MANGATA NETWORKS' NON-GEOSTATIONARY SATELLITE SYSTEM

Technical Narrative to Supplement Schedule S

This attachment contains the information required by §25.114, §25.146 and other sections of the FCC's Part 25 rules that cannot be captured by the Schedule S software.

I. INTRODUCTION AND SUMMARY

Mangata Networks' NGSO constellation is a hybrid solution, consisting of 791 satellites distributed in 27 medium earth orbit ("MEO") planes with inclinations between 45-52.5 degrees and 32 highly elliptical orbit ("HEO") planes with inclinations of 63.4 degrees, designed for optimal global coverage and system performance. Each satellite in the system will be technically and functionally identical, with a mass of less than 500 kg, will be fully operational (meaning no on-orbit spares will be deployed), and will have a design life of at least 10 years. These features, in combination with a redundant payload (two-for-one redundancy for all major platform components), and a hybrid MEO/HEO configuration enable the Mangata Networks' constellation to provide a robust, high-availability service to a number of consumer and government applications, while also protecting invaluable orbital resources.

The system's orbital configuration is constructed for accelerated deployment, providing service to all of North America and Europe after two launches, and targeted capacity offerings to specific latitudes -- a feature that is inherently challenging with other solutions that require near-global deployments in order to provide continuous coverage in specific geographical areas or key mobility markets.

A. Mangata Networks' Facilities, Operations and Services

This section addresses FCC rules §25.114(c)(6), §25.114(d)(1), §25.271(a), §25.271(d), §25.272(a), and 25.272(d)(5).

Mangata Networks will serve a number of connectivity driven markets that value high availability, lower latency (typically <100 ms roundtrip), high overall capacity and high capacity density. With the global reach of our multi-orbit system, Mangata Networks will provide a number of solutions to markets that have either been underserved, or poorly served by existing terrestrial and satellite networks. In accordance with §25.114(d)(6), these services support the public interest in a variety of ways including, but not limited to enabling access to first responders, disaster response, telehealth, education and global connectivity to both rural and urban communities. Given today's current events relating to the COVID-19 pandemic, the need for remote connectivity for health, work and general welfare has never been greater, and only through the ubiquitous coverage offered by satellites can this be offered universally.

As its primary mission the Mangata Networks' space segment will provide point-to-point connectivity between a geographically separated gateway and user terminal. This connectivity will be accomplished using high bandwidth Ka-/V-Band feeder links and more dynamically controlled, lower bandwidth user links. One gateway will provide service and capacity to many user terminals in a given region or country, and a single space station will provide connectivity between several gateways and a number of user terminals. It is anticipated that the physical transmission channels of the satellite will be compatible with a number of waveforms and standards, but as a baseline the DVB-S2X standard will offer the necessary operating range, spectral efficiency and robustness required by our customers, and is well tailored to millimeter spectrum.

The user terminals deployed by Mangata Networks will serve various fixed and mobility markets. Terminal size will be dependent on capacity served, with terminals less than 1 m in diameter serving capacities between 50-500 Mbps, and terminals greater than 1 m serving capacities 500 Mbps and greater. Terminal technology will include traditional parabolic reflectors for terminals greater than 1-meter, and a mix of parabolic reflectors and phased arrays for terminals less than 1-meter. In both cases, the technology implemented will provide inherent redundancy either through dual parabolic reflectors (nominally supporting make-before-break handovers), or active/passive phased arrays.

Gateway solutions will be tailored to the customer and application being served as well as the total capacity being supplied, but will consist of both regional gateways serving large geographical areas, and local gateways serving a specific country or countries. Gateway configurations will include either a dual Ka-/V-Band implementation or a Ka-Band only implementation. The dual Ka-/V-Band gateway will employ a geographically separated gateway with two (or more) antennas separated by greater than 50 km, and connected to a central location via terrestrial fiber. These locations will be selected based on existing terrestrial infrastructure and serve as large communication hubs serving capacities greater than 20 Gbps. Additionally, Ka-Band only gateways will also be implemented to provide additional flexibility in where connectivity will be serving capacity less than 10 Gbps. For both implementations gateway antennas will be 2 m or larger in diameter, and track to elevation angles that are generally greater than 20 degrees. The absolute minimum elevation angle for both user terminals and gateways will be 15 degrees and 20 degrees respectively.

Mangata Network's Telemetry, Tracking and Commanding (TT&C) operations will be performed at Ka-Band frequencies for both downlink (telemetry) and uplink (command) through gateways 4 m or larger in diameter with a minimum elevation angle of three degrees. These antennas will also serve user links, will be located in areas to allow for near continuous TT&C operations globally, and will be connected via a secure and dedicated terrestrial network to Mangata Network operations.

Mangata Networks will provide operations in a traditional architecture with the satellite network controlled and monitored by a Satellite Operations Center (SOC) and the terrestrial network controlled and monitored by a Network Operations Center (NOC). Additionally, a Mission Operations Center (MOC) will provide real time configuration of both the space and ground segments as it pertains to customer connectivity, continuously optimizing the network to provide the most robust customer experience. These centers will comply with §25.272(a), and monitor all system transmissions and coordinate transmissions with those of other systems to prevent harmful interference incidents or, in the event of harmful interference, identify the source of the interference and correct the problem promptly.

While locations of these resources are still to be determined, fully redundant capability will be maintained in either geographically separated locations, or virtualized within existing secure cloud infrastructure. Furthermore, in accordance with FCC's rules §25.271(a) and §25.271(d), Mangata Networks will ensure that all transmitting stations are properly operated, and maintained, and secured against unauthorized access or use whenever an operator is not present at the transmitter. This includes ensuring that all satellite commands are secured against unauthorized access and use. Lastly, Mangata Networks will comply with §25.272(d)(5) and take full responsibility for the duties and performance of the centers, or delegate the responsibility and duties to a technically qualified user or group of users.

B. Mangata Networks' Constellation Design and Coverage

This section provides a description of the Mangata Networks NGSO constellation and addresses FCC rule §25.146(b), which states that the proposed system must be capable of providing FSS on a continuous basis throughout the fifty states, Puerto Rico, and the U.S. Virgin Islands.

Table 1 summarizes the MEO parameters for the 27 MEO planes, of which there three types: MEO #1, MEO #2, and MEO #3. Each MEO plane consists of 21 satellites, is circular, orbits at an altitude of 6400 km with an orbital period of 4 hours, and orbits at one of three possible inclinations: 45°, 50°, or 52.5°. A total of 567 MEO satellites exist.

Table 1. MANGATA Constellation Parameters Summary (MEO)

Constellation Parameter	MEO #1	MEO #2	MEO #3
Number of Planes	9	9	9
Number of Satellites per Plane	21	21	21
Satellite Altitude	6400 km	6400 km	6400 km
Inclination	45°	50°	52.5°

Table 2 summarizes the HEO parameters for the 32 HEO planes, of which there four types: HEO #1, HEO #2, HEO #3, and HEO #4. Each HEO plane consists of seven satellites, has an inclination of 63.4^{o} and has an orbital period of 4 hours. A total of 224 HEO satellites exist.

Table 2. MANGATA Constellation Parameters Summary (HEO)

Constellation Parameter	HEO #1	HEO #2	HEO #3	HEO #4
Number of Planes	8	8	8	8
Number of Satellites per Plane	7	7	7	7
Satellite Altitude (perigee x apogee) (km)	1215 x 11585	1776 x 11024	3000 x 9800	3800 x 9000
Inclination	63.4^{o}	63.4^{o}	63.4^{o}	63.4^{o}

Figure 1 provides an overview of Mangata Networks' orbital configuration, depicting HEO planes (green) and MEO planes (yellow) operating in conjunction to provide the optimal global coverage. The MEO planes will enable continuous coverage of +/- 70° N/S latitude, while the HEO planes will provide targeted coverage to either the Northern or Southern hemisphere.

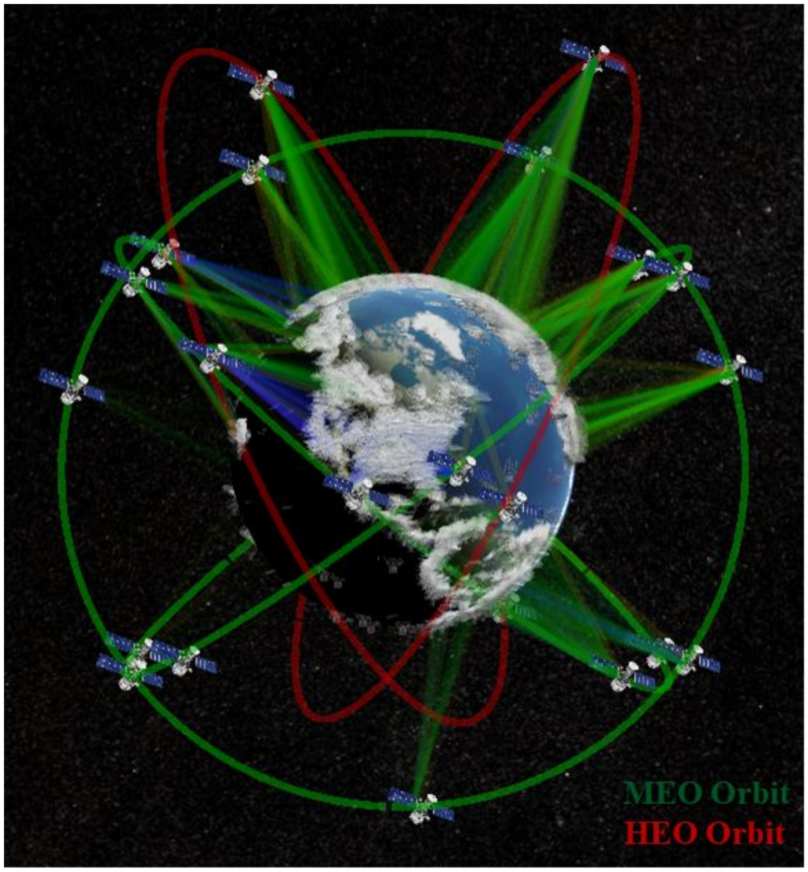

Figure 1: HEO/MEO Orbital Geometries (only a subset of orbital planes is included for visibility)

Figure 2 depicts the HEO northern and southern coverage areas, showing that the initial Mangata Networks'deployment will provide FSS on a continuous basis throughout the fifty states, Puerto Rico and the U.S. Virgin Islands meeting the Commission's geographic service requirement as specified in §25.146(b) of the Commission's rules.

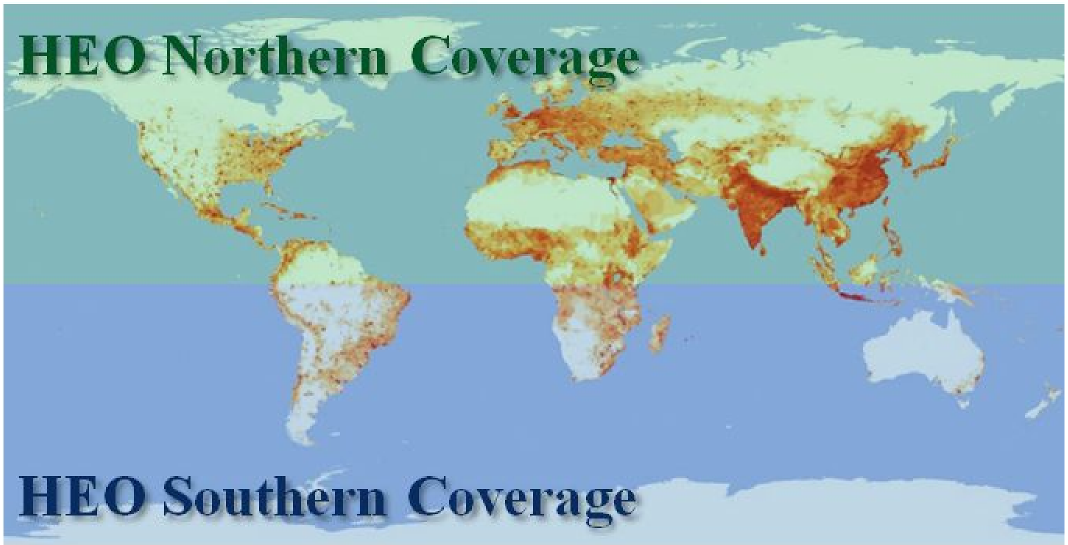

Figure 2: Mangata Networks Constellation Coverage Map

Figure 3 depicts the MEO coverage map from +/- 70° N/S latitude, and extended coverage +/- 90º N/S latitude. Like the coverage from the HEO planes, the MEO planes also provide FSS on a continuous basis throughout the fifty states, Puerto Rico, and the U.S. Virgin Islands enabling robust and diverse connectivity options.

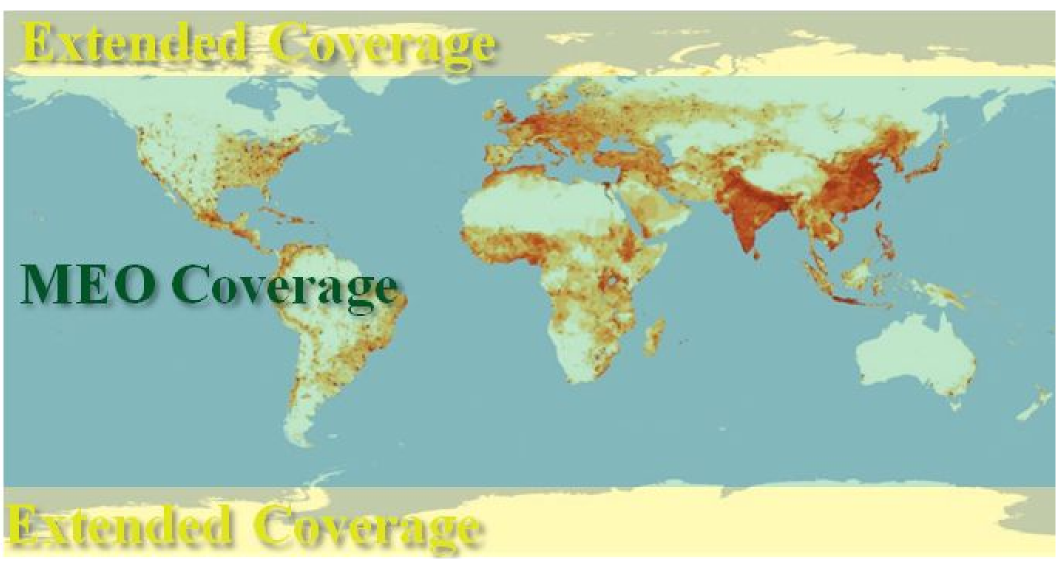

Figure 3: Mangata Networks Constellation Coverage Map

C. Mangata Networks' System Spectrum Plan

This section addresses spectrum related information not captured in the Schedule S. In particular this section documents how uplink frequency bands are connected to downlink frequency bands §25.114(d)(1), frequency tolerances / emission limits §25.202, frequency reuse §25.210(f) and cessation of emissions §25.207.

Mangata Networks' NGSO System will utilize Ka-band and V-band for feeder links, connecting the satellites and gateway earth stations and Ka-band for service links, connecting the satellites and user terminals. The specific frequency bands, transmission type and direction used in the Mangata Networks NGSO System are summarized in Table 3.

Table 3. Frequency bands used by the MANGATA NGSO System

Transmission Type and Direction	Frequency
Gateway-to-Satellite	27.5 - 30.0 GHz 47.2 - 50.2 GHz 50.4 - 51.4 GHz
Satellite-to-Gateway	17.3 - 17.7 GHz (Region 1 only) 17.7 - 18.6 GHz 18.8 - 20.2 GHz 37.5 - 42.5 GHz
User Terminal-to-Satellite	27.5 - 30.0 GHz
Satellite-to-User Terminal	17.3 - 17.7 GHz (Region 1 only) 17.7 - 18.6 GHz 18.8 - 20.2 GHz
TT&C Downlink	19.298-19.300 GHz
TT&C Uplink	29.094-29.100 GHz

Due to the implementation of on-board processing, there is no direct mapping of uplink frequencies to specific downlink frequencies, as in a traditional bent pipe architecture. This allows for any portion of the uplink spectrum to be routed to any portion of the downlink spectrum of equal bandwidth with a channelizer, enabling full spectrum flexibility and improving interference susceptibility and control. It is also noted that the carrier frequency of each space station transmitter will be maintained at 0.002 percent of the reference frequency as required in §25.202(e).

Additional information on channel bandwidths and power levels is provided in the Schedule S. As required in §25.210(f) of the Commission's rules, Mangata Networks will employ state-of-the-art full frequency reuse through the use of orthogonal polarizations (RHCP/LHCP) and will deploy spatially independent beams, allowing for up to 8x reuse or more per polarization. Additionally, each active satellite transmission chain (channel amplifiers and associated solid state power amplifier) can be individually turned on and off by ground telecommand, thereby causing cessation of emissions from the satellite, and complying with the FCC's §25.207 requirement.

FCC Rule §25.202(a)(1)(ii) states that the use of 37.5 - 40 GHz by FSS (space-to-Earth) is limited to individually licensed earth stations, which must not be ubiquitously deployed and must not be used to serve individual customers. Mangata Networks will comply with this regulation, as the use of this band will be limited to individually licensed gateway earth stations in specific locations.

II. TECHNICAL EXHIBIT

This section contains information on space station antenna gain contours, PFD compliance, orbital debris mitigation, and EPFD compliance.

A. Predicted Space Station Antenna Gain Contours

This section contains information on the satellite transmit and receive beams, not captured in the Schedule S, along with a subset of antenna gain contours included in the Schedule S for reference. The user link and feeder link beams are both steerable and shapeable in order to control the direction and power levels of the individual beams to ensure EPFD and PFD limit compliance.

Gateway contours and coverage areas will consist of individual beams centered on a gateway earth station. The beam will track continuously over the course of a contact pass, with some spreading expected at lower elevations. On average, gateways will experience coverage areas greater than 40° elevation with a space station minimum elevation angle > 20°. This allows for a single satellite to cover all of North America. Figure 4 shows the elevation contours as measured from a satellite altitude of 4,000 km and 6,400 km respectively. Figure 5 shows an antenna gain contour for a V-band gateway beam at nadir. The gain contours modelled in this section are in accordance with §25.114(c)(4)(vi)(B).

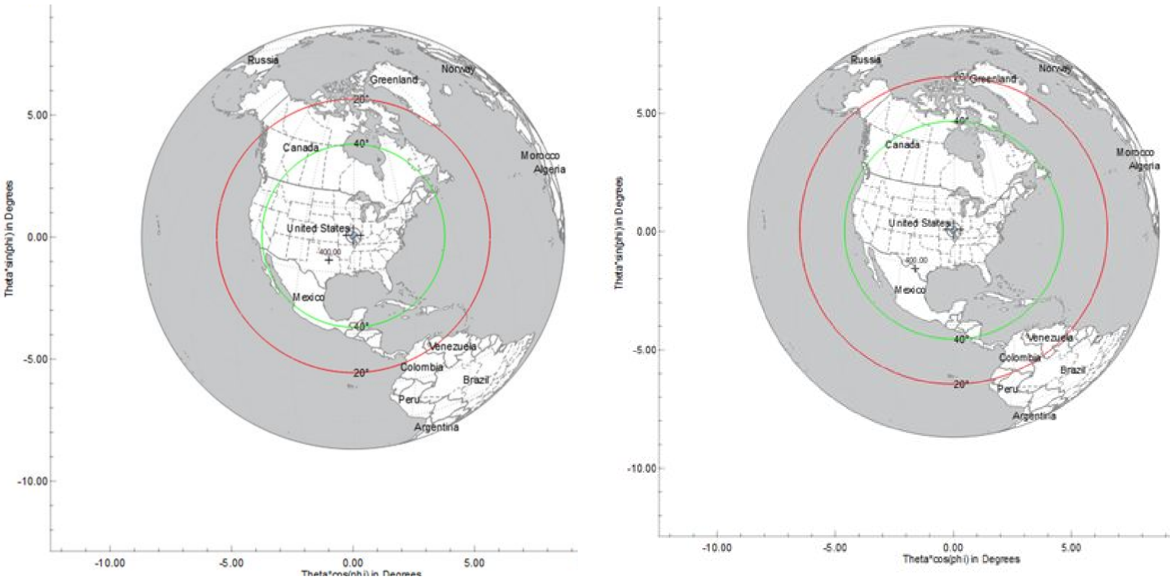

Figure 4(a,b). Space Station Elevation Contours (Red>20^{o} and Green>40^{o}) at 4,000 and 6,400 km Altitude

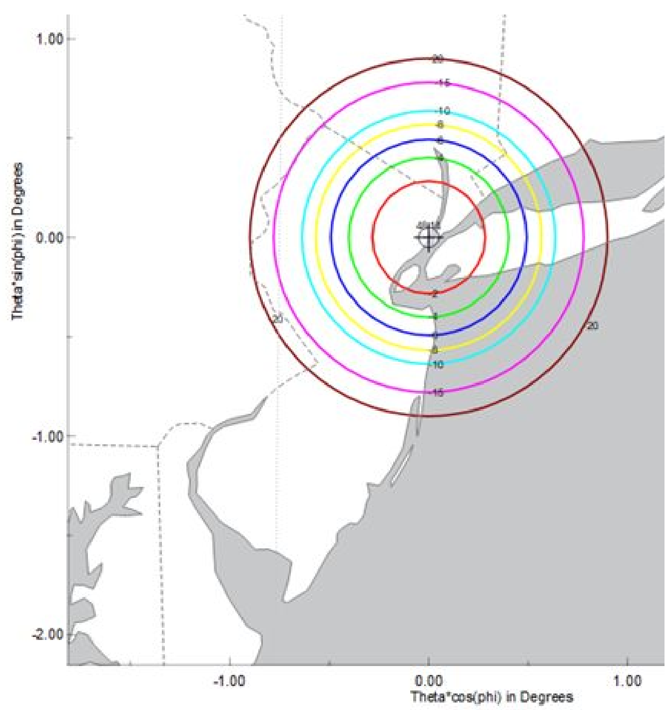

Figure 5. Antenna Gain Contour for V-band (Tx/Rx) Gateway Beams at Nadir

Figure 6(,b) provides antenna gain contours for V-band gateway beams at 20º and 40º elevation angles respectively.

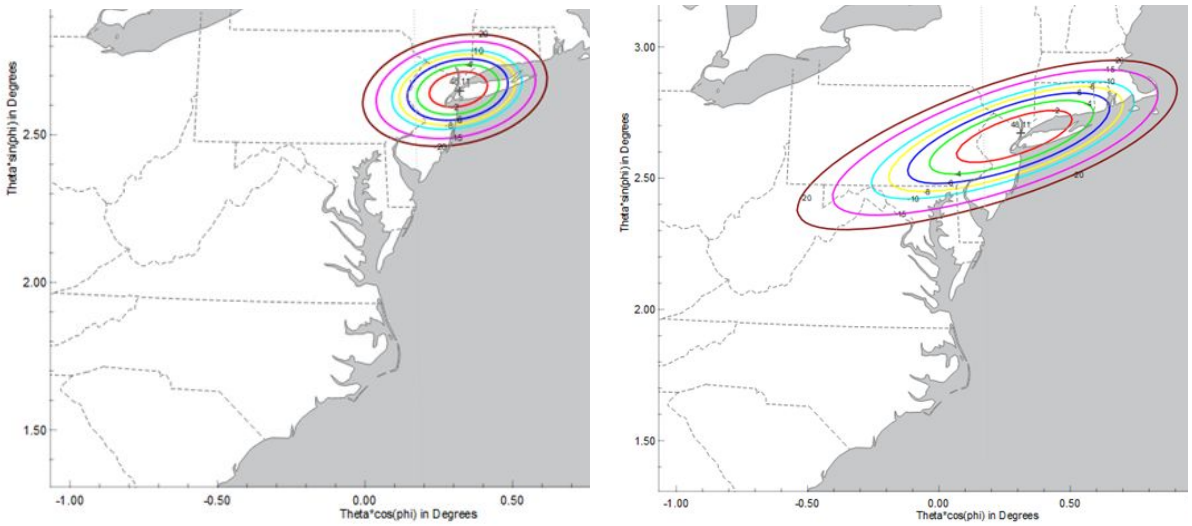

Figure 6(a, b). Antenna Gain Contour for V-band (Tx/Rx) Gateway Beams at 20º and 40º Elevation

User beam coverage areas will consist of individual beams centered on a user, or centered between multiple users. The beam will track continuously over the course of a contact, with some spreading expected at lower elevations. On average, users will experience coverage areas greater than 40º elevation. Figure 7 shows the gain contour for a Ka-band beam at nadir, which will support both user and feeder link traffic.

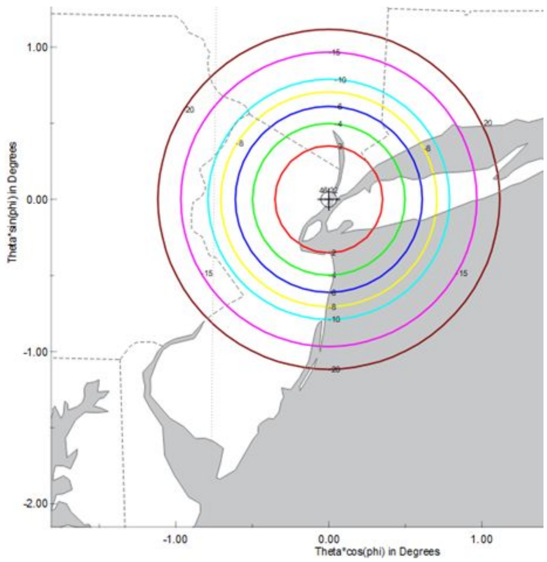

Figure 7. Antenna Gain Contour for Ka-band User & Gateway Beams at Nadir

Figure 8(a,b) shows the antenna gain pattern for a Ka-band beam, which supports both user and feeder link traffic, at 20º and 40º space station elevation angles.

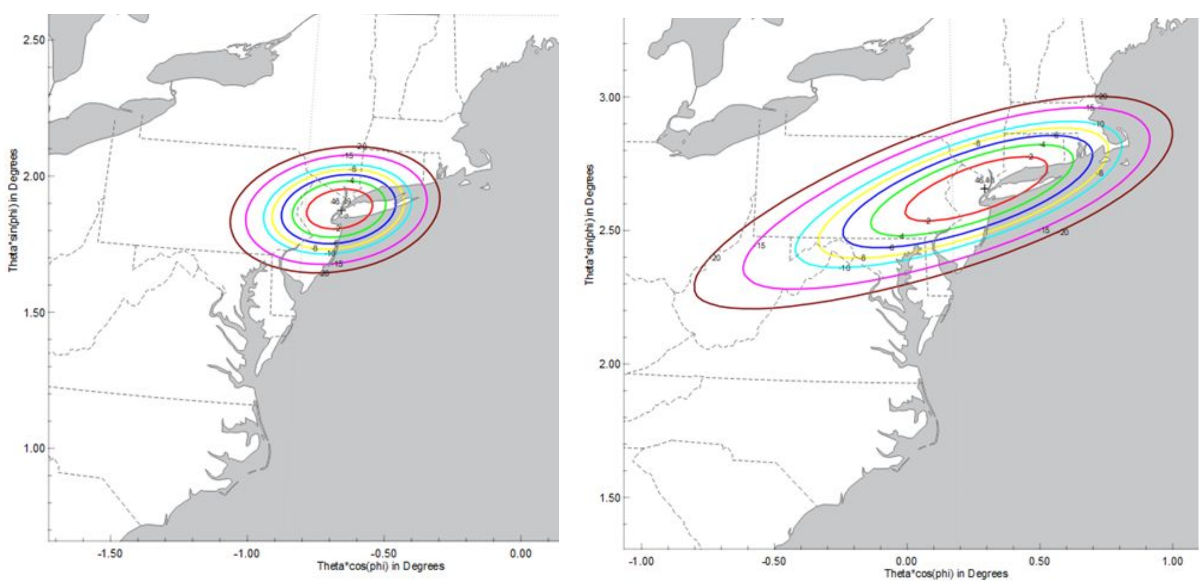

Figure 8(a, b). Antenna Gain Contour for Ka-band User & Gateway Beams at 20º and 40º Space Station Elevation Angles

TT&C operations will consist of two modes. A "high coverage" mode during early operations and contingencies that enable operations under multiple satellite orientations, as well as an “earth coverage” mode during nominal operations in which the gain pattern is optimized for a nadir orientation.

Lastly, Figure 9 shows the antenna gain contour for Ka-band TT&C beams, which provide full Earth coverage.

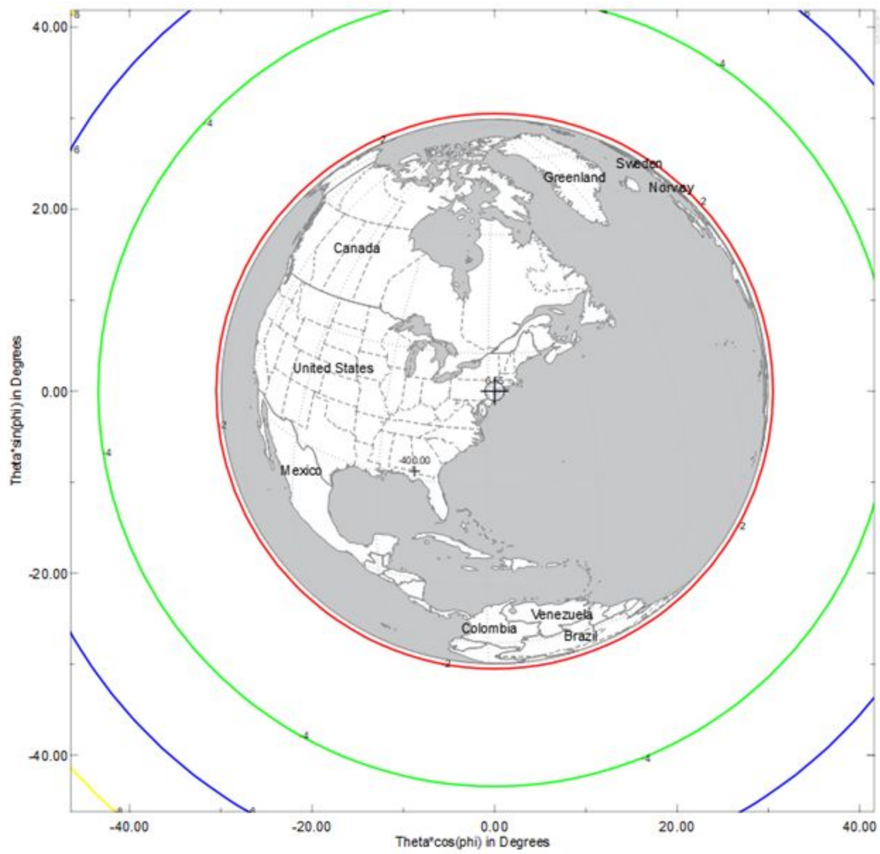

Figure 9. Antenna Gain Contour for Ka-band TT&C Beams at Nadir (Earth Coverage)

Additional information for the Ka-band and V-band beam contours is embedded in the associated Schedule S. This data is provided in the form required in §25.114(c)(4)(vi)(B), with contours plotted on a flat-Earth projection and with beam peak pointed to nadir.

B. PFD Limit Compliance

This section contains information on PFD Limit compliance, as required by the FCC rules (§25.114(d)(12), §25.146(a)(1), §25.146(a)(2), §25.208(r), §25.208(s) and §25.208(t)).

As required in §25.146(a)(1), the Mangata Network's System complies with all applicable FCC and ITU Power Flux Density ("PFD") limits set forth in Article 21, Section V, Table 21-4 of the ITU Radio Regulations, except that in 19.3-19.4 GHz and 19.6-19.7 GHz where Mangata Networks will comply with the ITU PFD limits governing NGSO systems in the 17.7 - 19.3 GHz band.

B.1 Downlink PFD Limits in Ka-band

The Ka-band PFD limits set forth in Article 21, Section V, Table 21-4 of the ITU Radio Regulations, which apply to FSS NGSO systems in the 17.7-19.3 GHz frequency bands shall not exceed the following:

- -115-X dB(W/m^2) in any 1 MHz band for angles of arrival between 0 and 5 degrees above the horizontal plane;
- -115-X+((10+X)/20)(δ-5) dB(W/m^2) in any 1 MHz band for angles of arrival (in degrees) between 5 and 25 degrees above the horizontal plane; and
- -105 dB(W/m^2) in any 1 MHz band for angles of arrival between 25 and 90 degrees above the horizontal plane.

Where X is defined as a function of the number of satellites in the NGSO FSS constellation, n, as follows:

- $X = 0$ dB for $n \leq 50$
- $X = (5/119)(n - 50)$ dB for $50 < n \leq 288$
- $X = (1/69)(n + 402)$ dB for $n > 288$

For the Mangata Networks System, the value of “n” is 791 and therefore X is equal to 17.29 dB according to the above formula.

Compliance with the ITU’s Ka-band PFD limits is demonstrated below for all Ka-band links (user +feeder and TT&C). It is important to note that Mangata Networks will operationally cease all transmissions below 4000 km, producing an associated spreading loss of 143.0 dB. Additionally, the minimum elevation angle for the user and feeder links is 15 degrees and 20 degrees respectively, which means the EIRP below this arrival angle will be less than the one used in these calculations, thus resulting in more margin. The figures below show PFD levels that result at the Earth’s surface for all elevation angles for the Mangata Networks feeder + user and TT&C links. The feeder and user link are shown together, because they are both transmitted through a shared Ka-band antenna. Operationally 10% of the power in the beam will be allocated to feeder link and 90% of the power in the beam will be allocated to the user link, For these two links a peak EIRP density of 15.98 dBW/MHz was used for the Ka-band user & feeder-link beams and 10 dBW/MHz, was used for TT&C beams.

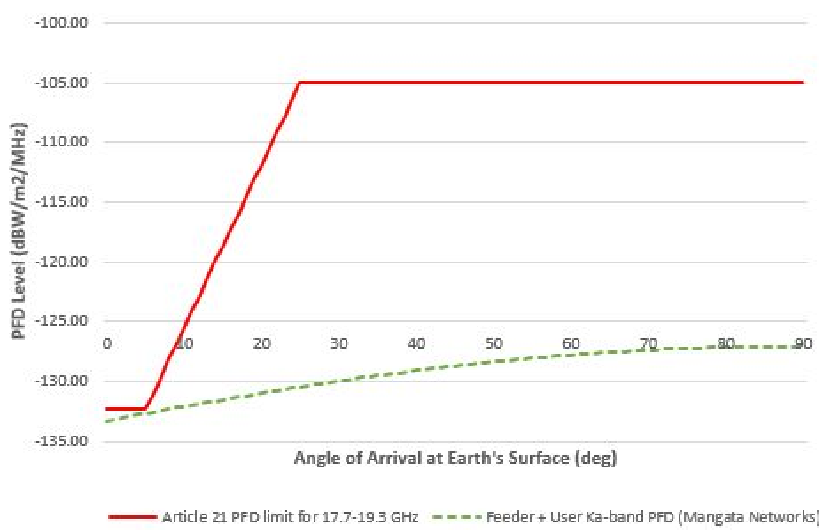

Figure 10. Ka-band PFD Compliance for the Feeder + User Link in Mangata Network’s System

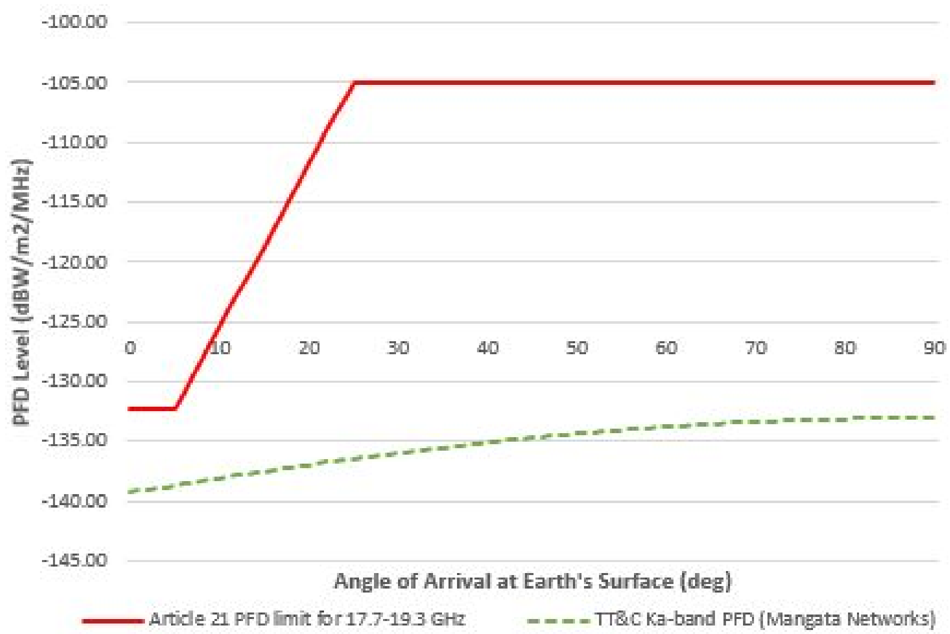

Figure 11. Ka-band PFD Compliance for the TT&C Links in Mangata Network's System

B.2 Downlink PFD Limits in the band 37.5 - 40.0 GHz

The FCC's V-band downlink PFD limits, which apply to the 37.5 - 40.0 GHz frequency bands, are given in §25.208(r)(1) and shall not exceed the following:

- -132 dB(W/m^2) in any 1 MHz band for angles of arrival between 0 and 5 degrees above the horizontal plane;
- -132 + 0.75 (δ-5) dB(W/m^2) in any 1 MHz band for angles of arrival δ (in degrees) between 5 and 25 degrees above the horizontal plane; and
- -117 dB(W/m^2) in any 1 MHz band for angles of arrival between 25 and 90 degrees above the horizontal plane;

Regulation §25.208(r)(2) defines maximum PFD limits during periods when the FSS system raises power to compensate for rain-fade conditions at the FSS ES:

- -120 dB(W/m^2) in any 1 MHz band for angles of arrival between 0 and 5 degrees above the horizontal plane;

- -120 + 0.75(δ-5) dB(W/m^2) in any 1 MHz band for angles of arrival δ (in degrees between 5 and 25 degrees above the horizontal plane; and
- -105 dB(W/m^2) in any 1 MHz band for angles of arrival between 25 and 90 degrees above the horizontal plane.

A note is attached to the FCC's rules that states, "The conditions under which satellites may exceed these power flux-density limits for normal free space propagation described in paragraph (q)(1) to compensate for the effects of rain fading are under study and have therefore not yet been defined. Such conditions and the extent to which these limits can be exceeded will be the subject of a further rulemaking by the Commission on the satellite service rules." The PFD limits for NGSO FSS systems in 37.5 - 40.0 GHz, as defined in Table 21-4 of the ITU Radio Regulations, are the same as the limits found in §25.208(r)(2).

Figure 12 contains the PFD limits in §25.208(r)(1), §25.208(r)(2), which is the same as the ITU PFD limits in 37.5 - 40.0 GHz, along with the PFD produced in this band by a Mangata Networks space station feeder links. The maximum V-band EIRP density submitted in the Mangata Networks ITU filing is 28.01 dBW/MHz, and is used in the calculation below.

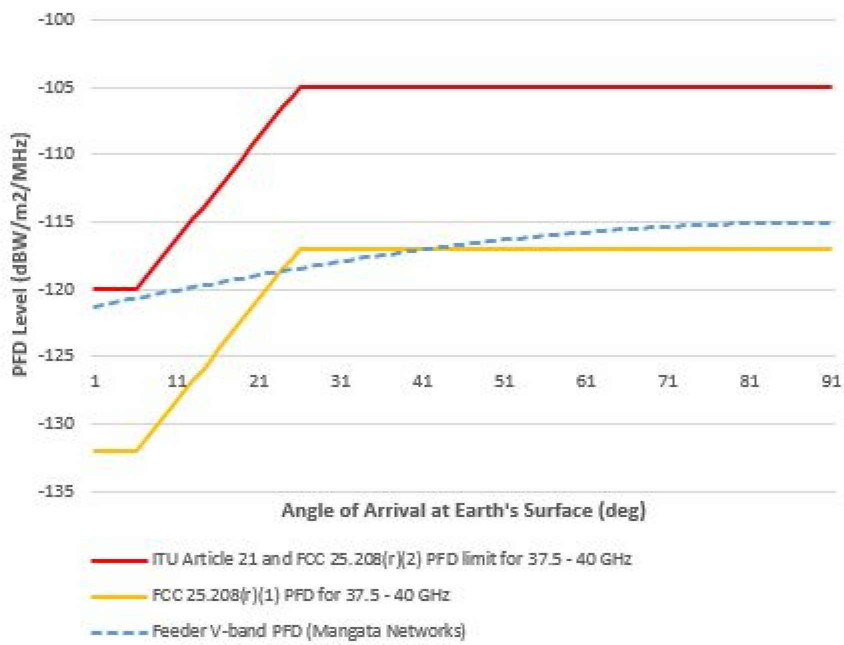

Figure 12. PFD Compliance in 37.5 - 40.0 GHz for the Mangata Network's System

From Figure 12, PFD compliance is shown against the ITU and FCC §25.208(r)(2) PFD limit. To improve compliance with the FCC's §25.208(r)(1) regulation, shown in yellow above, Mangata Networks can decrease its EIRP spectral density by 12 dB when transmitting in this band over the U.S., and ensure a steep rolloff occurs in its antenna beam. An operational situation with a 12 dB decrease in EIRP spectral density is shown in Figure 13. The Schedule S entries for this band, reduce power and gain until compliance with §25.208(r)(1) is met.

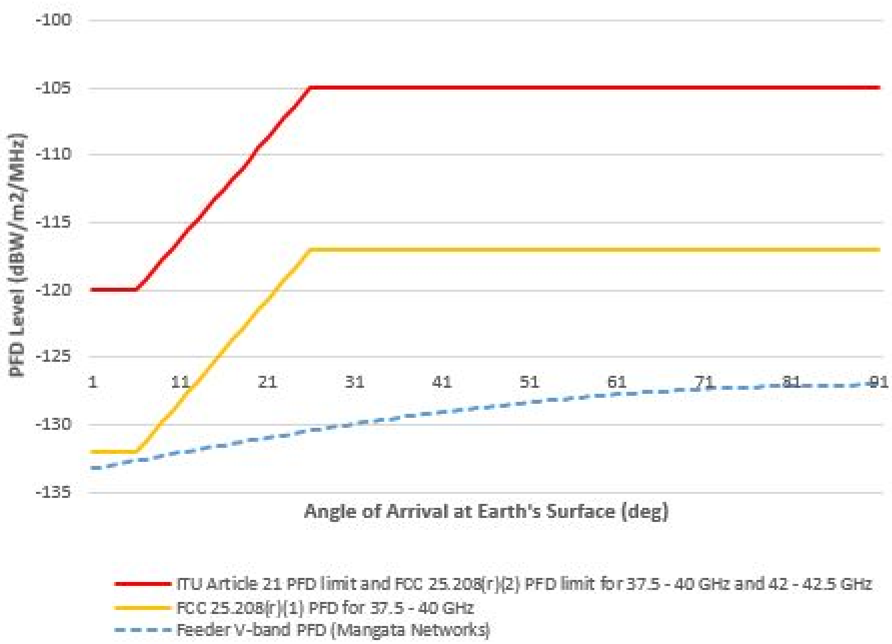

Figure 13. PFD Compliance in 37.5 - 40.0 GHz for the Mangata Network's System over the U.S. (EIRP spectral density decreased by 12 dB)

B.3 Downlink PFD Limits in the band 40.0 - 40.5 GHz

The FCC's V-band downlink PFD limits, which apply to the 40.0 - 40.5 GHz frequency bands, are given in §25.208(s), assume free-space propagation conditions, and shall not exceed the following:

- -115 dB(W/m^2) in any 1 MHz band for angles of arrival between 0 and 5 degrees above the horizontal plane;
- -115 + 0.5 (δ−5) dB(W/m^2) in any 1 MHz band for angles of arrival δ (in degrees) between 5 and 25 degrees above the horizontal plane; and
- -105 dB(W/m^2) in any 1 MHz band for angles of arrival between 25 and 90 degrees above the horizontal plane

These limits are the same as the ITU PFD limits for 40.0 - 40.5 GHz, as defined in Table 21-4 of the Radio Regulations. The figure below shows the FCC and ITU PFD limit along with the PFD produced in this band by a Mangata Networks space station.

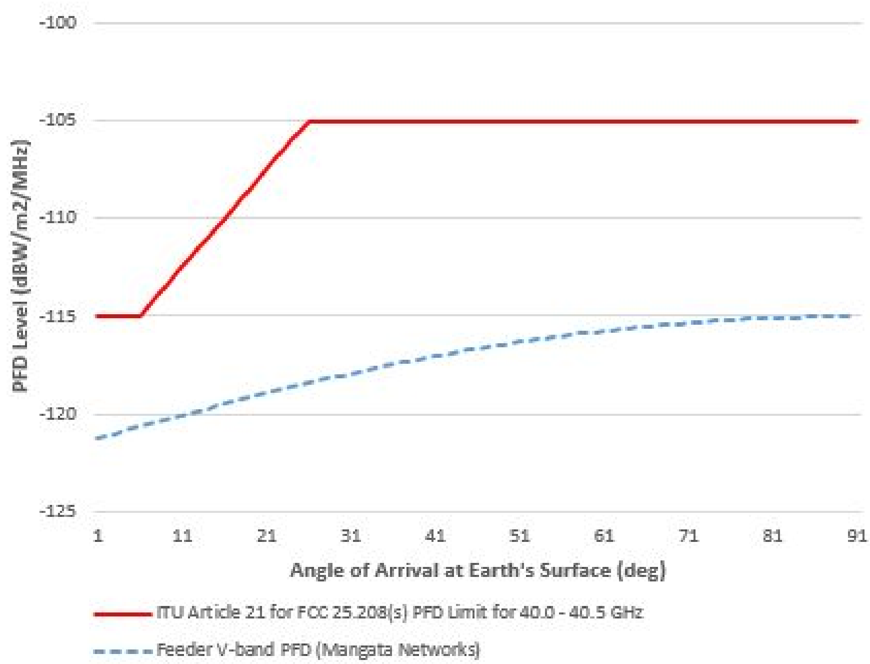

Figure 14. PFD Compliance in 40.0 - 40.5 GHz for the Mangata Network's System

B.4 Downlink PFD Limits in the band 40.5 - 42.0 GHz

The FCC's V-band downlink PFD limits, which apply to the 40.5 - 42.0 GHz frequency bands, are given in §25.208(t), assume free-space propagation conditions, and shall not exceed the following:

- -115 dB(W/m^2) in any 1 MHz band for angles of arrival between 0 and 5 degrees above the horizontal plane;
- -115 + 0.5 (δ−5) dB(W/m^2) in any 1 MHz band for angles of arrival δ (in degrees) between 5 and 25 degrees above the horizontal plane; and
- -105 dB(W/m^2) in any 1 MHz band for angles of arrival between 25 and 90 degrees above the horizontal plane;

These limits are the same as the ITU PFD limits for 40.5 - 42.0 GHz, as defined in Table 21-4 of the Radio Regulations, but have footnote 11 attached, which states that "the values given in this table entry shall apply to emissions of space stations of NGSO systems operating with 99 or fewer satellites. Further study concerning the applicability of these values is necessary in order to apply them to operating systems of 100 or more satellites.". Despite this footnote, PFD compliance for the Mangata Networks V-band feeder link is shown against these limits in the figure below.

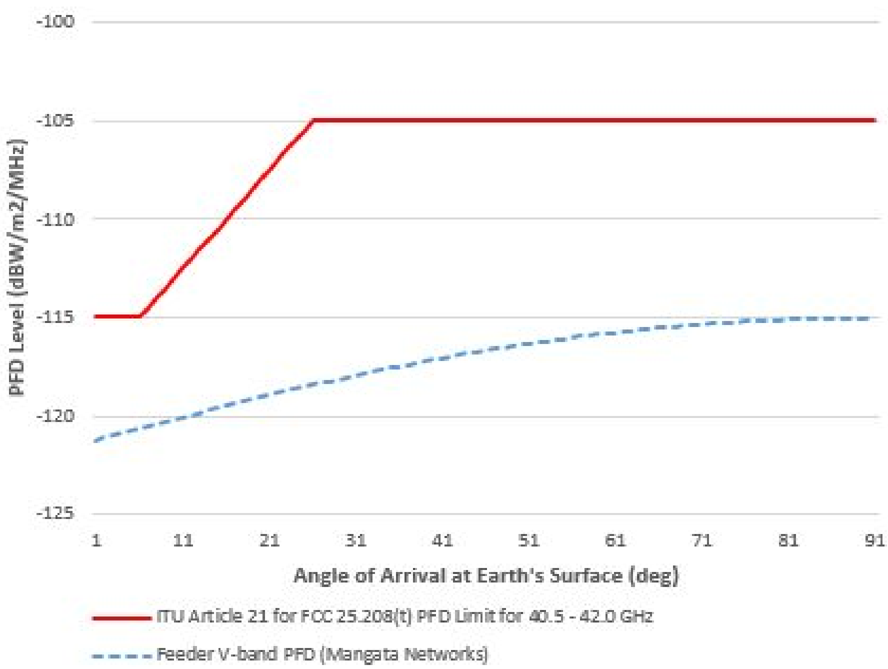

Figure 15. PFD Compliance in 40.5 - 42.0 GHz for the Mangata Network's System

B.5 Downlink PFD Limits in the band 42.0 - 42.5 GHz

The ITU's V-band downlink PFD limits that apply to the 42.0 - 42.5 GHz frequency bands are the same as those in 37.5 - 40.0 GHz, but also have footnote 11 attached, which states that "the values given in this table entry shall apply to emissions of space stations of NGSO systems operating with 99 or fewer satellites. Further study concerning the applicability of these values is necessary in order to apply them to operating systems of 100 or more satellites.". Figure 16 shows the FCC PFD limit along with the PFD produced in this band by a Mangata Networks V-band feeder link.

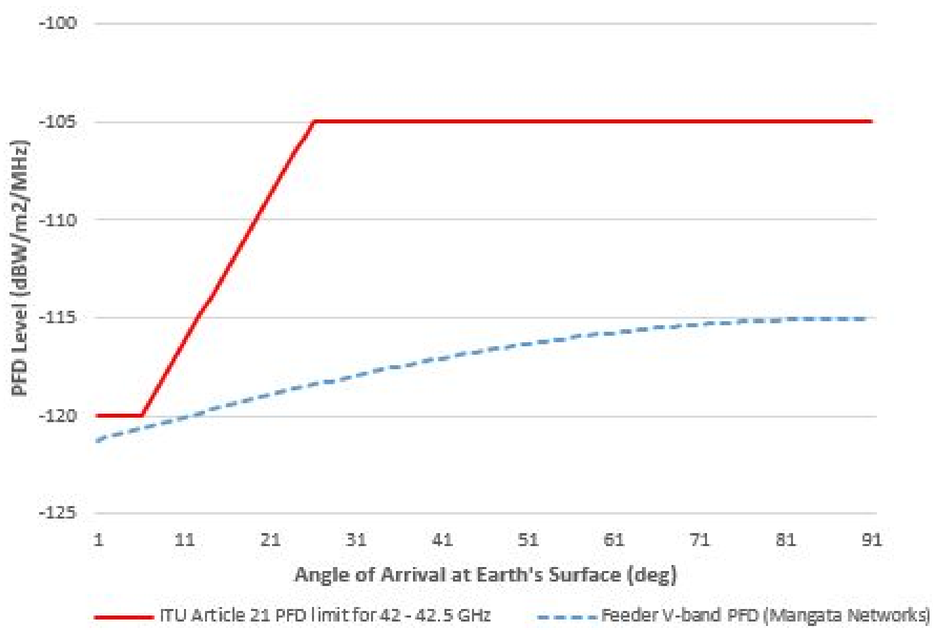

Figure 16. PFD Compliance in 42.0 - 42.5 GHz for the Mangata Network's System

C. Orbital Debris Mitigation

This section provides a description of the design and operational strategies that will be used to mitigate orbital debris, as required in §25.114(d)(14) and 25.283(c).

While the overall system and architectural trades for the Mangata Networks System design have been completed, the individual satellite bus and components selection is still in progress. As such, an overview of the orbital debris mitigation strategy, and a commitment to comply with the Commission's Part §25.114(d)(14) rules pertaining to orbital debris is provided herein, and a full orbital debris showing using NASA's Debris Assessment Software (DAS) will be submitted to the FCC as soon as the design is sufficiently advanced. Mangata Networks stresses that it prioritizes orbital debris assessment and mitigation in its system design and system operations, and is working to implement the latest technology to reduce the likelihood for collision, causality and explosion at any point of the mission life. Additionally, orbital selection was done in such a way to avoid more "congested" orbits.

Under §25.114(d)(A)(5) of the Commission's rules, Mangata Networks certifies that upon receipt of a space situational awareness conjunction warning, it will review and take possible steps to assess the collision risk, and mitigate the collision risk if necessary. These steps will include, but are not limited to: contacting the operator of any spacecraft involved in such warning; sharing ephemeris data and other appropriate information with any such operator; and modifying space station attitude and/or operations.

Mangata Networks' space stations will be trackable as they measure >10 cm in the smallest dimension, excluding deployable components, and therefore in accordance with §25.114(d)(14)(v). Operationally, Mangata Networks will identify the space station(s) following deployment with active tracking, then nominal GNSS for onboard positional and navigation information, and will not only register with, but work closely to share information (initial deployment, ephemeris, planned maneuvers, etc.) with the 18th Space Control Squadron, its successor entity or other entities that engage with space situational awareness or space traffic management (§25.114(d)(v)(A-C)). Additionally, orbital tolerances will be adjusted to maintain 15 km tolerances for apogee and perigee, and 0.5 degree tolerances for inclination and RAAN (§25.114(d)(iv)(4)).

In general, separate orbital debris mitigation approaches will be taken based on whether the satellites are in a HEO or MEO orbit. For HEO orbits with perigee altitudes > 2,000 km, a propulsive maneuver will be planned to position the spacecraft in a disposal orbit at end of life. For HEO orbits with perigee altitudes < 2,000 km, propulsive maneuvers will be conducted to decrease the orbital altitude, such that the satellites deorbit through controlled targeted atmospheric re-entry. Both the disposal orbit and re-entry maneuvers will be conducted in such a way that complies with FCC rules and NASA's Orbital Debris Mitigation Standard (ODMS) Practices[1]. Mangata Networks commits to submitting a more precise explanation of the end-of-life plan to the FCC that includes the:

- Altitudes to which the satellites will be lowered, as well as the number of maneuvers required for perigee and apogee lowering
- Time between the proposed maneuvers
- Fuel quantities for post mission disposal purposes
- Orbital life remaining following completion of the maneuvers

[1] https://orbitaldebris.jsc.nasa.gov/library/usg_orbital_debris_mitigation_standard_practices_november_2019.pdf

- Details concerning propulsion systems - propellant composition, passivation procedures (including the use of any non pressurized systems), and the efficacy of leaving fuel lines if such a system open

It is important to note that in accordance with §25.283(c), Mangata Networks has designed its system with the design requirement to discharge all energy sources by venting excess propellant, discharging batteries, relieving pressure vessels and other appropriate measures.

In addition to providing end-of-life maneuver and propulsion information, Mangata Networks commits to also submitting an Orbital Debris Assessment Report (ODAR), which will show compliance with the FCC's and NASA's Orbital Debris Requirements, and specifically will include an estimate of the:

- Potential energy of surviving debris along with a casualty risk. Noting that Mangata Networks has defined a system requirement for complete demise upon re-entry
- Collision risk for individual satellites that fail at different orbital configurations
- Aggregate collision risk for all satellites planned for launch, assuming satellite failure rates (failure that results in a loss of maneuver capability) of 5, 10, and 15%.
- Potential for a satellite to automatically enter an end-of-life configuration and become a possible source of uncontrolled debris, should the satellite lose communications capabilities with a ground station for an extended period of time

Mangata Networks also commits to complying with the following §25.114(d)(14) requirements, and assessing them quantitatively with a detailed showing, where applicable, after final design review and component selection. Specifically, Mangata Networks will include that it has:

- Assessed and limited the amount of debris released in a planned manner during operations (§25.114(d)(14)(i))
- Assessed and limited the probability that the space station(s) will be a source of debris by collision with small debris or meteoroids that would cause loss of control and prevent disposal (including a statement that indicates if the probability for an individual space station is 0.01 or less, calculated using DAS (§25.114(d)(14)(ii))
- Assessed and limited the probability, during and after completion of mission operations, of accidental explosions or of release of liquids that will persist in droplet form. This will include a demonstration that debris generation will not result from the conversion of energy sources (including chemical, pressure, and kinetic energy) on board the spacecraft into energy that fragments the spacecraft, as well as aforementioned information on depleting residual fuel (§25.114(d)(14)(iii))
- Assessed and limited the probability of the space station becoming debris by collisions with large objects (10 cm or larger in diameter) during the lifetime of the stations, including de-orbit phases, to <0.01 (§25.114(d)(14)(iv)) (§25.114(d)(14)(iv)(A), (§25.114(d)(14)(iv)(A)(1))
- Identified all characteristics of the space station that may present a collision risk, and has indicated which steps have to be taken to coordinate with other spacecraft or systems to avoid collision (§25.114(d)(14)(A)(2)

- Strategically designed, physically and operational, its system to minimize risk of collision and avoid posing any operational constraints to inhabitable spacecraft at any point in the mission or de-orbit phase (§25.114(d)(14)(A)(3)
- Assessed the probability of success of the chosen disposal method to be 0.9 or greater for any individual space station. Since there are multiple space stations in the Mangata Networks system, additional information regarding efforts to achieve a higher probability of success.

As previously mentioned, Mangata Networks considers orbital debris mitigation a foremost priority, and commits to taking appropriate design and operational measures to limit the probability of collision and increase our collective space situational awareness.

D. EPFD Limit Compliance

As required in §25.146(a)(2) and §25.289, the Mangata Network's System complies with applicable equivalent power flux density (EPFD) levels in Article 22, Section II and Resolution 76 of the ITU Radio Regulations. This section summarizes the results of the EPFD assessment providing associated EPFD masks and assumptions applicable for all latitudes and longitudes of the sub-satellite points and differing orbit altitudes. While these masks do pass the ITU's EPFD validation software, Mangata Networks notes that they may not reflect the optimum achievable performance. As such, Mangata Networks will continue to work to integrate techniques to further mitigate the potential to interfere with GSO systems, and will inform the FCC of any potential advancements in its analysis and system operational design.

D.1. Ka-band Uplink EIRP Mask and Uplink EPFD Compliance

Table 4 summarizes the input parameters used for defining the uplink EIRP mask.

Table 4. Input Parameters for Uplink EIRP Mask

Parameter	**Value**	**Unit**
Max. uplink power spectral density ($EIRP_{sd}$)	-32.9	dBW/Hz
Satellite beam gain	43.2	dBi
Topocentric Avoidance Angle ($\boldsymbol{\alpha}_{GSO}$)	3	deg
Frequency	27.5	GHz
Radius of Earth	6378.145	km
Minimum operating altitude	4000	km
Number of satellites providing service to the same point (n_{sat})	4	

In addition to these parameters, a Rec. ITU-R S.465 earth station antenna pattern, along with a frequency reuse of 8, and an FDMA access scheme were used in defining the EIRP mask and in showing uplink EPFD compliance.

The uplink EIRP mask is found by combining the maximum power spectral density in the system (-32.9 dBW/Hz for the TT&C links) with Rec. ITU-R S.465. Figure 17 shows uplink EPFD compliance, and specifically Ka-band uplink EPFD of the Mangata Networks system against the uplink EPFD limit as defined in Table 22-2 of the ITU Radio Regulations (a limit of -162 dBW/m^2/40 kHz of which to never exceed).

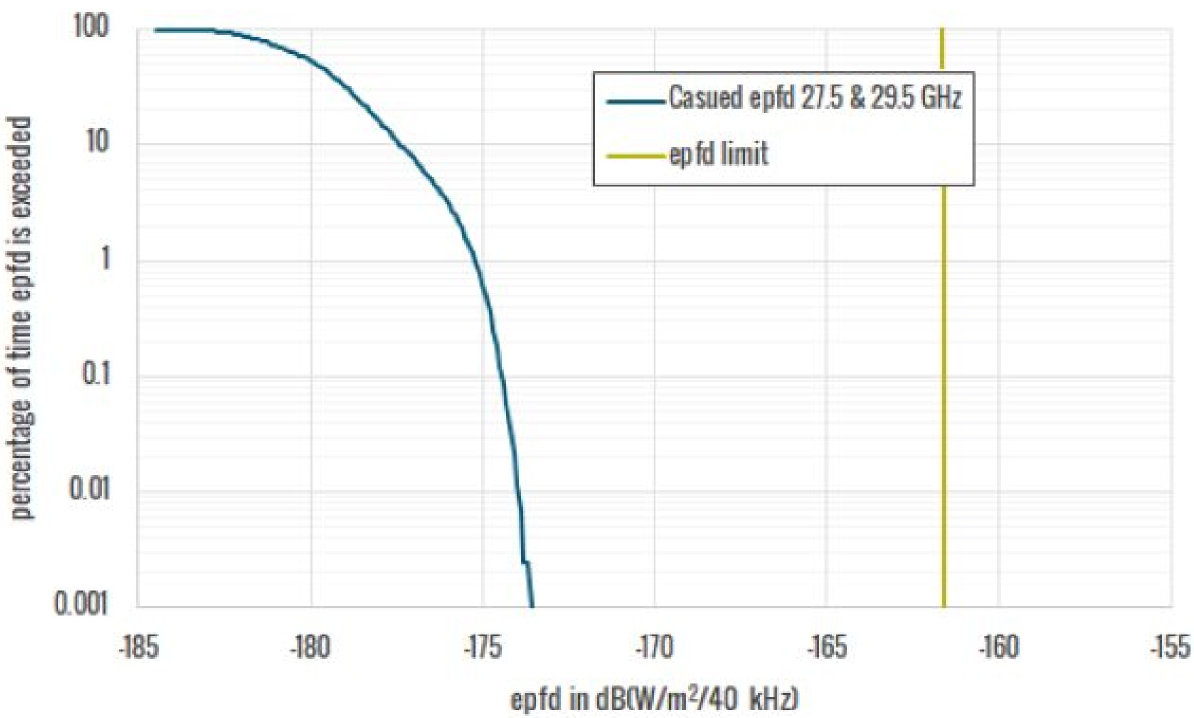

Figure 17. Ka-band uplink EPFD compliance for the 27.5 - 28.6 GHz and 29.5 - 30 GHz bands

D.2. Ka-band Downlink PFD Mask and Downlink EPFD Compliance

To show downlink EPFD compliance, a generic approach that assumes the same PFD mask for all orbital planes was taken. A higher fidelity approach that defines the PFD masks as a function of the different orbital parameters, and for the HEO orbits a PFD mask per longitude of the sub-satellite point could yield improved results. The following parameters were used to derive the PFD masks: a maximum downlink EIRP density of -87.2 dBW/Hz, a minimum elevation angle of 15 degrees, a minimum orbital altitude of 4000 km, a frequency of 18.2 GHz and a Rec. ITU-R S.1428 GSO terminal reference pattern. Incorporating these inputs and a resulting PFD of -141 dB(W/m^2/40 kHz) at the sub-satellite point (90 degrees earth station elevation), produces the PFD mask shown in Figure 18 below, valid for 17.8 - 18.6 GHz.

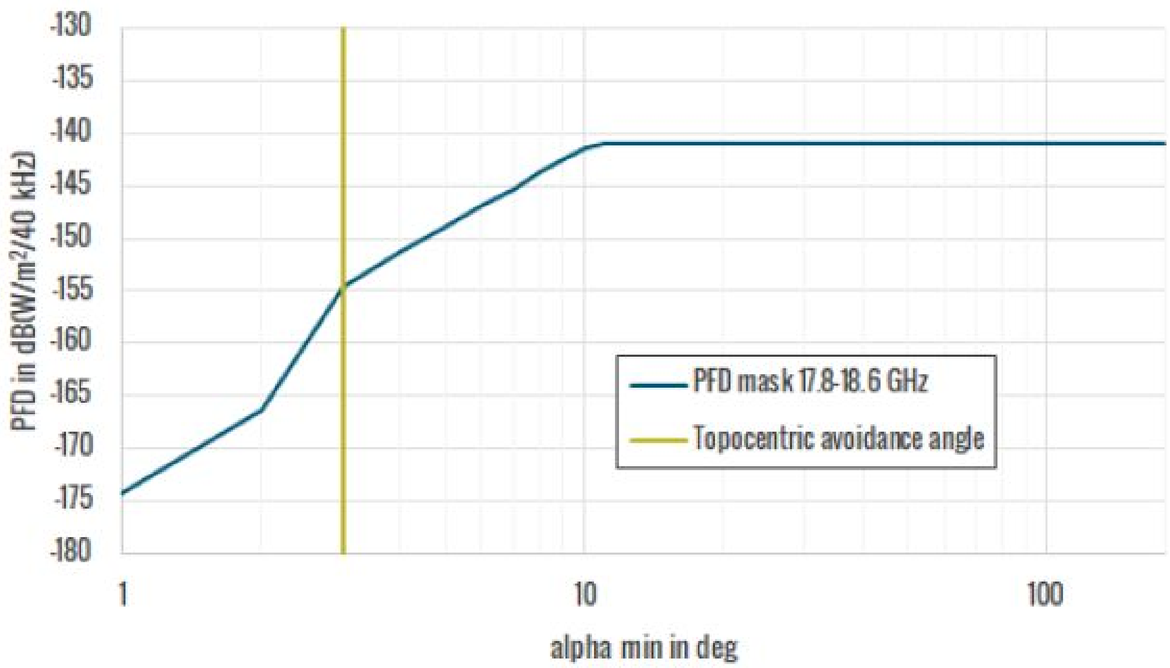

Figure 18. Ka-band (17.8 - 18.6 GHz) downlink PFD mask for the Mangata Networks System

. Figure 19 and Figure 20 show the application of the pfd mask, in the 17.8 - 18.6 GHz frequency band, not only for the protection of one GSO orbit location, but for the protection of the GSO arc as seen from the NGSO orbit at a NGSO latitude of 0 degrees and 15 degrees, respectively.

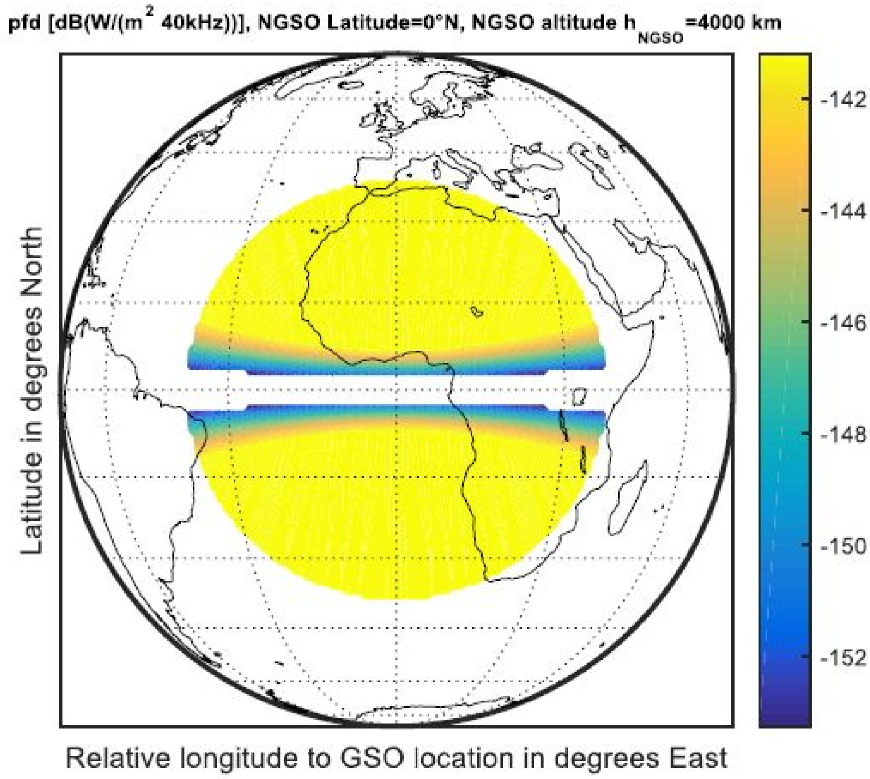

Figure 19. Ka-band (17.8 - 18.6 GHz) PFD mask at an NGSO Latitude of 0 degrees N, and an NGSO altitude of 4000 km

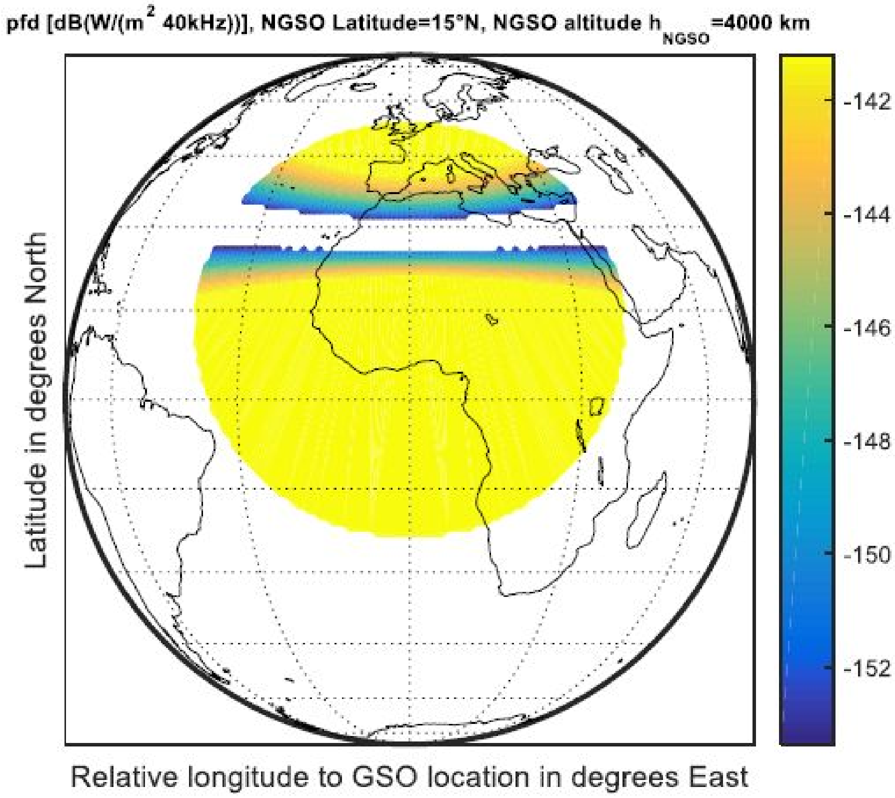

Figure 20. Ka-band (17.8 - 18.6 GHz) PFD mask at an NGSO Latitude of 0 degrees N, and an NGSO altitude of 4000 km

The downlink EPFD computed using the ITU EPFD validation tool is provided in Figure 21, and is shown to comply with the downlink EPFD limits documented in Table 22-1B of the ITU Radio Regulations.

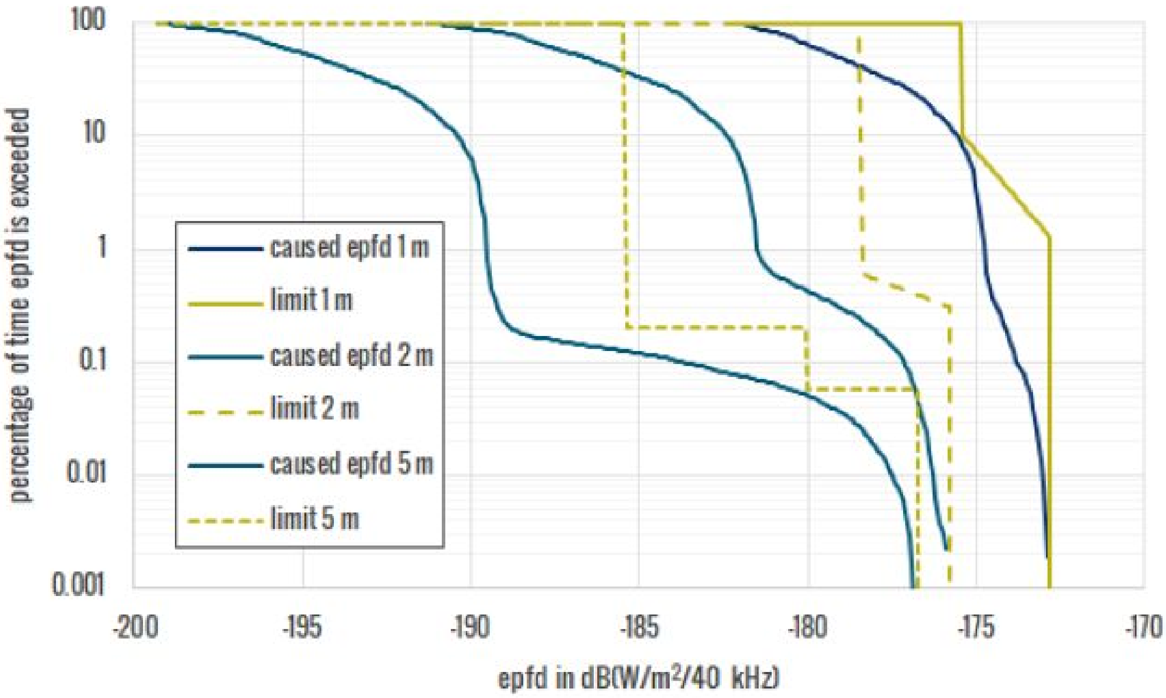

Figure 21. Ka-band downlink EPFD compliance in the 17.8 - 18.6 GHz frequency band

To show downlink EPFD compliance in the 19.7 - 20.2 GHz band, a similar approach was taken to produce the PFD mask, but with a frequency of 19.7 GHz, as opposed to 18.2 GHz in the lower band. Figure 22 depicts the downlink PFD mask in the 19.7 - 20.2 GHz band for the Mangata Networks System.

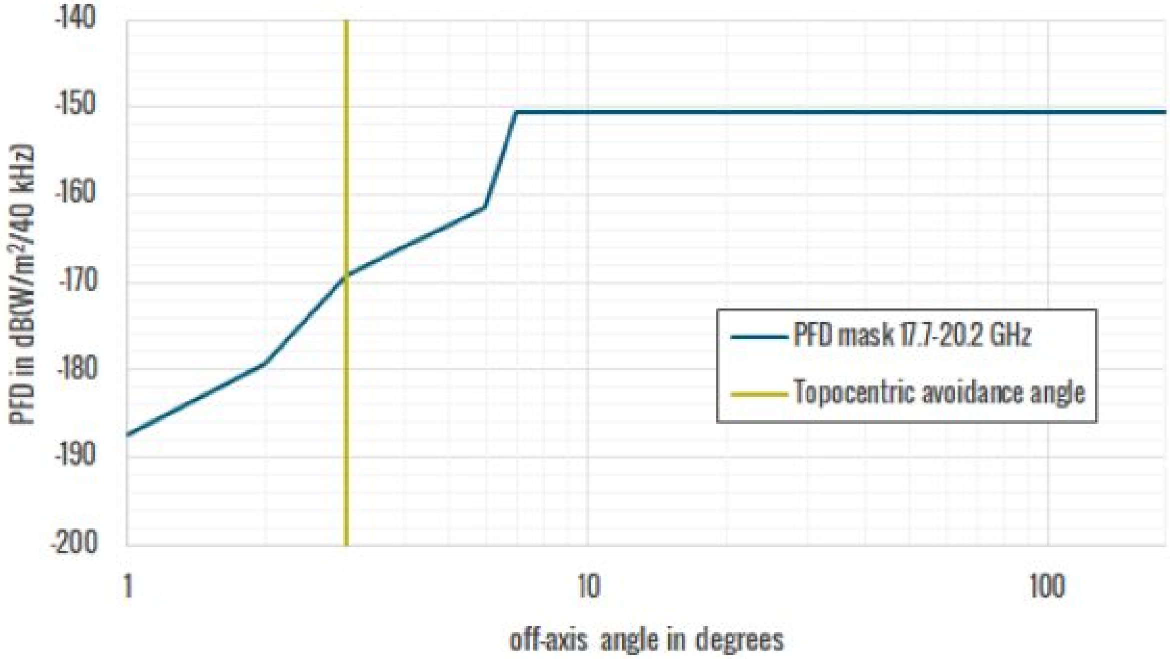

Figure 22. Ka-band (19.7 - 20.2 GHz) downlink PFD mask for the Mangata Networks System

Figure 23 and Figure 24 show the application of the pfd mask, in the 19.7 - 20.2 GHz frequency band, not only for the protection of one GSO orbit location, but for the protection of the GSO arc as seen from the NGSO orbit at an NGSO latitude of 0 degrees and 15 degrees respectively.

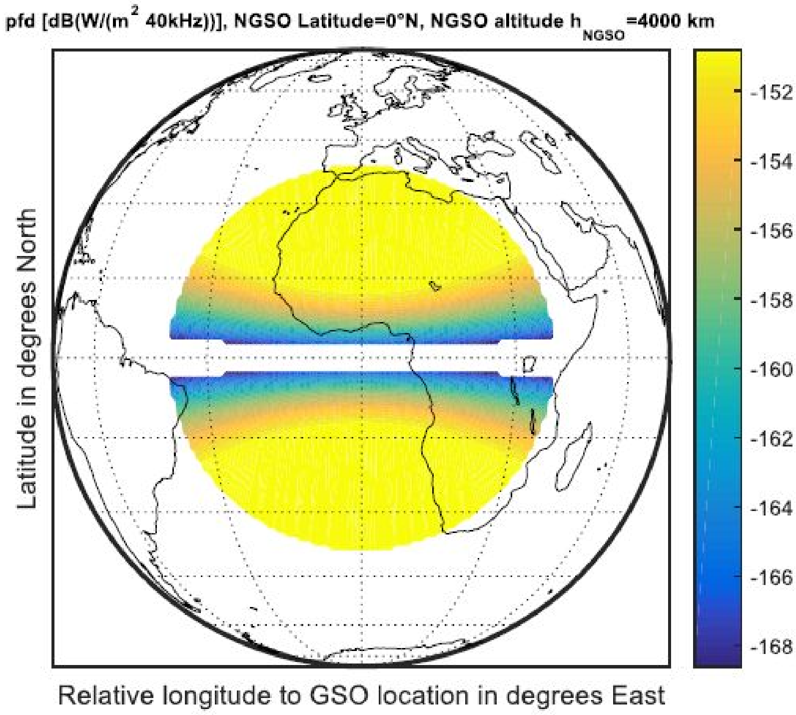

Figure 23. Ka-band (19.7 - 20.2 GHz) PFD mask at an NGSO Latitude of 0 degrees N, and an NGSO altitude of 4000 km

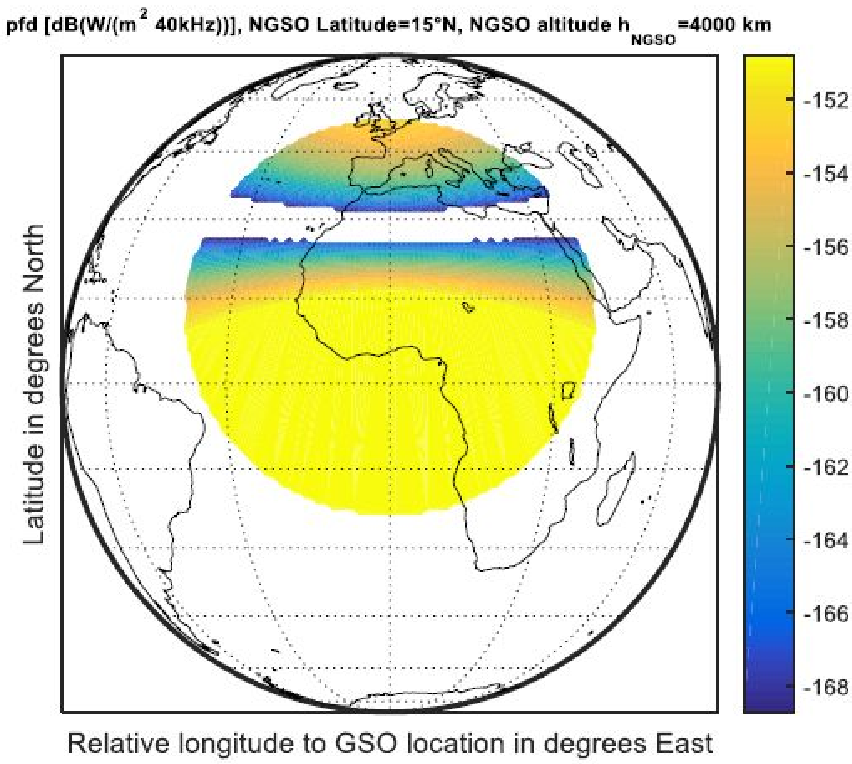

Figure 24. Ka-band (19.7 - 20.2 GHz) PFD mask at an NGSO Latitude of 15 degrees N, and an NGSO altitude of 4000 km

The Ka-band (19.7 - 20.2 GHz) downlink EPFD validation results computed from the PFD mask provided, applied to the complete constellation, are shown in Figure 25, and comply with the limits set forth in Table 22-1C of the ITU Radio Regulation.

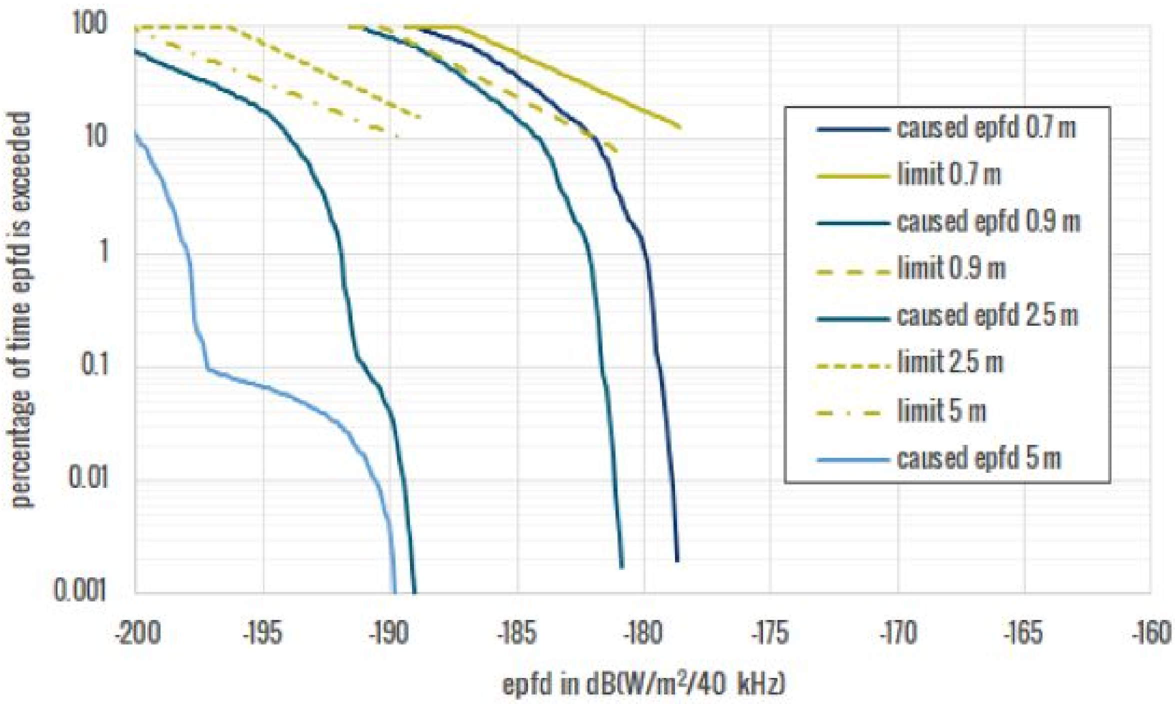

Figure 25. Ka-band downlink EPFD compliance in the 19.7 - 20.2 GHz frequency band

D.3. Ka-band Intersatellite (IS) Mask and EPFD Compliance

To generate the intersatellite transmit mask, Section 1.3 of the ITU-R S.1528 space station antenna specification, which is for MEO networks, was combined with the maximum EIRP spectral density. The resulting EPFDis is provided in the figure below.

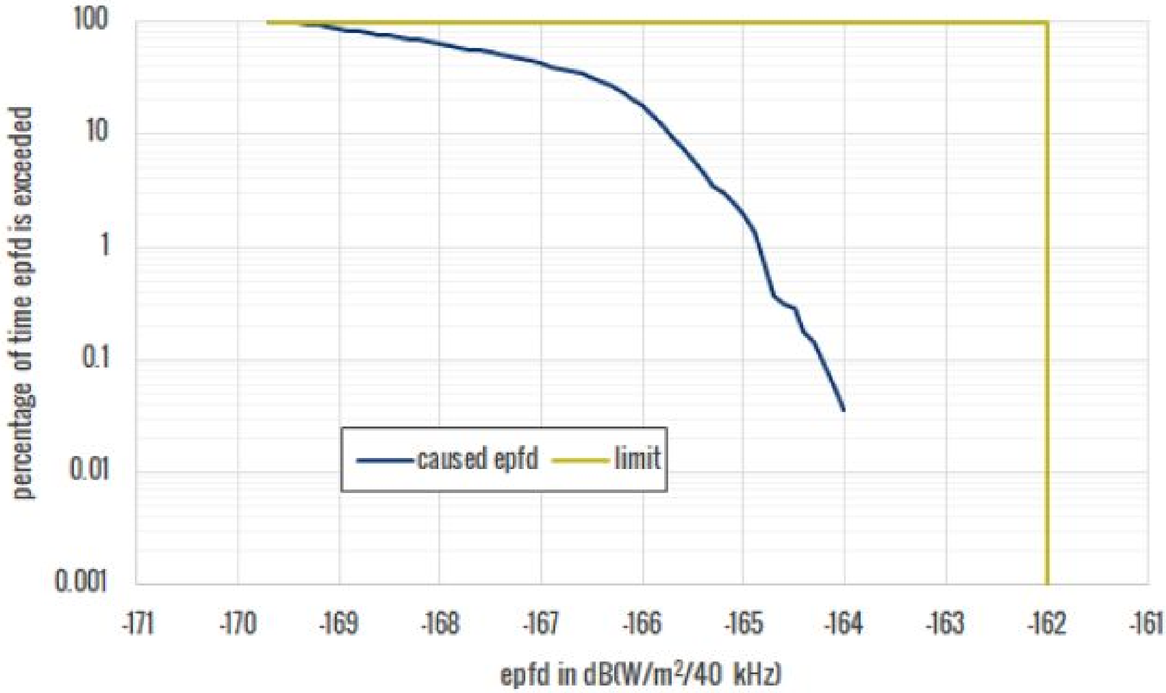

Figure 26. Ka-band EPFDis Compliance

E. Sharing among NGSO FSS Space Stations

Regulation §25.261 of the Commission's rules applies to sharing among NGSO FSS space stations operating with earth stations that consist of directional antennas anywhere in the world under a Commission license, or in the U.S under a grant of U.S. market access. Mangata Networks will comply with §25.261(a) and coordinate in good faith with other NGSO FSS operators using overlapping frequencies. It also commits to working closely with other NGSO operators to exchange operational information and develop novel techniques for spectrum sharing.

In combination with good faith coordination, the Mangata Networks' NGSO system, which consists of on-board processing and channelization, the use of diversity sites, steerable and shapeable spot beams, and state of the art network control facilities, will be capable of inline interference avoidance over various spectral, temporal and geographic scale and spectrum sharing among other NGSO systems. These design features and commitment to coordination will negate the necessity for band segmentation as defined in §25.261(c).

E.1 Sharing Between NGSO MSS Feeder links and Earth Stations

Mangata Networks will also comply with the rules contained in §25.257, which govern sharing between NGSO MSS feeder links and earth stations in the 19.3 - 19.7 GHz and 29.1 - 29.5 GHz bands, specifically.

In doing so, Mangata Networks will cooperate fully with other NGSO MSS operators to identify mutually acceptable locations for earth station complexes as required in §25.257(e), will deploy at most seven feeder link earth station complexes in the contiguous U.S., Alaska and

Hawaii, in the largest 100 MSAs, in the 29.1 - 29.25 GHz band, as defined in §25.257(b), and will comply with the other feeder link earth station location requirements in §25.257(c).

Mangata Networks is confident in its ability to share with existing NGSO MSS systems, because employees of Mangata Networks have successfully assessed coexistence and coordinated previous systems with existing NGSO MSS systems in this band, namely Iridium, prior to the formation of Mangata Networks.

F. Schedule S Nomenclature

This section provides an explanation behind the beam and channel nomenclature contained in the associated Schedule S.

The Beam IDs were named with the following system:

- First Character: E (Emission) / R (Reception)
- Second Character:U (User) / F (Feeder) / B (Both User + Feeder) / T (TT&C)
- Third Character: L (LHCP) / R (RHCP)
- Fourth Character: Beam Number

The Channel IDs were named with the following system:

- First Character: S (Service) / F (Feeder) / T (TT&C)
- Second Character: L (LHCP) / R (RHCP)
- Third/Fourth Characters: Channel ID incremented starting at 01 for each link type.

CERTIFICATION OF PERSON RESPONSIBLE FOR PREPARING ENGINEERING INFORMATION

I hereby certify that I am the technically qualified person responsible for preparation of the engineering information contained in this application, that I am familiar with Part 25 of the Commission's rules, that I have either prepared or reviewed the engineering information submitted in this application and that it is complete and accurate to the best of my knowledge and belief.

/s/ Ken Mentasti
Ken Mentasti
Systems Architect
Mangata Networks LLC

Date: May 25, 2020