Interference Analysis for the “Meshbed” Satellite

Mission Summary

The 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 the wideband AESA antenna connected to a wideband software defined radio to be operated at 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 June 1, 2019
- Altitude: 505 km ±20 km (3-sigma tolerance)
- Inclination: 97.48 degrees ±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
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 three 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 three beams. The resulting noise and power signature for each of the beams helps define 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 two C-band beams create worst-case noise footprints closely constrained to central New England, providing clear parameters for stakeholder search. After searching the FCC database, we found no interference stakeholders within the footprint area. The closest one we could identify 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, only 0.543 dBW ERP, and based on the following analysis is not anticipated to interfere with Earth based operations.

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

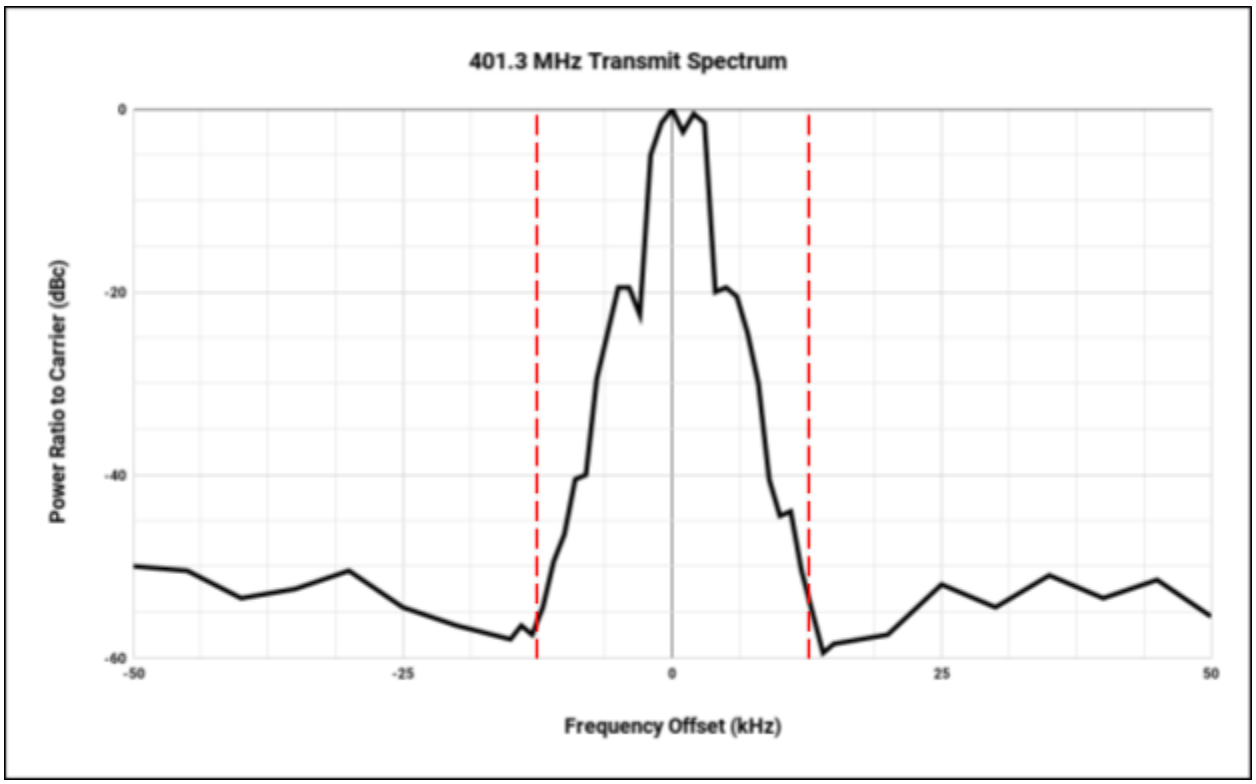

Figure 1 - Meshbed transmit spectrum efficiency. Red lines denote the 25 kHz bandwidth designation around 401.3 MHz.

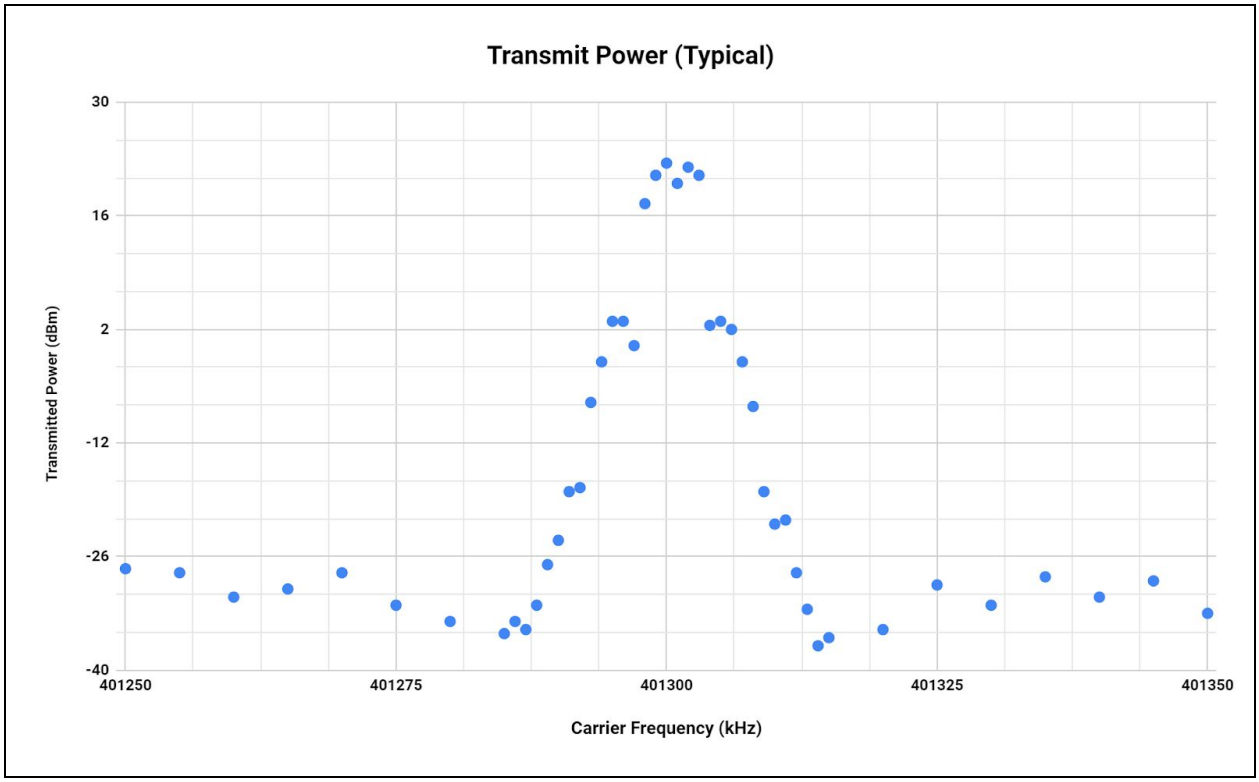

Figure 2 - Meshbed transmit power near 401.3 MHz.

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/m^2 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 reciever 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.

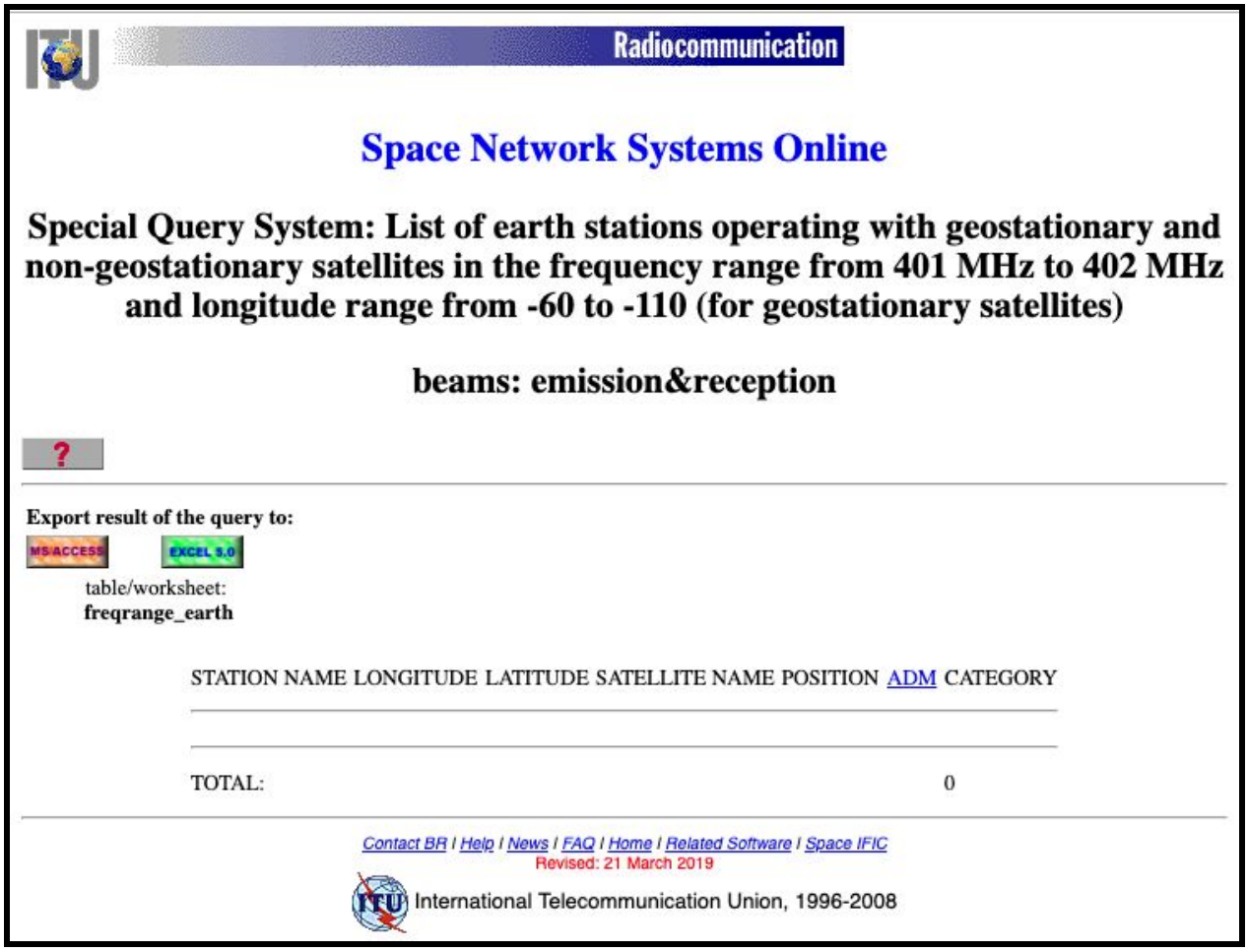

Figure 3 - Search criteria for international ground stations and results.

After doing 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 - C-Band Link

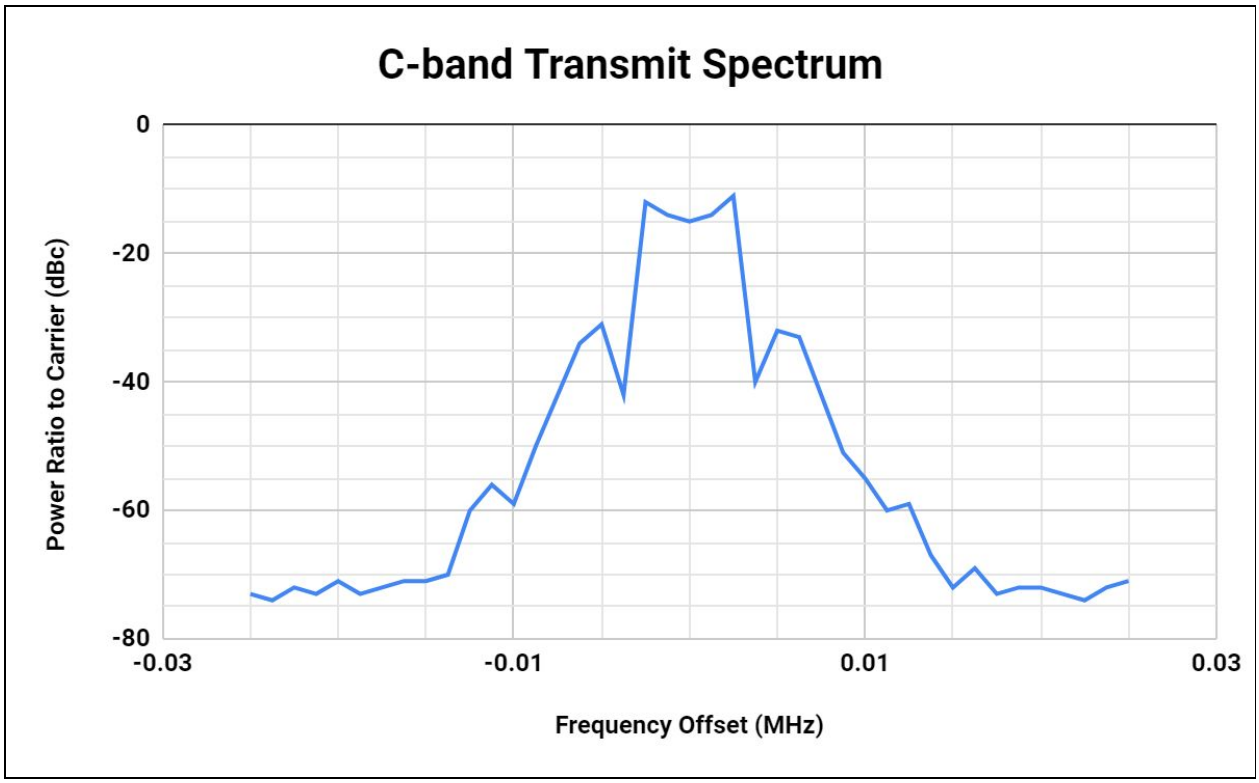

Figure 4 - General C-band output power ratio from satellite SDR, centered at 5 GHz.

Figure 4 above represents the general transmit power efficiency of the spacecraft SDR for the two C-bands. 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.

Beam Name: C-Band 1
Transmit frequency: 5.295 GHz
Transmitter allotted bandwidth: 50 MHz
Maximum ERP: 40.65 dBm
Modulation type: Binary CPFSK

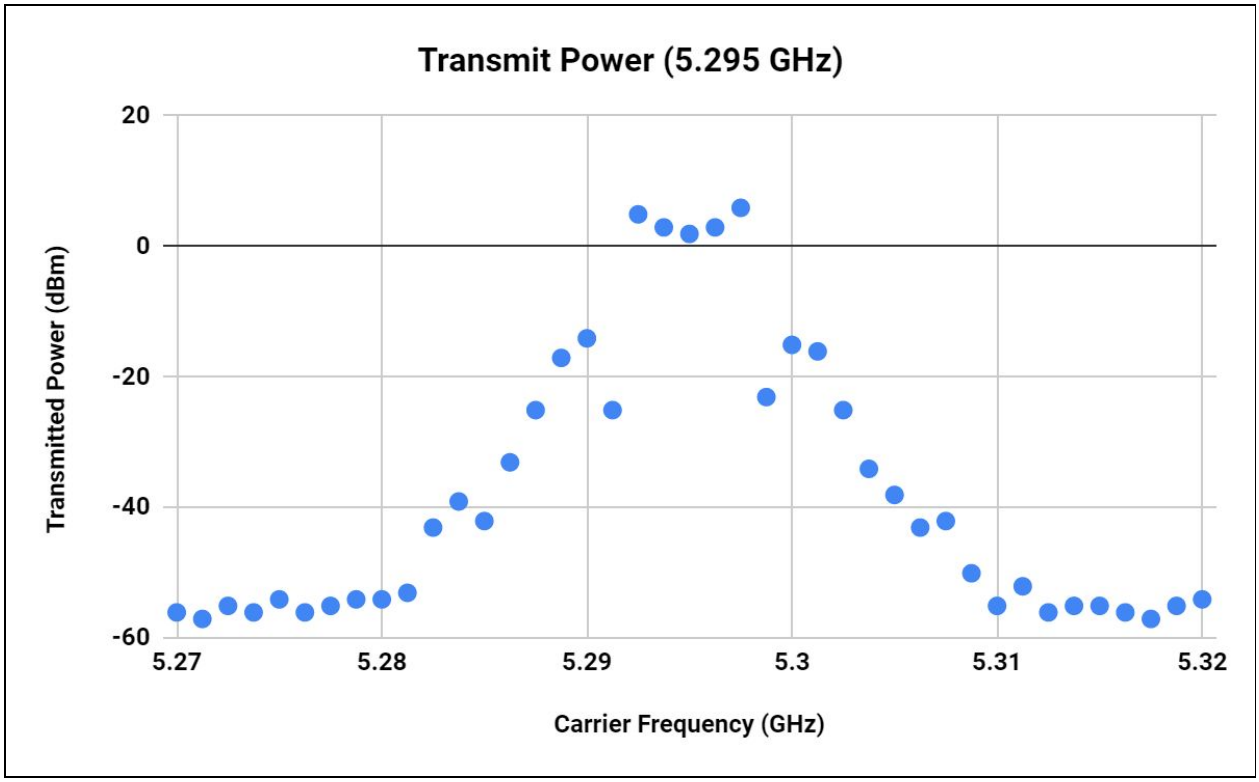

Figure 5 - Specific Meshbed C-band 1 output power from satellite with typical realized gain from powered antenna.

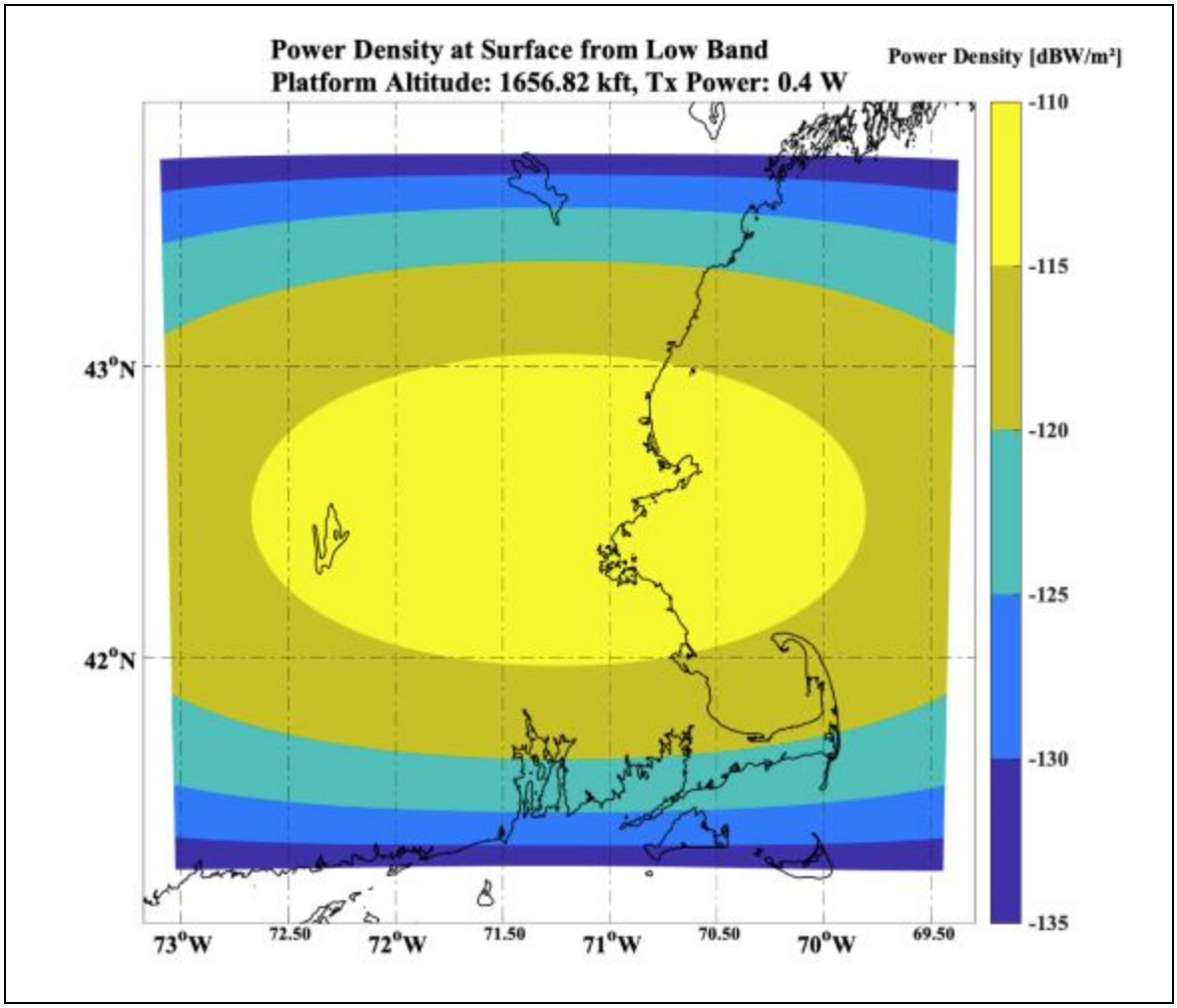

Figure 6 - Footprint overlay analysis for the C-band 1 beam with power density.

The worst-case interference footprint of the C-band 1 (5.295 GHz) beam can be represented as an ellipse bounded by latitudes ~41.38°N and ~43.66°N and longitudes ~67.81°W and ~74.61°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 5.270-5.320 GHz frequency 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° 51′ 32″ N 75° 19′ 11″ 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.

Beam Name: C-Band 2
Transmit frequency: 5.515 GHz
Transmitter allotted bandwidth: 50 MHz
Maximum ERP: 38.05 dBm
Modulation type: Binary CPFSK

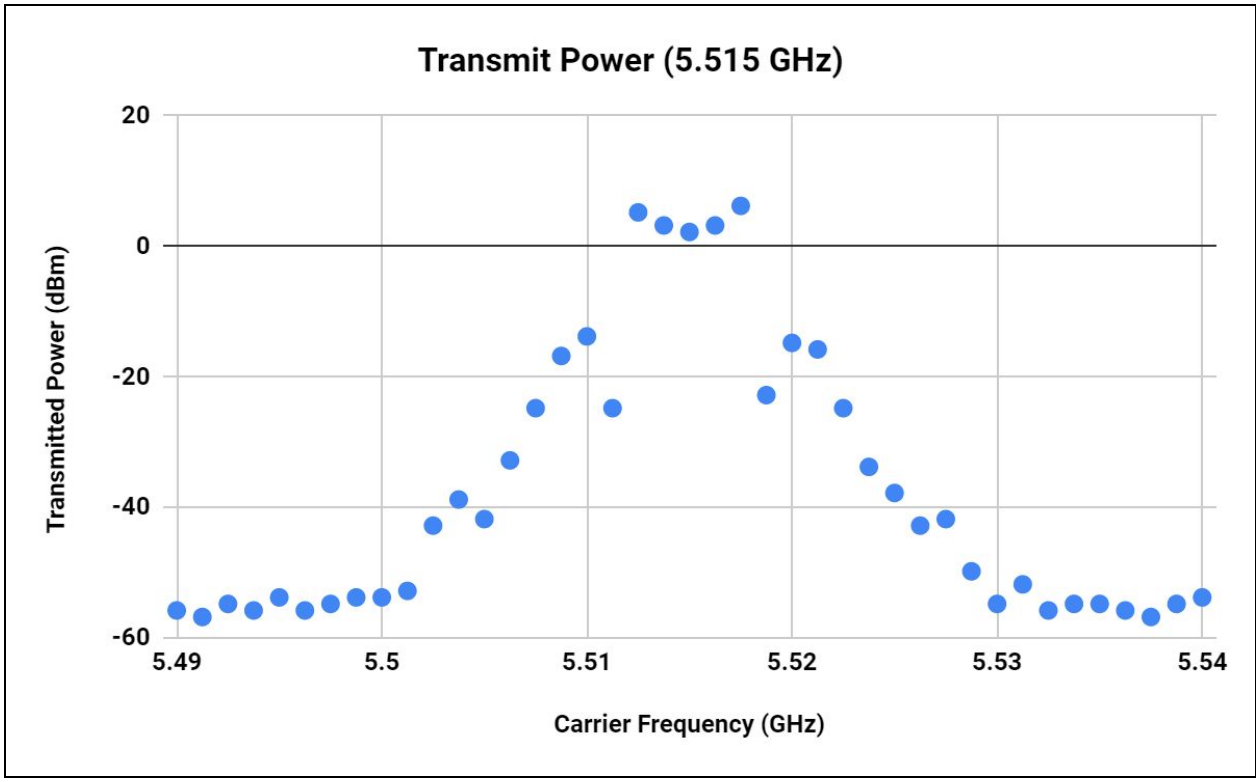

Figure 7 - Specific Meshbed C-band 2 output power from satellite with typical realized gain from powered antenna.

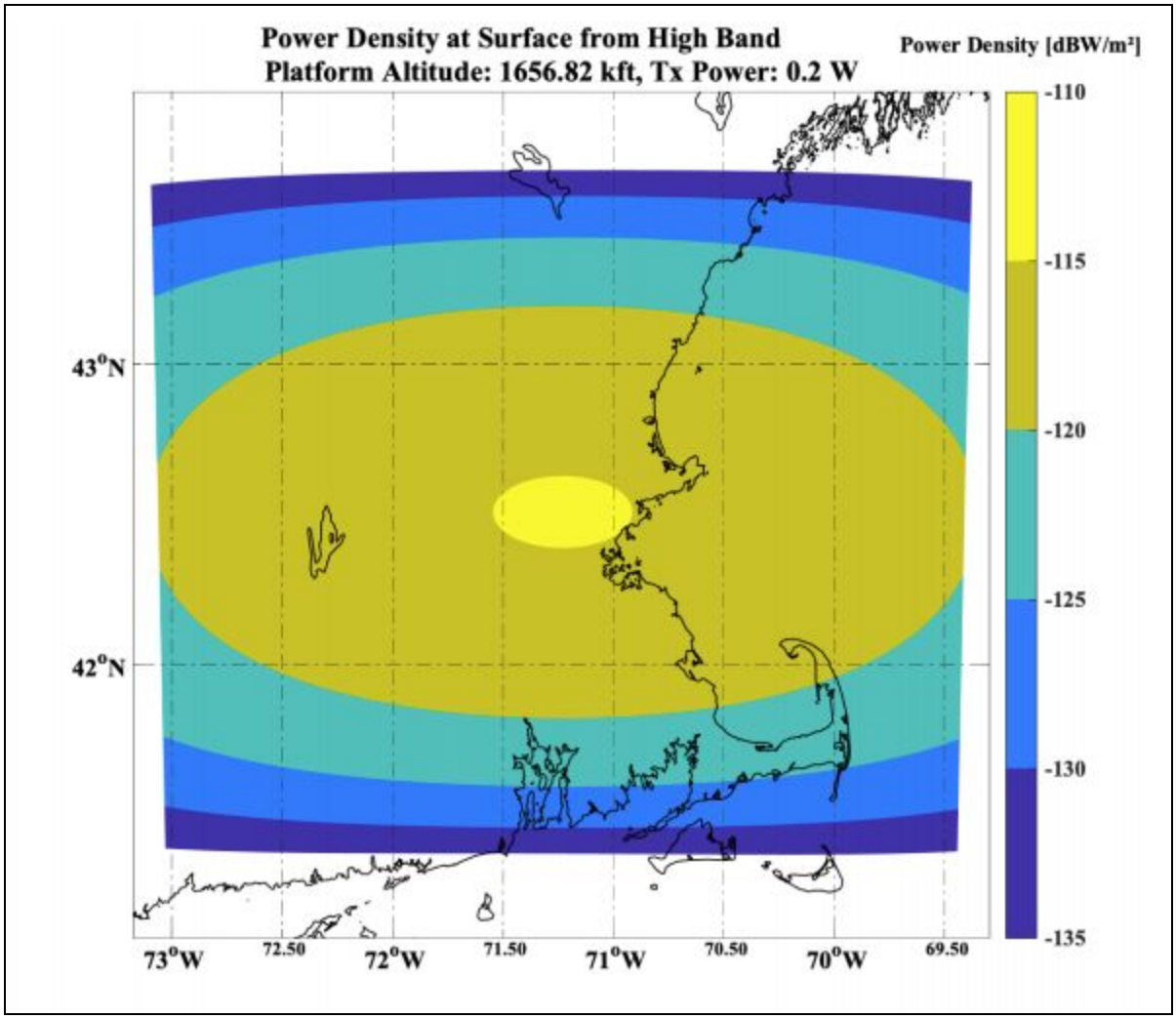

Figure 8 - Footprint overlay analysis for the C-band 2 beam with power density.

The worst-case interference footprint of the C-band 2 (5.515 GHz) beam can be represented as an ellipse bounded by latitudes ~41.44°N and ~43.53°N and longitudes ~68.01°W and ~74.50°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° 51′ 32″ N 75° 19′ 11″ 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.