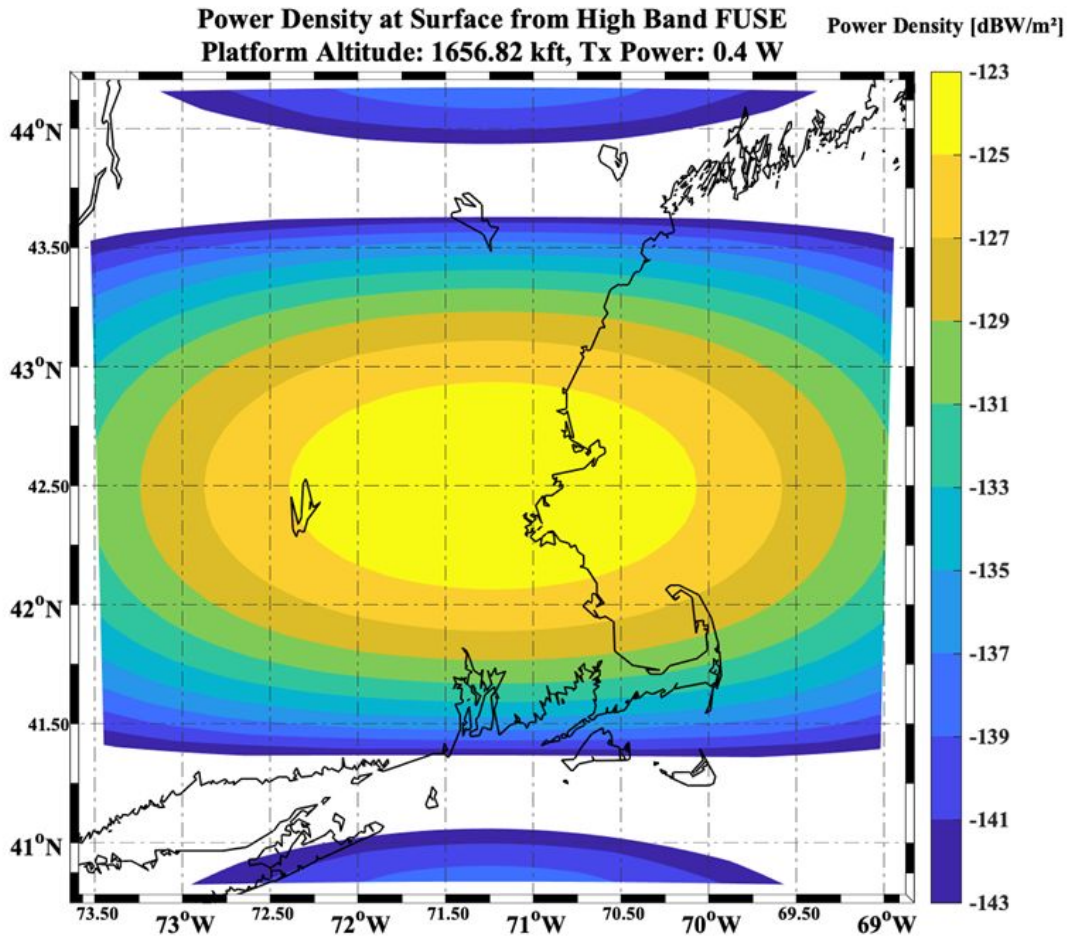


Figure 10 - Footprint overlay analysis for the C-Band 2 beam with power density.

The worst-case interference footprint of the C-Band 2 (5.515 GHz) beam can be represented as an ellipse bounded by latitudes $\sim 41.50^{\circ}\text{N}$ and $\sim 43.40^{\circ}\text{N}$ and longitudes $\sim 69.25^{\circ}\text{W}$ and $\sim 73.25^{\circ}\text{W}$, outside of which the power density is less than -130 dBW/m^2 .

Domestic Operator Search

There are no FCC licensed ground station operators within the 5.490-5.540 GHz frequency beam footprint of C-Band 2 besides the ground station servicing our satellite, WO9XCW. The nearest ground station that also uses this frequency is the same station in Philadelphia, PA (see FCC file number 0204-EX-CR-2017 and call sign WH2XTI). The station in Philadelphia is a mobile station using 5.3-8.9 GHz with an authorized power of 0.01 W (ERP), within 1.6km of $39^{\circ} 51' 32''\text{ N } 75^{\circ} 19' 11''\text{ W}$. This ground station is nearly 450km away, far outside of our Massachusetts footprint, and we do not anticipate any interference between our operations.

International Operator Search

Since the C-Band 2 footprint does not bleed over national borders, we conclude that there are no international interference stakeholders.

Conclusion

Based on this analysis, there is no expectation at this time that Meshbed satellite operations will interfere with any known systems.