Attachment B – Regulatory Compliance Matrix

Reference	Reference Location	Topic
25.114(a)(1)	Form 312, Schedule S	Overall context of filing
25.114(a)(2)	Schedule S, Attachment, Narrative	NGSO Constellation
25.114(a)(3)	N/A	Application filed pursuant to two-step procedure
25.114(b)	Form 312	Waiver required by 47 U.S.C. §304
25.114(c)(1)	Schedule S, Narrative	Applicant information
25.114(c)(2)	Schedule S	Information for correspondence individual
24.114(c)(3)	Narrative	Type of authorization
25.114(c)(4)(i)	Schedule S, Attachment C – Section 5	Channel frequency, bandwidth, and polarization
25.114(c)(4)(ii)	Schedule S	Maximum EIRP and EIRP density
25.114(c)(4)(v)	Schedule S	RX bean: G/T, SFD
25.114(c)(4)(vi)(B)	Schedule S, Attachment C – Exhibit 1	NGSO Antenna Gain Contours
25.114(c)(4)(vi)(C)	Schedule S, Attachment C – Exhibit 1	Shapeable beam Antenna Gain Contours
25.114(c)(4)(vi)(D)	Schedule S, Attachment C – Exhibit 1	Steerable non-shapeable beam contours
25.114(c)(6)(i-ix)	Schedule S, Attachment C – Section 3.1	NGSO: Orbital Parameters
25.114(c)(7)	Schedule S, Attachment C – Section 2	Frequency Bands, Types of Service, and Coverage Areas
25.114(c)(8)	Schedule S	Max Power Flux-Density levels
25.114(c)(10)	Schedule S	Operational Lifetime
25.114(c)(11)	Schedule S	Common Carrier Status
25.114(c)(13)	Schedule S	Polarization information
25.114(d)(1)	Narrative, Attachment C	Overall description
25.114(d)(6)	Narrative	Public interest
25.114(d)(12)	Narrative, Attachment C – Section 7	NGSO FSS
25.114(d)(14)(i-v)	Narrative, Attachment C – Section 8	Orbital Debris
25.136	Narrative, Attachment C – Section 7	UMFUS Sharing Restrictions
25.137	Narrative	Requests for U.S. market access through non-U.S.-licensed space stations
25.146(a, c, d)	Narrative, Attachment C – Section 7	Licensing and operating provisions for NGSO FSS space stations
25.146(e)	Attachment C – Section 8	Sharing Ephemeris Data
25.202(a)(1)	Narrative, Attachment C – Section 7	Sharing with UMFUS
25.202(a)(10)(ii)	Narrative, Attachment C – Section	Ku/Ka bands available for use by ESIMs communicating with NGSO FSS space stations
25.202(e)	Attachment C – Section 5.4	Frequency Tolerance
25.202(f)	Attachment C – Section 5.5	Emission Limitations

25.202(g)	Attachment C – Section 3.2.3	TT&C - Not at band edge
25.202(j)	Attachment C – Section 7.2	V-band FSS Unwanted Emission Levels (49.7-50.2, 50.4-50.9 GHz)
25.207	Attachment C – Section 5.7	Cessation of Emissions
25.208(r)	Attachment C – Section 7	PFD Limits
25.208(s)		
25.208(t)		
25.208(u)		
25.250	Attachment C – Exhibit 2	Sharing between NGSO MSS feeder link stations
25.257	Attachment C – Section 7.2	Special requirements for NGSO MSS operations
25.258	Attachment C – Section 7.2	Sharing between NGSO MSS FL and GSO FSS
25.261	Attachment C – Section 7	Sharing among NGSO FSS space stations
25.289	Attachment C – Section 7	NGSO/GSO interference

Attachment C - Technical Annex

Technical Annex

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Technical Annex

This Technical Annex contains a description of technical aspects of the SN Space Systems Limited non-geostationary orbit ("NGSO") satellite system (the "Constellation") required by Part 25 of the Federal Communications Commission ("Commission") rules, including information that cannot be entered into the Schedule S online submission system. Where indicated, this Technical Annex includes reference frequencies for which U.S. market access is not requested to provide a comprehensive overview of the Constellation but such frequencies are not included in the Schedule S.

1. General Description (Section 25.114(d)(1))

The Constellation will consist of 1190 active NGSO satellites[1] equally spaced on a unique, single-track orbit that results in repeating ground tracks above the surface of the Earth, along with another 60 spare satellites in lower parking orbits.

The Constellation will provide fixed and mobility satellite broadband applications between 62.5°N and 62.5°S latitude. Without any inter-satellite links, the communications payload on each Constellation satellite will be active only when in view of a gateway earth station.

Figure 1 below illustrates the Constellation's unique orbit.[2] Each satellite is station-kept so that the ground track traced out by the satellite is exactly the same on each day of the satellite's mission life.

[1] SN Space Systems would note that approximately 625 satellites are needed to commence initial commercial operations.

[2] The ground track in *Figure 1* reflects ground tracks optimized for U.S. coverage and could potentially be adjusted as a result of coordination or other factors. In the event of an adjustment, SN Space Systems will update the information filed with the Commission but any such adjustment would not materially affect the spectrum sharing capabilities of the Constellation.

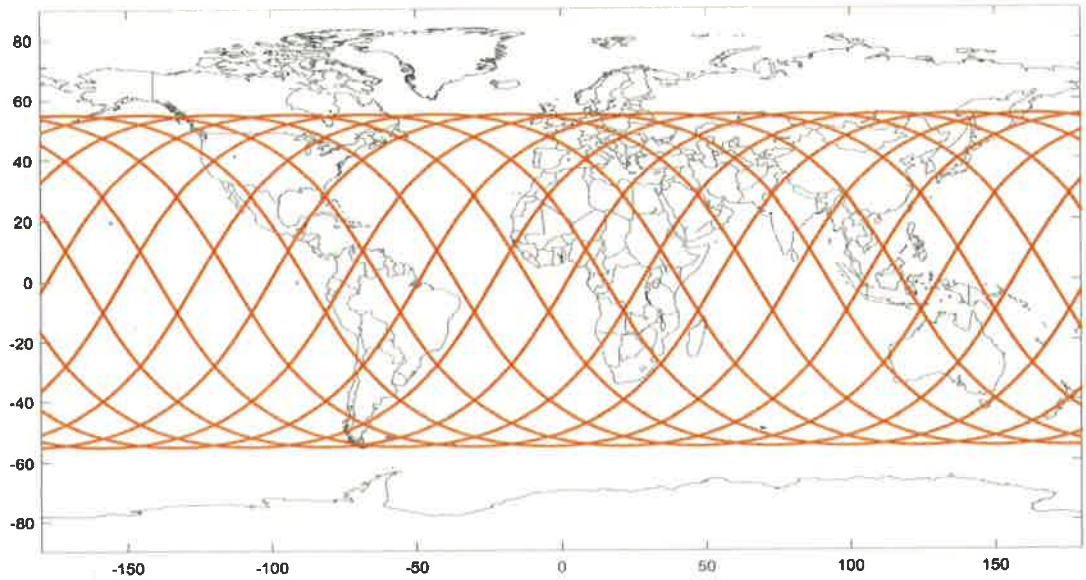

Figure 1 Constellation Repeating Ground Track

Constellation satellites use exactly the same orbit with different right ascensions so as to create the appearance of a fixed line of satellites in the sky. Some locations on the Earth's surface, especially near the equator, can see only one fixed line of satellites in the sky. Other locations can see multiple fixed lines of satellites. This concept is illustrated in *Figure* 2.

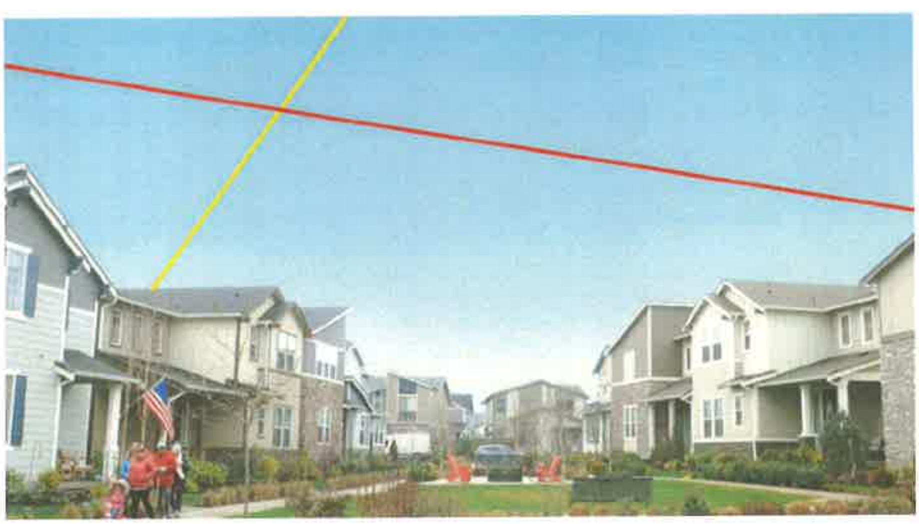

Figure 2 Fixed Satellite Tracks in the Sky

Relative to the center of the Earth, the satellites are spaced about 4.2° apart in one fixed line. This spacing becomes much wider when viewed from the surface of the Earth. Relative to any location on the surface of the Earth, the satellites are between 17.8° apart (when along the horizon) and 33.4° (when directly overhead), which prevents adjacent satellites in a line from interfering with each other. Of course, such separation will not exist as northbound satellites cross southbound satellites in the repeating ground track but interference is avoided by using frequency diversity or orthogonal polarizations.

Because the Constellation satellites travel along a fixed line in the sky, stationary user terminals and gateway antennas can employ fixed toroidal reflector antennas with a field of view of as much as 120° to see as many as six satellites simultaneously. A toroidal reflector is more efficient, less costly, suffers no scan loss, and can operate at lower power spectral densities than comparably sized electronically steered array antennas. Furthermore, including multiple feeds on a toroidal antenna can support simultaneous communications with multiple satellites, enabling link bonding for higher throughput and continued network connection even if communications with one or more satellites must be temporarily suspended to address inline interference events. *Figure 3* illustrates a toroidal antenna.

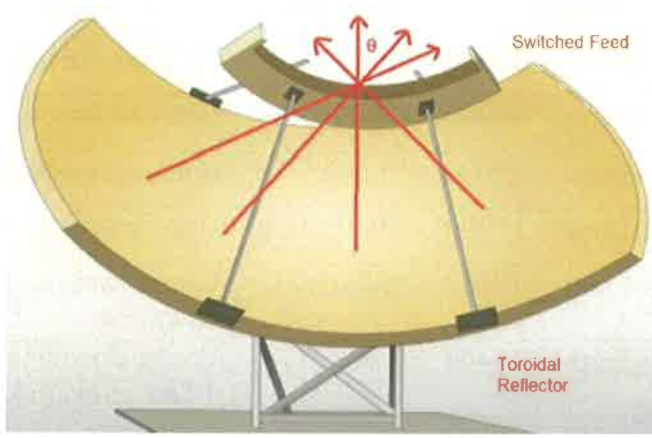

Figure 3 Toroidal Antenna

Mobility terminals will employ different types of steerable antennas depending on application. Some mobility terminals may produce a single beam for interruption-tolerant applications like intermittent store-and-forward data delivery while other mobility terminals may produce multiple beams to support premium applications that require higher availability.

The full range of user terminals and applications to be served continue to be refined and, like all Constellation earth stations, will be the subject of future earth station applications seeking to communicate with the Constellation from the United States. In addition, all earth station operations will be subject to the Constellation's advanced network management capabilities to ensure compatibility with other co-frequency operations.

2. Spectrum Plan

The Constellation will operate under the SN-CONSTELLATION1 satellite network filing submitted by the United Kingdom at the International Telecommunication Union ("ITU"). The Constellation will operate gateway links in the V-band (downlink/uplink), Ku-band (uplink), and Ka-band (uplink) frequencies, as well as user links in the Ku-band (uplink) and Ka-band (downlink) frequencies, as described more fully herein. Telemetry, tracking, and command ("TT&C") links will operate in Ku-band (uplink) and Ka-band (downlink) frequencies. The Constellation spectrum plan is indicated in Table 1 below.

Table 1 SN Space Systems Spectrum Plan

V-band	Earth-to-space	47200 - 50200 MHz	Gateway uplink
	Earth-to-space	50400 – 51400 MHz	Gateway uplink
	space-to-Earth	37500 - 40000 MHz	Gateway downlink
	space-to-Earth	40000 – 42000 MHz	Gateway downlink
Ka-band	Earth-to-space	27000[3] – 30000 MHz	Gateway/feeder (MSS) uplink
	space-to-Earth	17700[4] – 19300 MHz	User downlink, TT&C downlink[5]
	space-to-Earth	19300 – 19400 MHz	User downlink (ESIM), TT&C downlink
	space-to-Earth	19400 – 19600 MHz	Feeder downlink (MSS), TT&C downlink
	space-to-Earth	19600 – 19700 MHz	User downlink (ESIM)
	space-to-Earth	19700 – 20200 MHz	User downlink
Ku-band	Earth-to-space	13750 – 14000 MHz	Gateway uplink, TT&C
	Earth-to-space	14000 – 14500 MHz	User uplink

[3] The 27000 – 27500 MHz band will be used for FSS Earth-space operations in parts of Region 2 (not including the United States) and Region 3. SN Space Systems is not requesting market access using this band and did not include this band in the Schedule S.

[4] The 17700 – 17800 MHz band will be used for FSS space-Earth services in Region 1, portions of Region 2 (not including the United States) and Region 3. SN Space Systems is not requesting market access using this band and did not include this band in the Schedule S.

[5] TT&C downlinks will be conducted in the 19200 – 19300 MHz sub-band only.

3. Space Segment Overview

The space segment of the Constellation will consist of 1190 active repeating ground-track satellites. Each satellite will employ eight-color frequency reuse among user beams. Gateway beam operates across all available gateway spectrum in both polarizations because the teleports will be sited sufficiently far apart from each other to prevent interference among beams.

All of the antennas in the bent-pipe repeater satellite payload are array-fed lens antennas, each of which can form multiple steerable and shapeable beams without losing any gain (except for scan loss) as the number of beams increases. Every antenna in the payload can generate beams in both circular polarizations.

The bent-pipe payload employs a channelizer that breaks each receive beam into its constituent carriers, translates every carrier to an intermediate frequency (IF), and inserts every carrier individually into an analog switch. The analog switch dynamically maps each received carrier to the assigned transmit carrier on the assigned downlink beams. The switch updates the mapping between uplink beams/carriers and downlink beams/carriers continuously as the satellite passes over different regions.

With this dynamic channelizer and IF switch, the payload is capable of translating, on the return link, any uplink carrier from any user receive beam to any downlink carrier on any downlink gateway beam. Similarly, the payload is capable of translating, on the forward link, any uplink carrier from any gateway receive beam to any downlink carrier on any downlink user beam.

On each satellite, a Ka-band transmit antenna produces up to 140 user downlink beams (in any combination of RHCP and LHCP) while a separate Ku-band receive antenna produces up to 140 user uplink beams (in any combination of RHCP and LHCP). Each satellite also has four multi-beam lens antennas to produce 10 Ku-band gateway link receive beams (five RHCP and five LHCP), 10 Ka-band gateway link receive beams (five RHCP and five LHCP), 10 V-band gateway link receive beams (five RHCP and five LHCP), and four V-band gateway link transmit beams (two RHCP and two LHCP), respectively.

The gateway links connect each satellite to teleports on the ground. At each teleport, gateway/ feeder link earth stations are deployed in groups of five: (i) a Ku-band earth station to uplink forward-link traffic; (ii) a Ka-band earth station to uplink forward-link traffic; (iii) a Ka-band earth station to receive return-link traffic; (iv) a V-band earth station to uplink forward-link traffic; and (v) a V-band earth station to receive return-link traffic. The gateway earth station antennas may include multi-band feed arrays and may share the same physical aperture. There can be up to five earth station groups to access up to five different satellite lines each teleport.

Forward-link carriers are received by a satellite from as many as five teleports on 10 Ku-band beams (five RHCP and five LHCP) through a Ku-band receive-only antenna, 10 Ka-band beams (five RHCP and five LHCP) through a Ka-band receive-only antenna, and 10 V-band beams (five RHCP and five LHCP) through a V-band receive-only antenna.

For each of the 140 Ka-band downlink user beams, a satellite typically produces an overlapping uplink user beam. If a user link experiences excessive uplink or downlink interference in certain link directions, uplink and downlink communications can be provided by different satellites not experiencing such interference.

3.1 Constellation Design

The Constellation consists of 1190 active repeating ground-track satellites with the following characteristics:

Table 2 Constellation Summary

Orbit altitude (km)	830
Inclination (deg)	55
No. of satellites	1190
No. of orbital planes	1190
Orbital period (sec)	6090
Orbits per repeat ground track	14
Min. gateway elev. angle (deg)	35
Min. user terminal elev. angle (deg)	30
Min. TT&C earth station elev. angle (deg)	30 (primary) 5 (back-up)

With this configuration, although each satellite may be considered to be in its own individual orbital plane (*i.e.*, it has the same number of planes as satellites), all Constellation satellites are effectively in the same orbit but offset in time. The time offset per satellite is one sidereal day divided by the number of satellites in the constellation which results in an interval of approximately 72.4 seconds.

SN Space Systems also seeks to deploy 60 in-orbit spares to reduce the time needed to replace a satellite. SN Space Systems will coordinate the physical operation of the Constellation with and through appropriate UK, U.S. and other governmental officials and international organizations.

Due to the number of satellites in the Constellation and the limitations of the online Schedule S system, a subset of satellite information has been entered into Schedule S with the full Constellation information included as a spreadsheet attachment to the Schedule S.

3.1.1 Constellation Coverage/Multiple-Coverage

The Constellation will provide fixed and mobility satellite broadband applications between 62.5°N and 62.5°S latitude, which include the vast majority of the U.S. population (and large majority of its territory), with the exception of northern Alaska. A depiction of the coverage of the Constellation is shown in Figure 4.

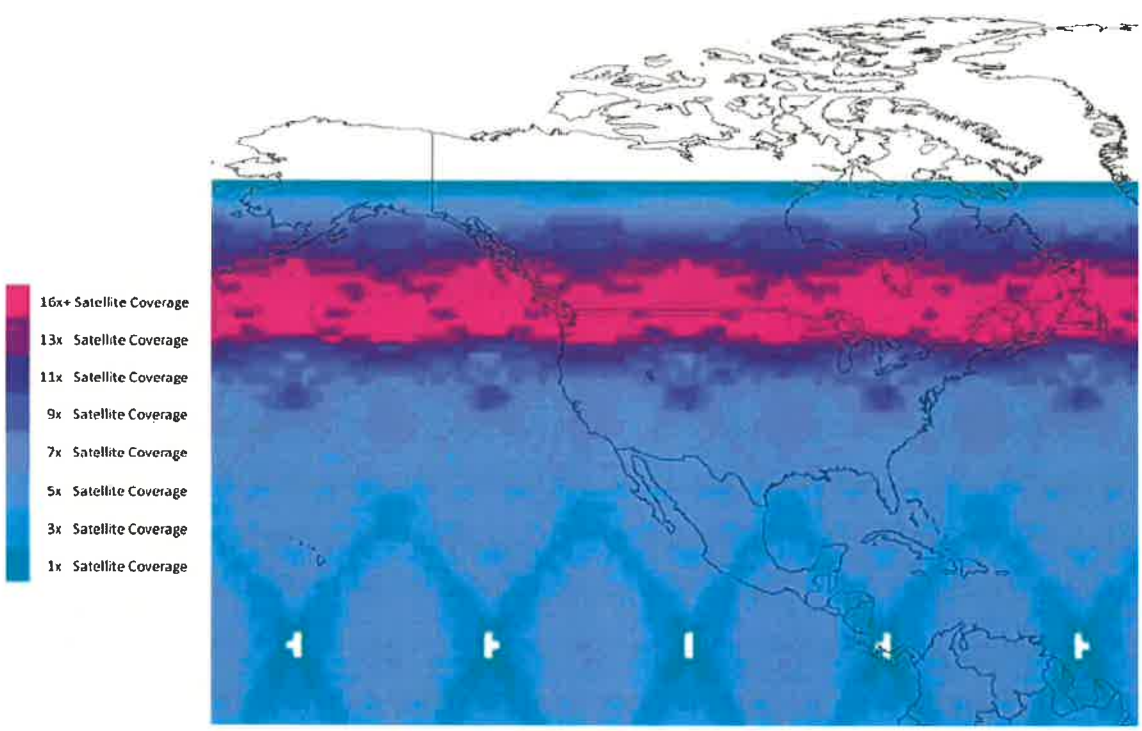

Figure 4 Constellation Coverage Map – North America

Due to its repeating ground tracks, multiple-satellite coverage of the Constellation varies by both latitude and longitude. The Constellation provides coverage from a minimum of 16 satellites over the northern part of the United States and southern Canada. Coverage from a minimum of three to four satellites is generally provided over the contiguous United States ("CONUS"), with some additional coverage limitations experienced at certain latitudes in areas roughly equidistant between repeating ground tracks.

SN Space Systems' gateway/feeder link earth station sites generally will be designed to operate with the maximum number of Constellation satellites in view. User terminals will typically be designed to communicate with satellites along the closest or most accessible satellite track.

Examination of the Constellation's multiple coverage characteristics supports the conclusion that it can effectively share spectrum with co-frequency systems pursuant to the Commission's rules and policies. The ability to provide service within the United States using multiple satellites suggests that communications with certain satellites can be suspended to avoid inline interference events while maintaining communications using other serving satellites. Furthermore, SN Space Systems believes that service interruptions, if any, would be rare, brief, and manageable.

3.2 Satellite Design

Each SN Space Systems satellite will have a wet mass of approximately 200 kg, with approximately 350 Watts of mean on-orbit power. Each satellite's power management system will be able to process up to 1500 Watts of peak power from the solar panels to the batteries and up to 1000 Watts of peak power from the batteries to the onboard electrical power system.

The satellites will have a five-year operational design life. In addition to surviving traditional launch environments, the satellites are being designed specifically to survive the high acceleration and centrifugal forces that are expected during the kinetic launch process offered by SpinLaunch. The satellite design includes orbital control, power generation and storage, flight control, and satellite pointing capabilities. The satellite communications payload will be placed into operation once the satellite is in its intended orbital position, nadir pointing, and in communication with the primary TT&C, the network management system, and gateway earth stations.

Extensive TT&C capability exists onboard each spacecraft, allowing for both onboard automated controls and the capability to control each spacecraft via ground command, as well as to update the flight software as needed. Primary TT&C and payload control/monitoring services use the same electronically steered Ka-band band transmit antennas and Ku-band receive antennas used for service links. Back-up TT&C uses the same TT&C frequencies but will operate using a set of lower-gain antennas that work together to provide full spherical coverage.

A combination of onboard and ground control measures will be implemented for collision avoidance, including those resulting from coordination of the physical operations of the Constellation with other satellite systems. Additional information regarding SN Space Systems' approach to collision avoidance and minimizing orbital debris is provided in Section 8, below.

3.2.1 Satellite Bus Operations and Deorbit

The satellite bus will be designed to handle the unique launch environment of the SpinLaunch kinetic launch system while providing the required capabilities to support the Constellation's communications mission. The solar arrays are sized to provide over 1500W of power at end of mission-life.

As shown in the propulsion budget provided in **Error! Reference source not found.**, each satellite carries enough propellant for orbit-raising, deorbiting, station-keeping, and collision-avoidance maneuvers. A 1.25 km/s delta-V budget in the electric propulsion system accounts for all active propulsion phases of the satellite. The 1.25 km/s delta-V budget also includes a significant margin for unforeseen contingencies.[6]

All software and hardware components needed to de-orbiting a satellite are designed for high reliability and includes significant redundancy. Typical deorbits periods using propulsion are expected to be one year. Additional deorbiting mechanisms are also being considered, such as an electrodynamic tether to deorbit the satellite should the propulsion system be unusable.

[6] Analysis using NASA DAS 3.1.2 Orbital Debris simulation software suggests that 225-250 m/s of delta-V would be sufficient to lower the orbit altitude from 830km circular to below the ISS at 400km.

Table 3 SN Space Systems Satellite – Propulsion Budget

Estimated Delta-V (with contingency) per satellite:	
Parking Orbit	0.25 km/s
Orbit-raising	0.25 km/s
Station-keeping and Collision Avoidance	0.25 km/s
Deorbit (including significant margin)	0.5 km/s
Total Delta-V Budget:	1.25 km/s

Additional information regarding SN Space Systems' approach to deorbiting and minimizing orbital debris is provided in Section 8, below.

3.2.2 Communications Payload

The SN Space Systems satellite uses an array-fed lens antenna to generate multiple simultaneous co-frequency steerable and shapeable gateway and user link transmit and receive beams. Beam projections were created in GIMS using the GSO footprint tool. Note that this results in nadir beam projections that are equatorial and outside U.S. territory. SN Space Systems has supplemented those GIMS projections with beam projections images over U.S. territory using the GIMS-created contours.

As required by Section 25.114(c)(4)(vi)(B), nadir beam projections are included in Exhibit 1. As required by Section 25.114(c)(4)(vi)(C), beam scan projections associated with scanning the beams to all possible points within the operational footprint are also included in Exhibit 1. The 0 dBi contour in this diagram reflects the extent of the beam boresight scan locations.

3.2.3 Telemetry, Tracking and Control (TT&C)

SN Space Systems plans to operate both primary TT&C and backup TT&C using Ku-band uplink (13.75-14.0 GHz) and Ka-band downlink (19.2-19.6 GHz) spectrum. Most TT&C earth stations will employ multiple toroidal reflector antennas with an effective reflector diameter of at least 4.5m.[7] A small number of TT&C earth stations will employ a mechanically steered 4.5m (or larger) parabolic reflector to communicate with any satellite that may have drifted outside of its planned track. SN Space Systems contemplates operating up to eight TT&C earth station sites in the United States, subject to Commission licensing.

[7] *See* ITU Radio Regulation No. 5.502.

For backup TT&C, each satellite uses a set of six Ku-band and Ka-band antennas to provide full spherical coverage. As required by Part 25.114(c)(4)(vi)(B), a nadir beam projection of the Ku-band receive satellite TT&C beam and the Ka-band transmit satellite TT&C beam are included in Exhibit 1.

Primary TT&C will use satellite uplink and downlink user beam antennas for data services for the bus, traditional TT&C operations, and payload control applications. The transmit and receive chains will route the TT&C carriers to and from dual-redundant TT&C radios. Primary TT&C will be used at all times when the satellite payload is providing communications services.

Backup TT&C services will be provided on a limited basis to support LEOPS and anomaly resolution. Separate, lower-gain uplink and downlink antennas will be provided to create full spherical coverage to allow communications with the satellite even when not operating in a three-axis stabilized orientation. Due to the reduced space station antenna directivity in the backup TT&C mode, the link throughput will be reduced by several orders of magnitude. As a result, the backup TT&C service will be capable of providing course controls of payload hardware via the bus but will not support payload controls necessary to enable communication services. Communications payload operations will resume only when full control of the satellite is restored and it is in communication with primary TT&C, the Constellation network management system, and gateway earth stations.

Pursuant to 25.202(g), the primary TT&C service is not limited to operations at the band edge since the primary TT&C operations cause no more interference and are no more susceptible to interference than other communications links. In addition, operations in the backup TT&C configuration cause no more interference and are no more susceptible to interference than operations in the primary TT&C configuration.

As previously described, the primary TT&C links employ highly directional antennas at both the earth station and the satellite and thus results in interference levels comparable with gateway and user links. When operating in the backup TT&C configuration, the EIRP density of both uplink and downlink transmissions remains unchanged but link throughput is reduced to accommodate reduced satellite antenna gain.

4. Ground Segment

The Constellation ground segment comprises several earth station types operating throughout the United States, including gateways, user terminals, and TT&C earth stations. In addition, the Constellation leverages 5G technologies to perform the bulk of network control, traffic management, and related back-end operations.

4.1 Gateway Earth Stations

Constellation teleports contain five types of gateway/feeder link earth stations: (i) a Ku-band earth station to uplink forward-link traffic; (ii) a Ka-band earth station to uplink forward-link traffic; (iii) a Ka-band earth station to receive return-link traffic; (iv) a V-band earth station to uplink forward-link traffic; and (v) a V-band earth station to receive return-link traffic. The gateway earth station antennas may include multi-band feed arrays and may share the same physical aperture. The gateway antennas are circular polarized and can transmit and receive on both polarizations simultaneously. Teleport locations generally will include toroidal gateway reflector antennas for each visible Constellation satellite ground track.

Leveraging the repeating ground track nature of the Constellation, the gateway earth stations will employ fixed toroidal reflector antennas (approximately 2.4m wide and up to 10m long) to scan over as much as a 120° arc, which allow for the simultaneous communications with multiple satellites in a visible satellite track. Each gateway earth station antenna feed can form four independently scanned beams on each polarization to track satellites moving along a fixed line repeating ground track.

4.2 User Terminals

Every user terminal consists of two elements: (i) an outdoor unit; and (ii) an indoor unit. The outdoor unit includes an antenna system, frequency converters, low-noise amplifiers, and high-power amplifiers. The indoor unit consists of a modem, a switch/router, a processor, a power supply, software, and other accessories.

All user terminals are circular polarized, typically receiving Ka-band on one polarization while transmitting Ku-band on the opposite polarization. User terminals will be available in a variety of sizes and form factors, with generally equivalent emission characteristics so they have predictable and similar impacts on spectrum sharing.

Leveraging the repeating ground track nature of the Constellation, fixed user terminals use multi-beam, toroidal reflector antennas to simultaneously communicate with up to four satellites moving along a fixed line repeating ground track. Because user terminals are capable of simultaneously communication with multiple satellites, temporary suspension of communications with individual satellites to facilitate GSO arc avoidance or NGSO-NGSO inline event avoidance will reduce throughput but typically maintain service availability.

Most consumers will utilize fixed user terminals with 60 cm toroidal reflector antennas while most enterprises will utilize fixed user terminals with 1.2m toroidal reflector antennas. User terminals for mobility applications can use a variety of electronically steered antenna types. Some mobility terminals will produce only one beam to access a single Constellation satellite at a time, while others may produce multiple beams to access multiple satellites at a time. Unlike fixed user terminals that typically access satellites on one fixed line repeating ground track, mobility terminals can access satellites on all visible tracks.

4.3 TT&C Earth Stations

The TT&C earth stations provide essential links to control Constellation satellite operations. These links include spacecraft flight control and communications payload control for primary TT&C operations, as well as spacecraft flight control only for back-up TT&C operations.

TT&C earth stations use one or more 4.5m (or larger) lens antennas with steerable beams to communicate with Constellation satellites in any satellite track visible from the TT&C site. TT&C earth stations are circular polarized and can receive Ka-band downlink signals and transmit Ku-band uplink signals on both polarizations simultaneously.

Sufficient TT&C earth stations will be deployed to maintain full-time control of Constellation satellites while their communications payloads are active. Continuous control over the communications payloads enables repointing of satellite beams and suspension of communications to avoid harmful interference and facilitate spectrum sharing with co-frequency GSO and NGSO systems. It will also allow for real-time response to anomalous spacecraft operational circumstances and flight adjustments for conjunction avoidance, as appropriate.

4.4 Network Operations Center and Satellite Operations Center

SN Satellite Systems' Network Operations Center ("NOC") and the Satellite Operations Center ("SOC") will be co-located at the same physical facility, which is run as a joint operations center. A secondary NOC/SOC facility will be maintained at a geographically separate location to be utilized if the primary operations center becomes unavailable.

The Constellation operations center will be staffed 24 hours per day, 365 days per year, to operate the satellite telecommunications system and will employ industry-leading network and physical security measures. The NOC will control communications payload configuration, manage spectrum assignments and beam pointing, address satellite energy consumption, and take other measures to optimize network operations while managing spectrum sharing with co-frequency GSO and NGSO systems. The NOC will maintain close coordination with the SOC to access information about satellite ephemeris, health status, and energy balance.

The SOC is responsible for Constellation satellite flight control, including station-keeping, conjunction avoidance, and deorbit operations. The SOC will also be responsible for sharing satellite ephemeris with the 18th Space Control Squadron or successor entity, other entities that engage in space situational awareness or space traffic management functions, and/or other NGSO operators. The SOC will receive telemetry from all satellites, monitor satellite health, conduct predictive analysis to facilitate deorbit in advance of potential anomalies, and similar spacecraft management functions.

5. Frequency & Polarization Plan

5.1 V-Band

The following tables list the V-band downlink and uplink channel plan for the Constellation. Only gateway link operations will be conducted in these bands. This information is also provided in the accompanying Schedule S but is included here for completeness.

Table 4 V-Band Downlink Frequency Plan

Channel ID	Channel Bandwidth (kHz)	Center Frequency (MHz)	Polarization	Link Type
Q01D	500000	41750	LHCP / RHCP	Gateway
Q02D	500000	41250	LHCP / RHCP	Gateway
Q03D	500000	40750	LHCP / RHCP	Gateway
Q04D	500000	40250	LHCP / RHCP	Gateway
Q05D	500000	39750	LHCP / RHCP	Gateway
Q06D	500000	39250	LHCP / RHCP	Gateway
Q07D	500000	38750	LHCP / RHCP	Gateway
Q08D	500000	38250	LHCP / RHCP	Gateway
Q09D	500000	37750	LHCP / RHCP	Gateway

Table 5 V-Band Uplink Frequency Plan

Channel ID	Channel Bandwidth (kHz)	Center Frequency (MHz)	Polarization	Link Type
V01D	500000	51150	LHCP / RHCP	Gateway
V02D	500000	50650	LHCP / RHCP	Gateway
V03D	500000	49950	LHCP / RHCP	Gateway
V04D	500000	49450	LHCP / RHCP	Gateway
V05D	500000	48950	LHCP / RHCP	Gateway
V06D	500000	48450	LHCP / RHCP	Gateway
V07D	500000	47950	LHCP / RHCP	Gateway
V08D	500000	47450	LHCP / RHCP	Gateway

5.2 Ku-Band

The following tables list the Ku-band uplink user link, gateway uplink, and TT&C channel plan for the Constellation. This information is also provided in the accompanying Schedule S but is included here for completeness.

Table 6 Ku-Band Uplink Frequency Plan

Channel ID	Channel Bandwidth (kHz)	Center Frequency (MHz)	Polarization	Link Type
KT1U	50000	13975	LHCP / RHCP	TT&C
KT2U	50000	13925	LHCP / RHCP	TT&C
KT3U	50000	13875	LHCP / RHCP	TT&C
KT4U	50000	13825	LHCP / RHCP	TT&C
KT5U	50000	13775	LHCP / RHCP	TT&C
KG1U	50000	13975	LHCP / RHCP	Gateway
KG2U	50000	13925	LHCP / RHCP	Gateway
KTGU	50000	13875	LHCP / RHCP	Gateway
KTGU	50000	13825	LHCP / RHCP	Gateway
KTGU	50000	13775	LHCP / RHCP	Gateway
KU1U	125000	14062.5	LHCP / RHCP	User
KU2U	125000	14187.5	LHCP / RHCP	User
KU3U	125000	14312.5	LHCP / RHCP	User
KU4U	125000	14437.5	LHCP / RHCP	User

5.3 Ka-Band

The following tables list the Ka-band downlink user link, MSS feeder link, and TT&C channel plan and the Ka-band uplink gateway link channel plan for the Constellation. This information is also provided in the accompanying Schedule S but is included here for completeness.

Table 7 Ka-Band Downlink Frequency Plan

Channel ID	Channel Bandwidth (kHz)	Center Frequency (MHz)	Polarization	Link Type
KA1D	500000	19950	LHCP / RHCP	User
KA2D	100000	19650	LHCP / RHCP	User
KA3D	100000	19350	LHCP / RHCP	User
KA4D	500000	19050	LHCP / RHCP	User
KA5D	300000	18450	LHCP / RHCP	User
KA6D	500000	18050	LHCP / RHCP	User
KA7D[8]	500000	17750	LHCP / RHCP	User
KT1D	50000	19575	LHCP / RHCP	TT&C
KT2D	50000	19525	LHCP / RHCP	TT&C
KT3D	50000	19475	LHCP / RHCP	TT&C
KT4D	50000	19425	LHCP / RHCP	TT&C
KT5D	50000	19375	LHCP / RHCP	TT&C
KT6D	50000	19325	LHCP / RHCP	TT&C
KT7D	50000	19275	LHCP / RHCP	TT&C
KT8D	50000	19225	LHCP / RHCP	TT&C
KG1D	50000	19575	LHCP / RHCP	MSS Feeder
KG2D	50000	19525	LHCP / RHCP	MSS Feeder
KG3D	50000	19475	LHCP / RHCP	MSS Feeder
KG4D	50000	19425	LHCP / RHCP	MSS Feeder

[8] Not included in Schedule S because this channel will not be used in the United States and market access is not being requested in this Petition.

Table 8 Ka-Band Uplink Frequency Plan

Channel ID	Channel Bandwidth (kHz)	Center Frequency (MHz)	Polarization	Link Type
KA1U	850000	27925	LHCP / RHCP	Gateway
KA2U	750000	28725	LHCP / RHCP	Gateway
KA3U	150000	29175	LHCP / RHCP	MSS Feeder
KA4U	250000	29375	LHCP / RHCP	MSS Feeder
KA5U	500000	29750	LHCP / RHCP	Gateway

5.4 Frequency Tolerance

The frequency tolerance requirements of Section 25.202(e) that the carrier frequency of each space station transmitter be maintained within 0.002% of the reference frequency will be met.

5.5 Out-of-Band Emissions

The out-of-band emission limits of Section 25.202(f)(1), (2) and (3) will be met.

5.6 Frequency Reuse

The Constellation employs full frequency reuse in all Ku-band, Ka-band, and V-band uplink and downlink spectrum by using dual orthogonal circular polarization (LHCP and RHCP) and frequency reuse across multiple steerable uplink and downlink spot beams.

5.7 Cessation of Emissions

All Constellation transmissions can be turned on and off by ground telecommand, thereby causing cessation of emissions from the satellite, as required by Section 25.207 of the FCC's rules.

6 ITU Filings

The Constellation is associated with the SN-CONSTELLATION1 satellite network filing submitted to the ITU by the United Kingdom.

7 Interference Analysis

In this section, the information specified in Section 25.146 is presented (as required by Section 25.114(d)(12)). Included in this section is:

- Power flux density ("PFD") analysis for the protection of terrestrial services in the following space-Earth bands:
  - 17.7-20.2 GHz
  - 37.5-42.0 GHz
- Equivalent power flux density (EPFD) analysis for the protection of GSO systems in the following bands:
  - 13.75-14.5 GHz (Earth-to-space)
  - 17.8-18.6 GHz (space-to-Earth)
  - 19.7-20.2 GHz (space-to-Earth)
  - 27.5-28.6 GHz (Earth-to-space)
  - 29.5-30.0 GHz (Earth-to-space)
  - 37.5-42.0 GHz (space-to-Earth)
  - 47.2-50.2 GHz, 50.4-51.4 GHz (Earth-to-space)
- NGSO-NGSO sharing analysis in all bands.

7.1 Sharing with FS – PFD Analysis

The PFD limits for space stations operating in the 17.7-19.3 GHz and 19.3-19.7 GHz bands are specified in Section 25.146(a)(1), of the Commission's rules which requires compliance with ITU Article 21, Table 21-4 PFD limits. The PFD limit in the 17.7-19.3 GHz band is a function of the number of satellites in the operational constellation as defined by ITU Article 21.16.6.

Because the Constellation consist of 1190 active satellites, the X-factor for the PFD limit is calculated as X = (number of satellites + 402)/69 which equals approximately 23.1 dB. Therefore, the PFD limit at low elevation angles is -138.1 dB. With a minimum operational elevation angle of 30°, the PFD analysis demonstrates that the peak PFD must be maintained below -110 dBW/m^2/MHz to meet the PFD limits in the 17.7-19.3 GHz band, as show in *Figure 5*. In the 19.3-19.7 GHz band, the PFD limit is less constraining and the Constellation can operate up to the PFD limit of -105 dBW/m^2/MHz down to an elevation angle of 30° and meet the PFD limits at all elevation angles as demonstrated in *Figure 6.*

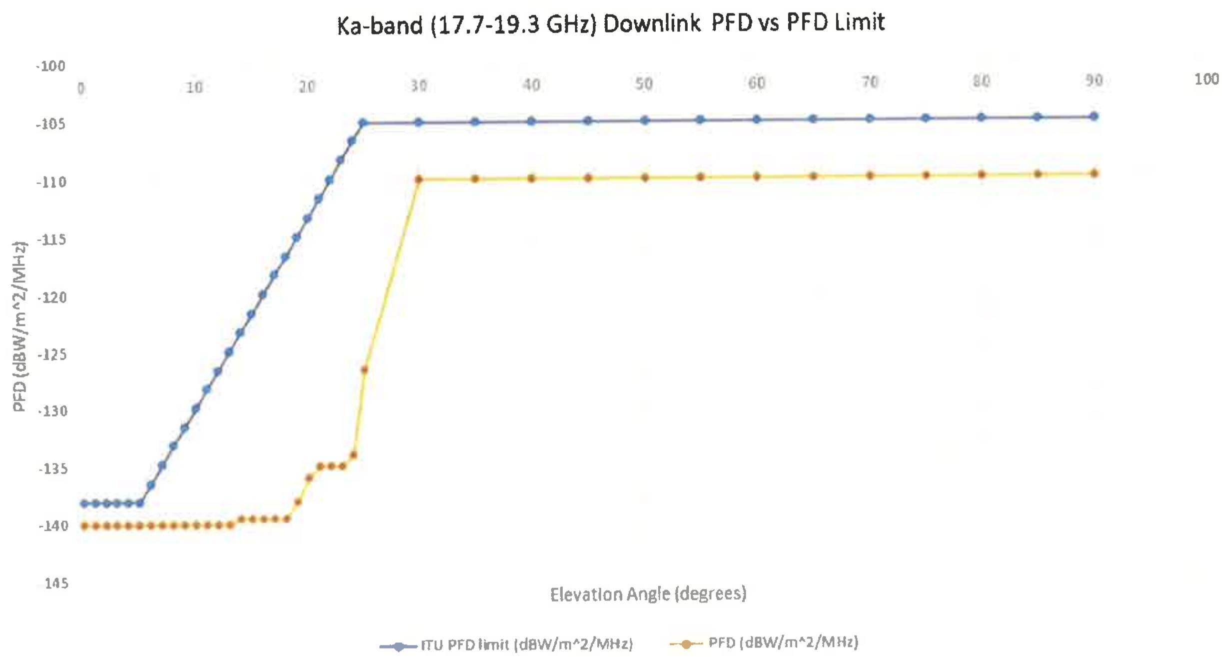

Figure 5 PFD Analysis - 17.7-19.3 GHz

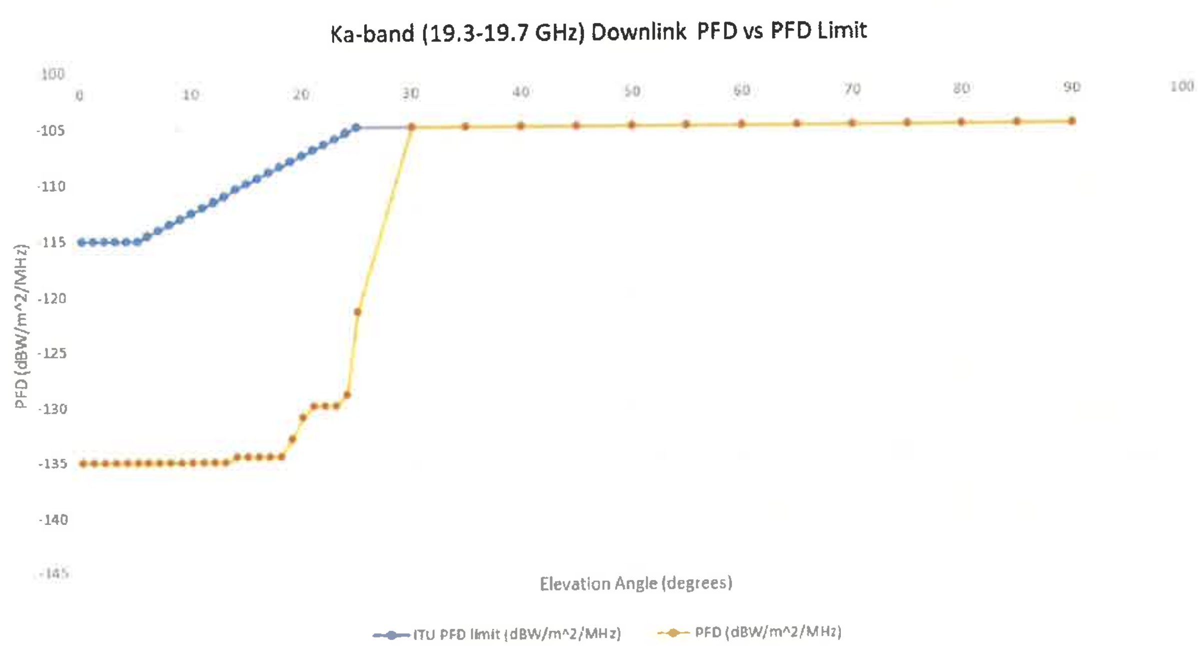

Figure 6 PFD Analysis - 19.3-19.7 GHz

The PFD limits for space stations operating in the 37.5-40.0 GHz, 40.0-40.5 GHz, and 40.5-42.0 GHz bands are specified in Section 25.208(r), (s), (t) respectively, of the Commission's rules, which are illustrated in *Figure 6*. In the 37.5-40.0 GHz band, the PFD limit (shown by the blue curve) reflects a maximum PFD of -117 dBW/m^2/MHz from 25°-90° elevation which declines in a log-linear fashion between 25° and 5° to a PFD of -132 dBW/m^2/MHz. However, this reflects the clear sky PFD limit. The FCC PFD limit for this range also allows for 12 dB of power control margin to combat rain fading effects. In the 40.0-42.0 GHz band, the PFD limit (shown by the blue curve) reflects a maximum PFD of -105 dBW/m^2/MHz from 25°-90° elevation which declines in a log-linear fashion between 25° and 5° to a PFD of -115 dBW/m^2/MHz.

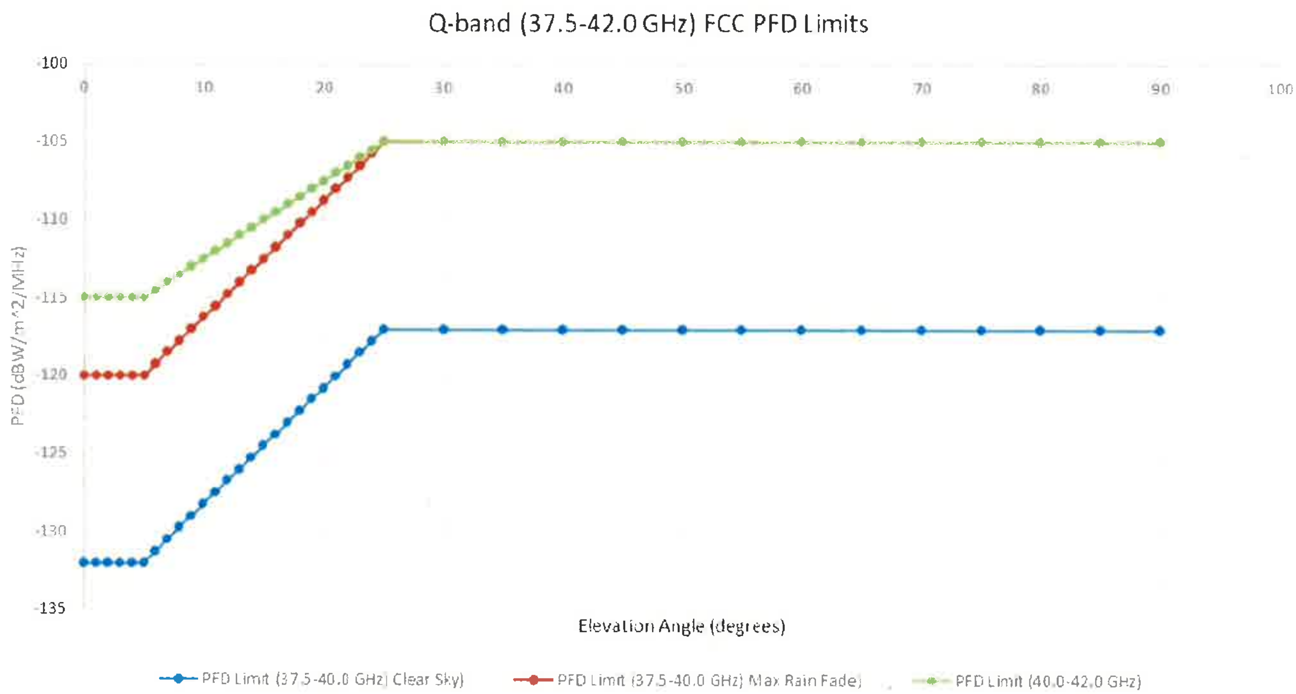

Figure 7 FCC 37.5-42.0 GHz PFD Limits

In the 37.5-40.0 GHz band, the downlink PFD was analyzed for the gateway downlink operating with clear sky conditions defined by a maximum PFD of -117 dBW/m^2/MHz down to a minimum elevation angle of 35° and under a maximum rain fade condition defined by a maximum PFD of -105 dBW/m^2/MHz down to a minimum elevation angle of 35°. The results of the PFD analysis for this band in maximum rain fade conditions is show in *Figure 8,* while the results of the PFD analysis for this band in clear sky conditions in show in *Figure 9.*

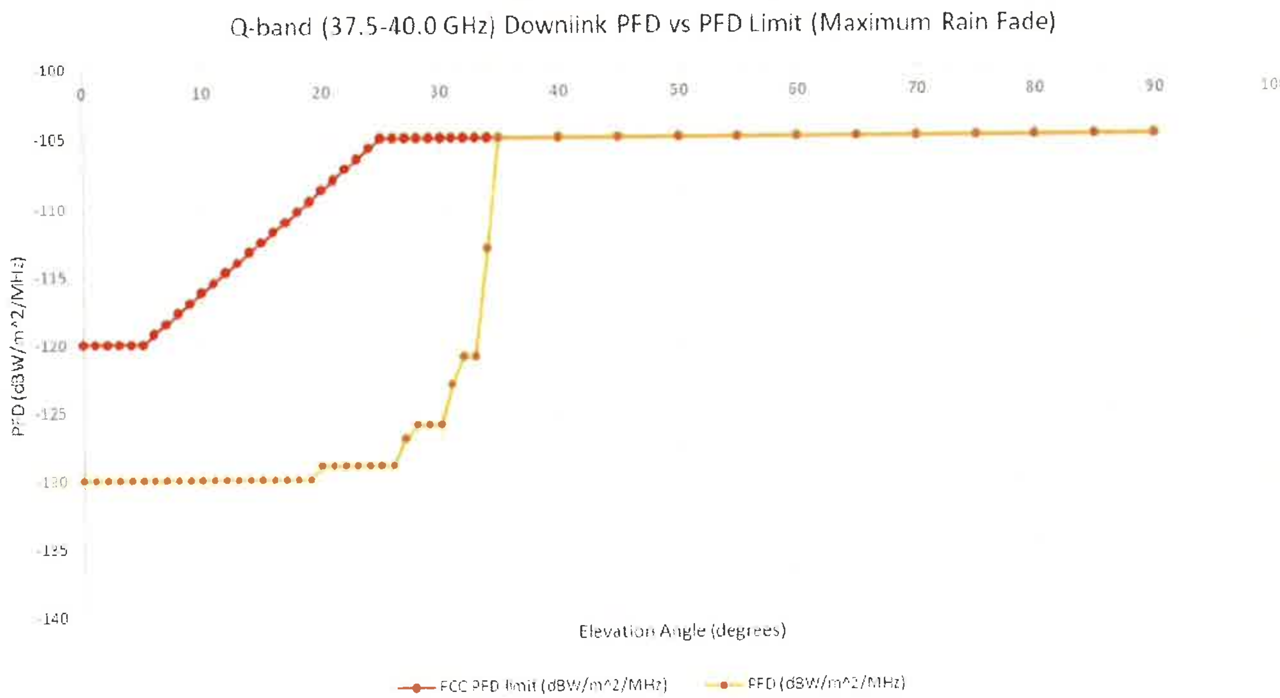

Figure 8 37.5-40.0 GHz PFD Analysis (Maximum Rain Fade PFD)

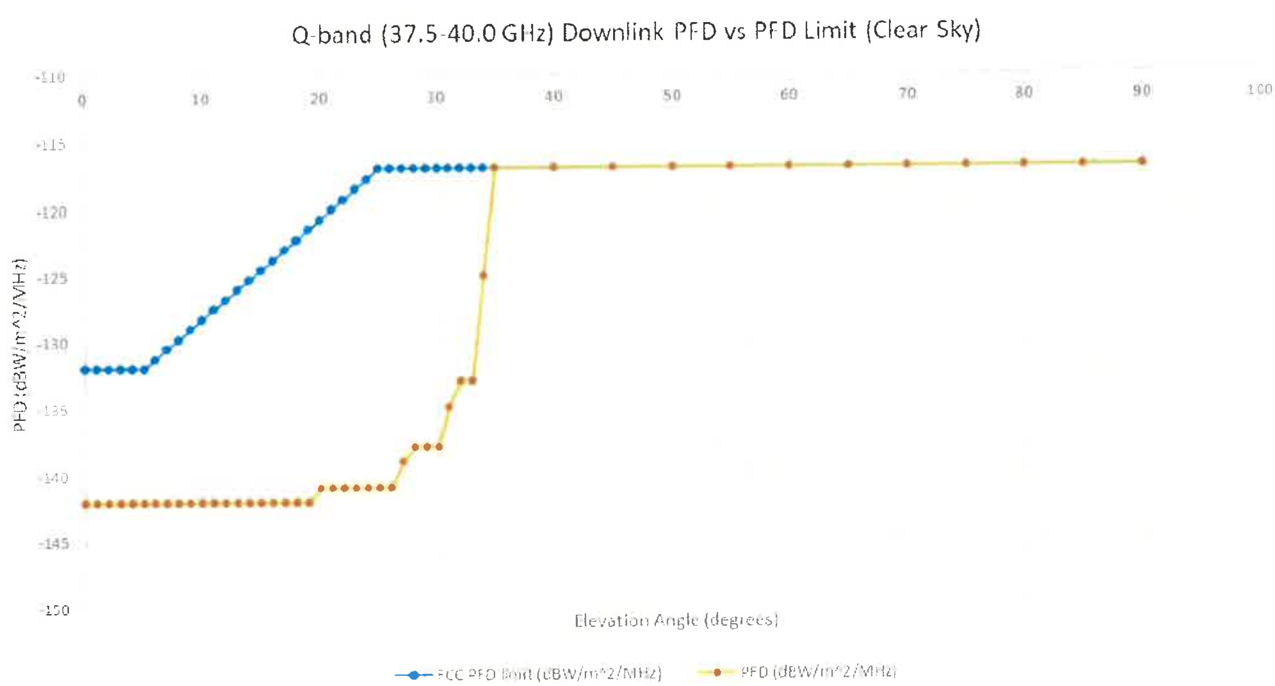

Figure 9 37.5-40.0 GHz PFD Analysis (Clear Sky PFD)

In the 40.0-42.0 GHz band, the downlink PFD was analyzed for the gateway downlink operating with clear sky conditions defined by a maximum PFD of -105 dBW/m^2/MHz down to a minimum elevation angle of 35°. The results of the PFD analysis for the band in clear sky conditions is show in *Figure 10.*

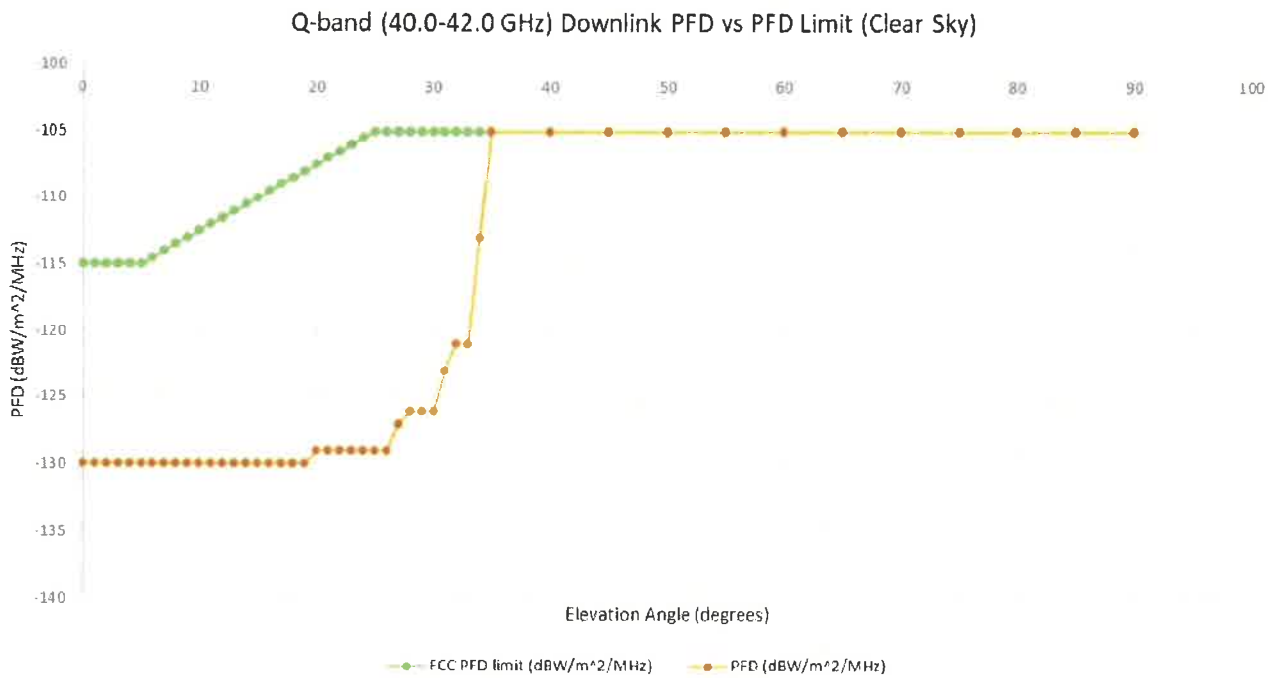

Figure 10 40.0-42.0 GHz PFD Analysis (Clear Sky Conditions)

7.2 Sharing with Terrestrial Services

The Constellation's use of the 27.5-28.35 GHz, 48.2-49.2 GHz, and 50.4-51.4 GHz uplink bands is limited to gateway earth stations and will conform to the constraints of Section 25.136 regarding spectrum sharing with Upper Microwave Flexible User Services (UMFUS) in this band.

The Constellation's use of the 29.1-29.25 GHz and 29.25-29.5 GHz bands is limited to MSS feeder link earth stations and will conform to the constraints of Section 25.257 for sharing with LMDS and Section 25.258 for sharing with GSO FSS services, respectively. Specifically, earth stations that will use the 29.1-29.25 GHz band in the United States will be located to meet all of the constraints for sharing with the LMDS service; and SN Space Systems will coordinate operations in the 29.25-29.5 GHz band with GSO operators, likely employing GSO avoidance techniques similar to EPFD compliance to facilitate mutually acceptable spectrum sharing with GSO FSS operators.

7.3 Sharing with GSO FSS – EPFD Analysis

Sharing with GSO FSS with be accomplished through meeting the ITU EPFD requirements from Article 22, where applicable, or via coordination with GSO operators, as appropriate, in bands where EPFD limits do not apply.

7.3.1 Ku-band Uplink (13.75-14.0 and 14.0-14.5 GHz) EPFD Analysis

The Ku-band uplink EPFD limits for the 13.75-14.0 GHz band are defined in Table 22-2 of the ITU Radio Regulations. The SN Space Systems NGSO constellation's use of this band includes TT&C uplinks in the 13.75-14.0 GHz band and user uplinks in the 14.0-14.5 GHz band. The operational parameters for each of these bands, as submitted to the ITU in the corresponding SRS databases are listed below in Table 9 and Table 10.

For each Ku-band sub-band, EIRP density masks were developed to reflect the planned uplink operations and the ITU EPFD software was employed to simulate the resultant uplink EPFD and validate that the EPFD constraints from Table 22-2 were met. The results of the EPFD simulations are illustrated in *Figure 11* for gateway/TT&C uplinks and in *Figure 12* for user uplinks.

Table 9 Ku-band Uplink (13.75-14.0 GHz) EPFD Input Parameters

Ku-band Gateway/TT&C Uplink EPFD Simulation Parameters	
Spectrum Band	13.75-14.0 GHz
Service Types	TT&C Uplink
Minimum Elevation Angle	35°
Alpha (GSO Avoidance) Angle	8°
Nco	16
Earth Station Spacing	250 km
Earth Station Density	0.000016 km^2 / user

Table 10 Ku-band Uplink (14.0-14.5 GHz) EPFD Input Parameters

Ku-band User Uplink EPFD Simulation Parameters	
Spectrum Band	14.0-14.5 GHz
Service Type(s)	User Uplink
Minimum Elevation Angle	30°
Alpha (GSO Avoidance) Angle	15°
Nco	16
Earth Station Spacing	250 km
Earth Station Density	0.000016 km^2 / user

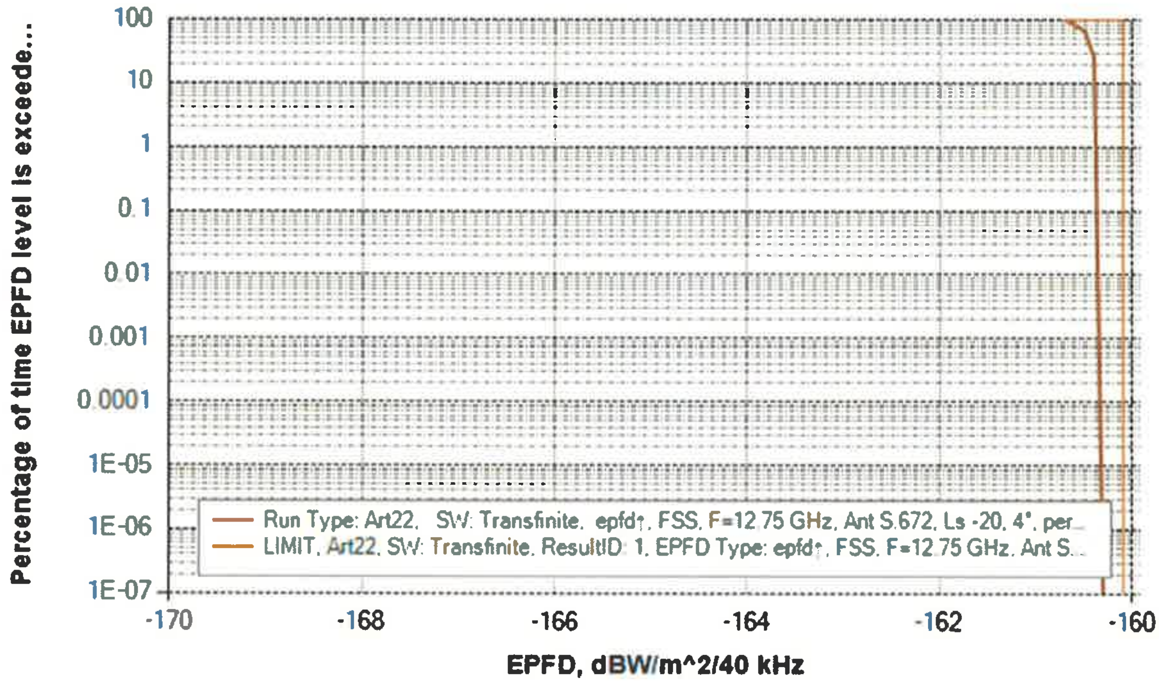

Figure 11 13.75-14.0 GHz TT&C Uplink - EPFD Results

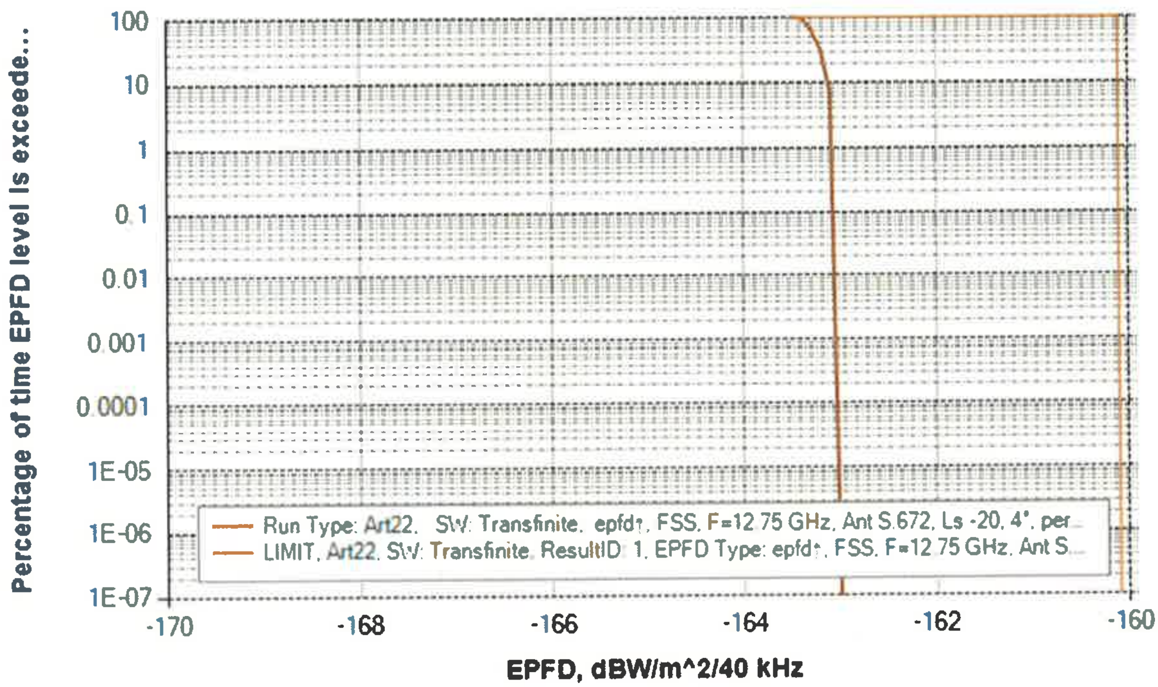

Figure 12 14.0-14.5 GHz User Uplink - EPFD Results

7.3.2 Ka-band Downlink (17.8-18.6 GHz and 19.7-20.2 GHz) EPFD Analysis

The downlink EPFD limits for the 17.8-18.6 GHz band are defined in Table 22-1B of the ITU Radio Regulations and the downlink EPFD limits for the 19.7-20.2 GHz band are defined in Table 22-1C of the ITU Radio Regulations. The Constellation uses these bands for user downlinks. The operational parameters for each of these bands, as submitted to the ITU in the corresponding SRS databases are listed below in Table 11.

For each Ka-band sub-band, PFD masks were developed, accounting for peak operational PFD versus scan angle, alpha angle, minimum elevation angle, number of co-frequency beams, and beam sidelobe characteristics to reflect the planned downlink operations and the ITU EPFD software was employed to simulate the resulting downlink EPFD and validate that the EPFD constraints from Table 22-1B and Table 22-1C were met. The results of the EPFD downlink simulations are illustrated in *Figure 13*, *Figure 14*, *Figure 15*, *Figure 16*, *Figure 17*, *Figure 18*, and *Figure 19*. The results of the EPFD intersatellite simulation is illustrated in *Figure 20*.

Table 11 Ka-band Downlink (17.8-18.6 GHz and 19.7-20.2 GHz) EPFD Input Parameters

Ka-band User Downlink EPFD Simulation Parameters	
Spectrum Band	17.8-18.6 GHz, 19.7-20.2 GHz
Service Type(s)	User Downlink
Minimum Elevation Angle	30°
Alpha (GSO Avoidance) Angle	22°
Nco	16

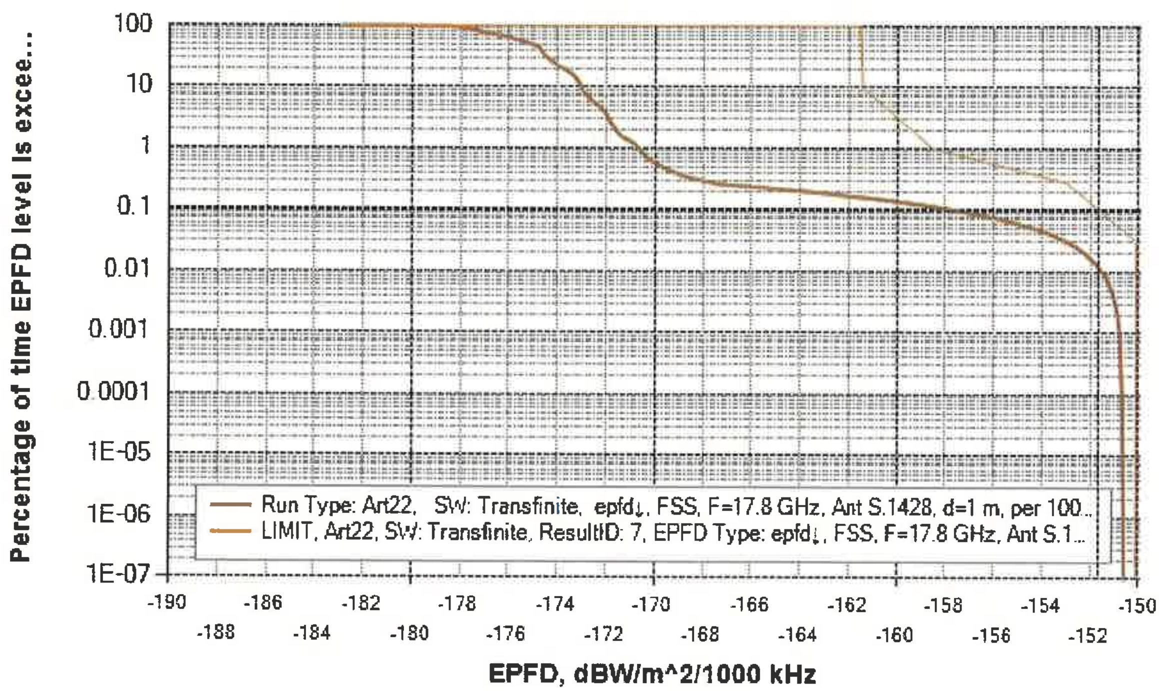

Figure 13 17.8-18.6 GHz Downlink 1.0m Victim GSO ES - EPFD Results

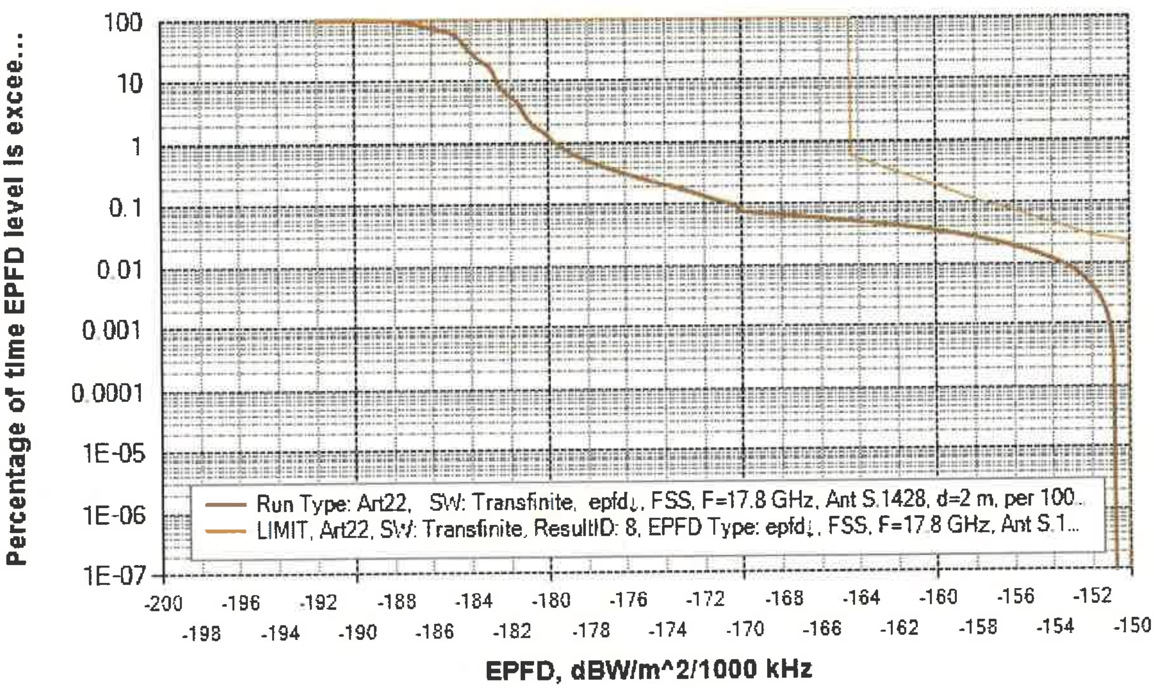

Figure 14 17.8-18.6 GHz Downlink 2.0m Victim GSO Earth Station - EPFD Results

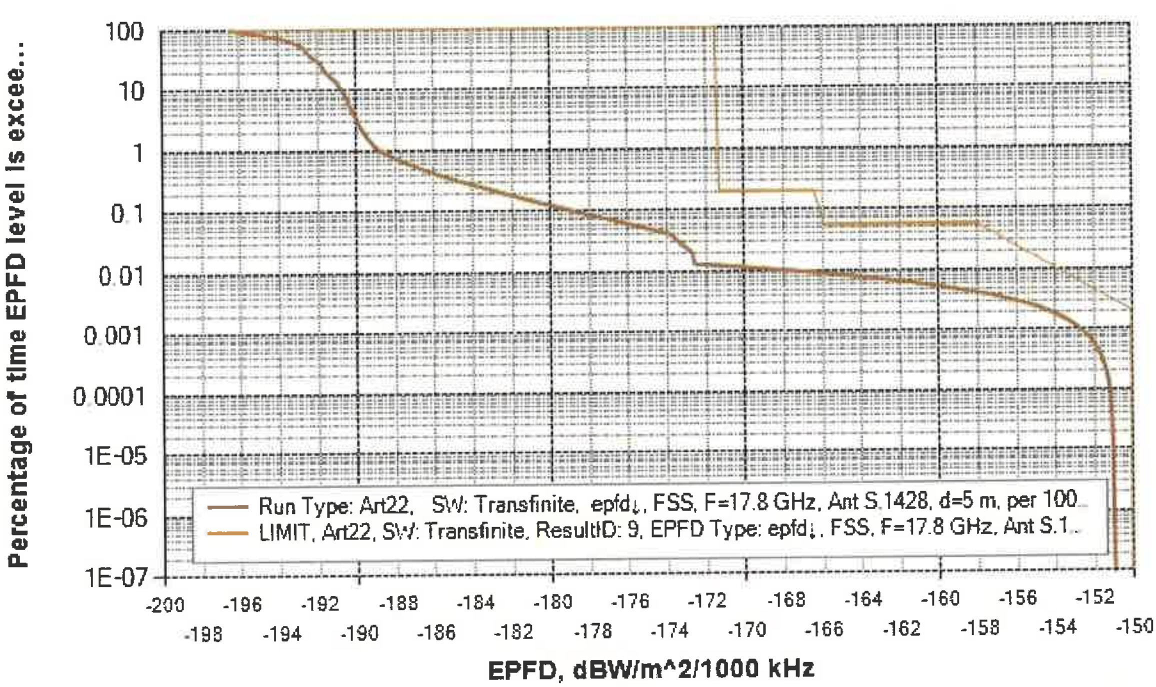

Figure 15 17.8-18.6 GHz Downlink 1.0m Victim GSO Earth Station - EPFD Results

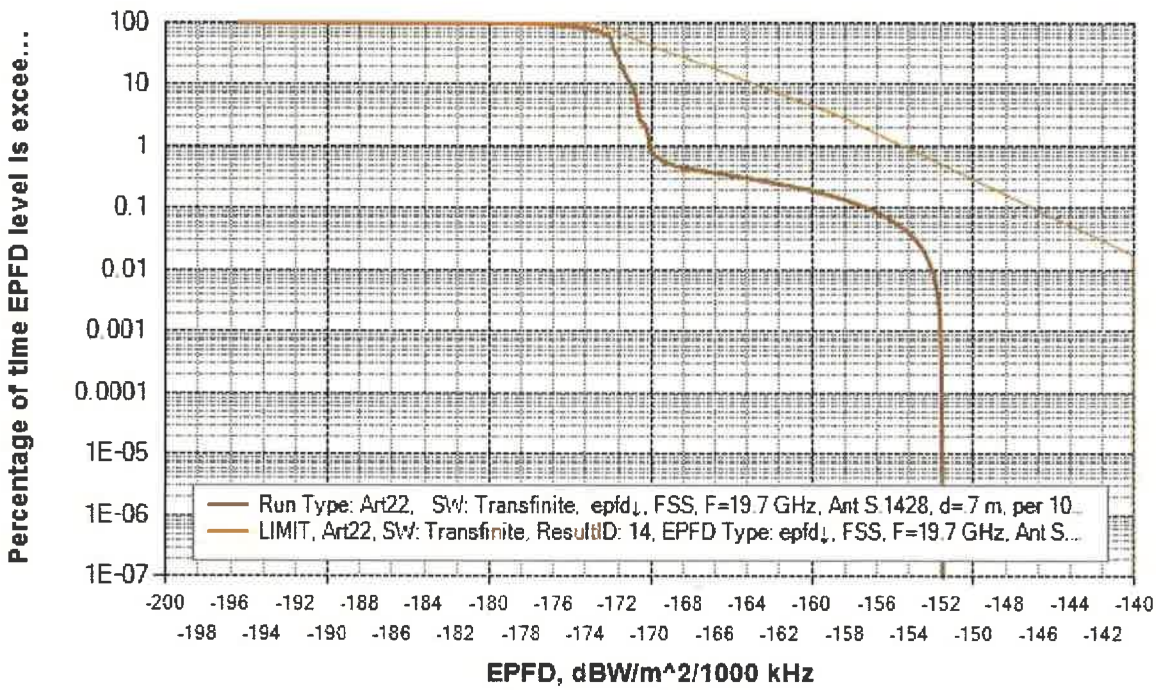

Figure 16 19.7-20.2 GHz Downlink 0.7m Victim GSO Earth Station - EPFD Results

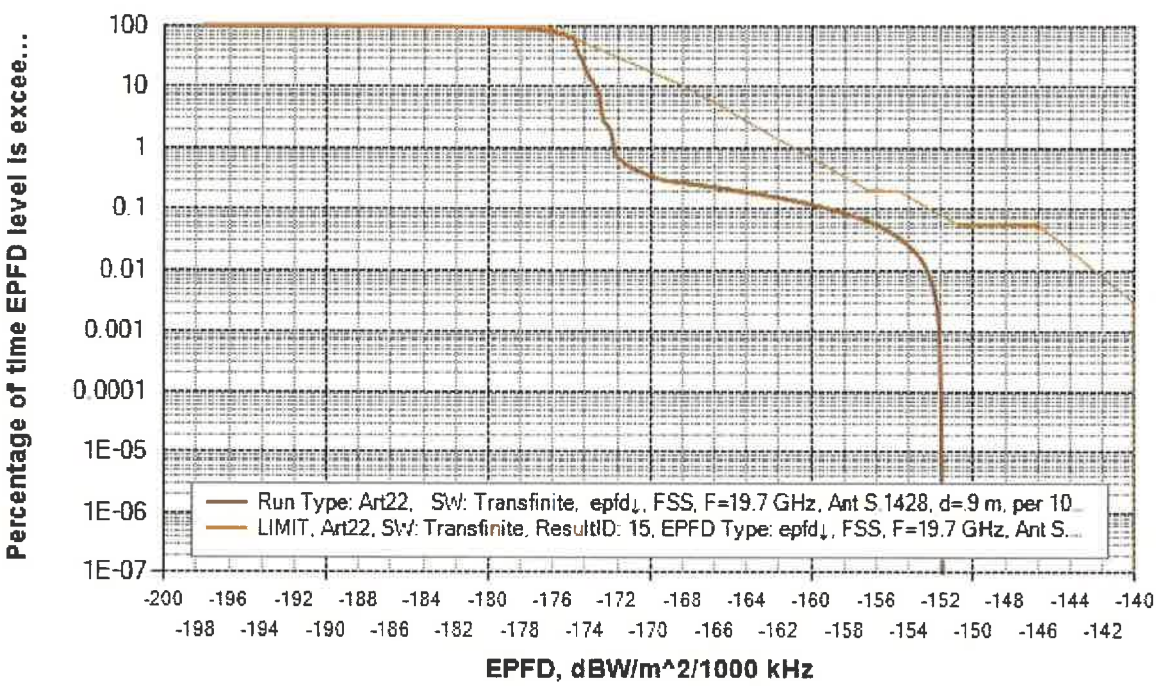

Figure 17 19.7-20.2 GHz Downlink 0.9m Victim GSO Earth Station - EPFD Results

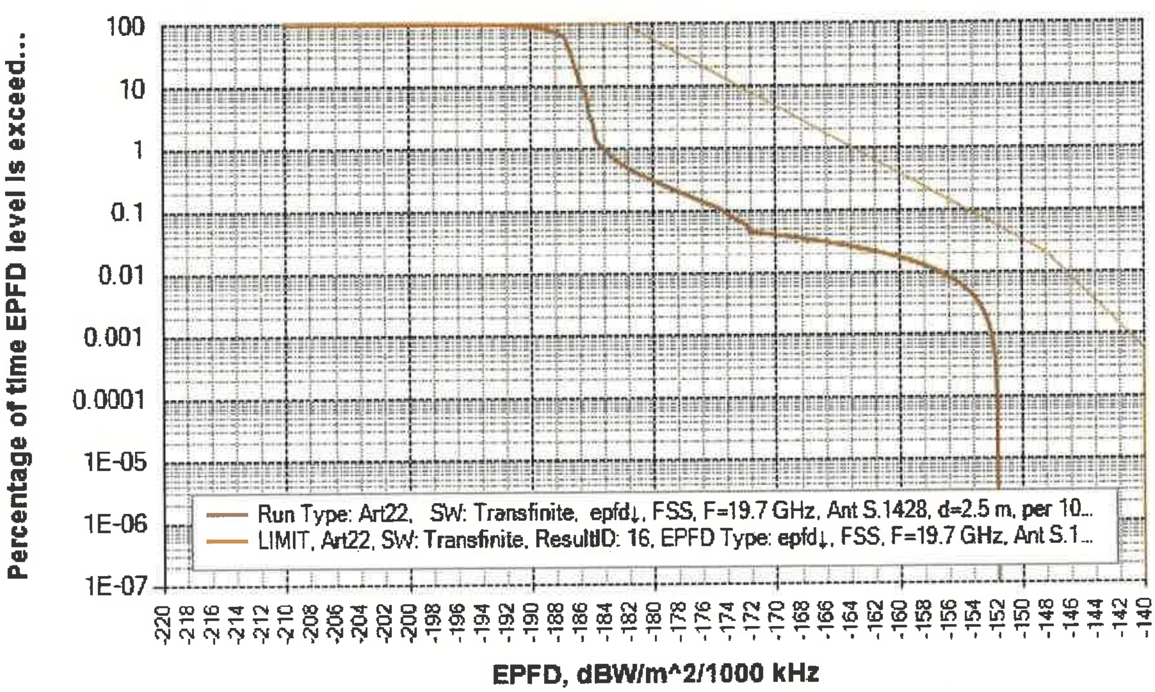

Figure 18 19.7-20.2 GHz Downlink 2.5m Victim GSO ES - EPFD Results

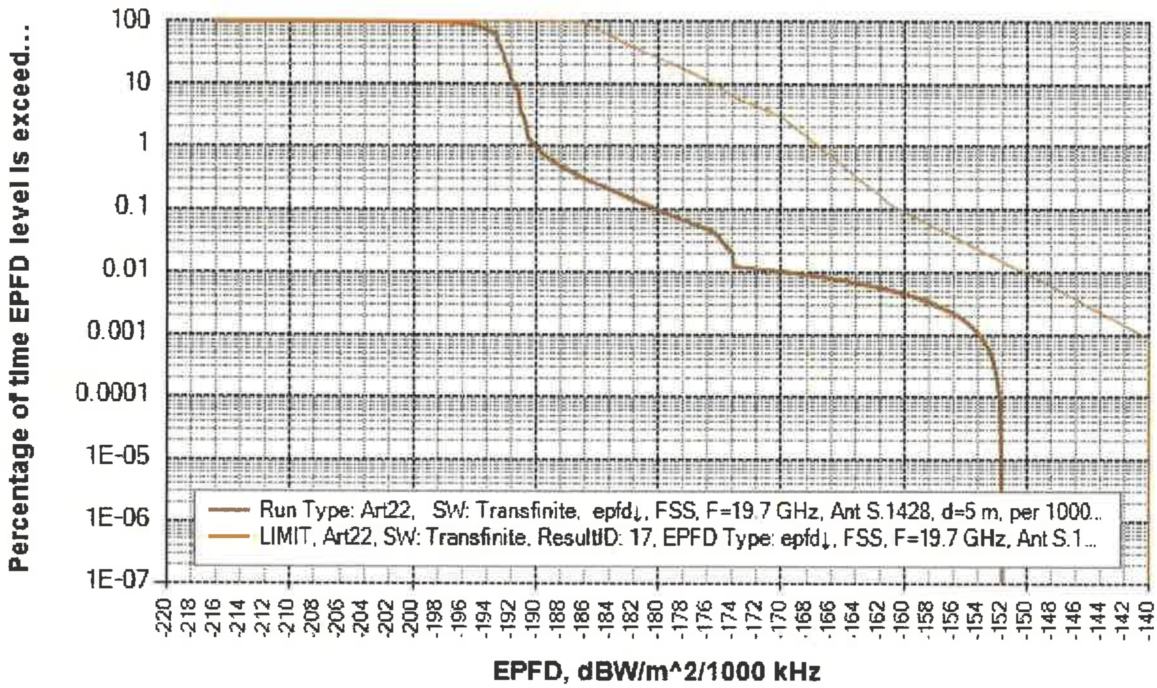

Figure 19 19.7-20.2 GHz Downlink 5.0m Victim GSO ES - EPFD Results

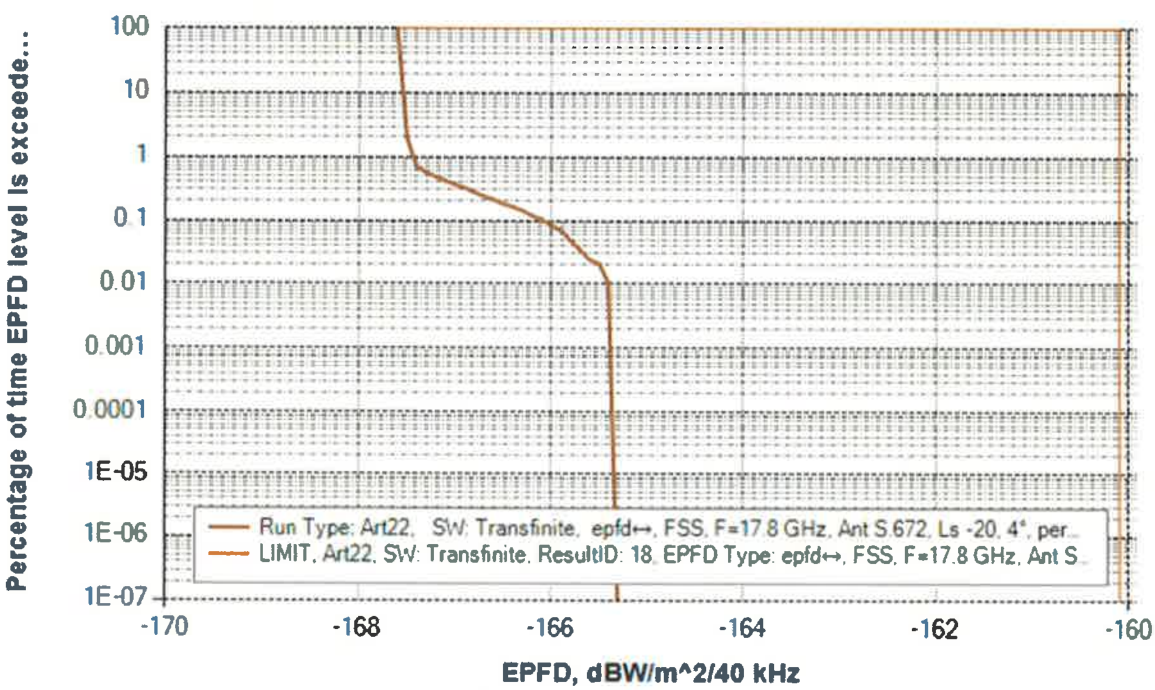

Figure 20 17.8-18.6 GHz Downlink Intersatellite - EPFD Results

7.3.3 Ka-band Uplink (27.5-28.6 GHz and 29.5-30.0 GHz) EPFD Analysis

The Ka-band uplink EPFD limits for the 27.5-28.6 GHz and 29.5-30.0 GHz bands are defined in Table 22-2 of the ITU Radio Regulations. The Constellation uses these bands for gateway uplinks. The operational parameters for each of these bands, as submitted to the ITU in the corresponding SRS databases are listed below in Table 12. For both of these bands, a common EIRP density mask was developed to reflect the planned uplink operations and the ITU EPFD software was employed to simulate the resultant uplink EPFD and validate that the EPFD constraints from Table 22-2 were met. The results of the EPFD simulations are illustrated in Figure 21.

Table 12 Ka-band Uplink (27.5-28.6 GHz and 29.5-30.0 GHz) EPFD Input Parameters

Ka-band Gateway Uplink EPFD Simulation Parameters	
Spectrum Band	27.5-28.6 GHz, 29.5-30.0 GHz
Service Type(s)	Gateway Uplink
Minimum Elevation Angle	35°
Alpha (GSO Avoidance) Angle	8°
Nco	16
Earth Station Spacing	250 km
Earth Station Density	0.000016 km^2 / user

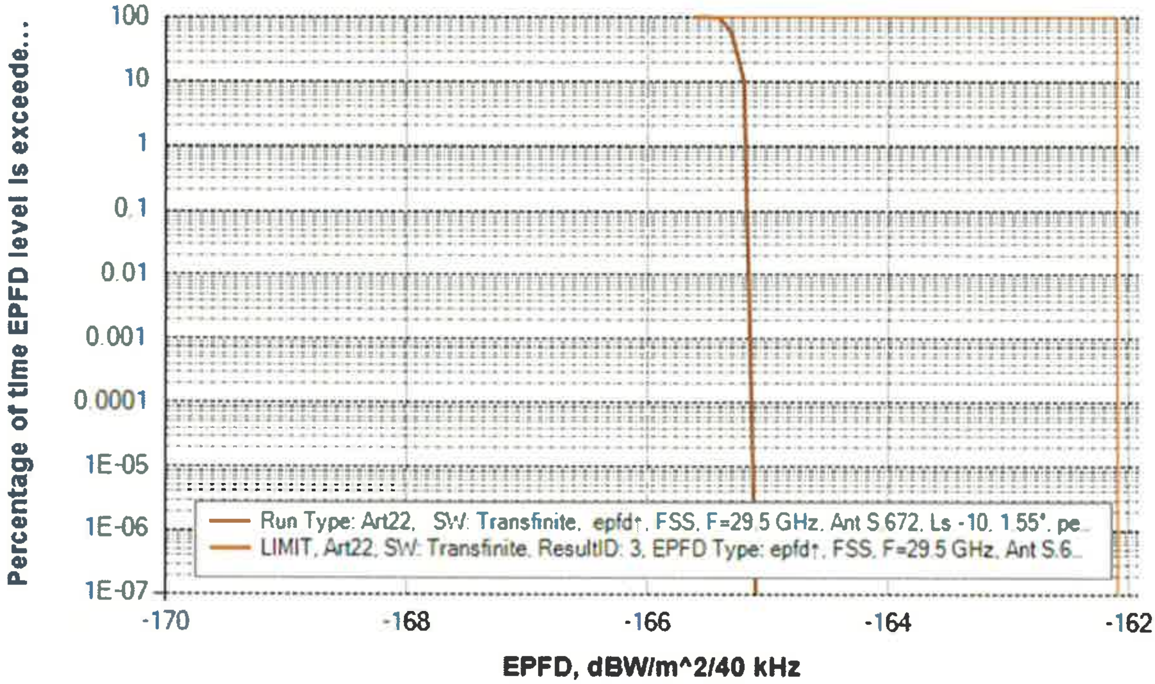

Figure 21 27.5-28.6 GHz and 29.5-30.0 GHz Uplink - EPFD Results

7.3.4 V-band Downlink (37.5-42.0 GHz) EPFD Analysis

The downlink EPFD limits for the 37.5-42.0 GHz band are defined in No. 22.5L and No. 22.5M of the ITU Radio Regulations. The Constellation uses this band for gateway downlink services. The operational parameters for each of these bands, as submitted to the ITU, are listed below in Table 13. For this band, PFD masks were developed, accounting for peak operational PFD versus scan angle, alpha angle, minimum elevation angle, number of co-frequency beams, and beam sidelobe characteristics to reflect the planned downlink operations and custom EPFD simulation software was employed to simulate the resulting downlink EPFD and validate that the EPFD constraints were met based upon the procedures defined in Resolution 770.

The ITU EPFD software does not yet support validation of V-band EPFD. A custom EPFD simulation was employed to provide confidence that the proposed operational parameters listed will meet the V-band EPFD limits once the ITU EPFD software is available. SN Space Systems has committed to meeting the requirements in No. 22.5L and No. 22.5M and will update their inputs as necessary once the ITU has distributed appropriate EPFD validation software for this spectrum band.

Table 13 V-band Downlink (37.5-42.0 GHz) EPFD Input Parameters

V-band Gateway Downlink EPFD Simulation Parameters	
Spectrum Band	37.5-42.0 GHz
Service Type(s)	Gateway Downlink
Minimum Elevation Angle	35°
Alpha (GSO Avoidance) Angle	8°
Nco	16

7.3.5 V-band Uplink (47.2-50.2 GHz and 50.4-51.4 GHz) EPFD Analysis

The V-band uplink EPFD limits for the 47.2-50.2 GHz and 50.4-51.4 GHz bands are defined in No. 22.5L and No. 22.5M of the ITU Radio Regulations. The Constellation uses this band for gateway uplink services. The operational parameters for each of these bands, as submitted to the ITU are listed below in Table 14. For both of these V-band sub-bands, a common EIRP density mask was developed to reflect the planned uplink operations and custom EPFD simulation software was employed to simulate the resulting uplink EPFD and validate that the EPFD constraints were met based upon the procedures defined in Resolution 770.

The ITU EPFD software does not yet support validation of V-band EPFD. A custom EPFD simulation was employed to provide confidence that the proposed operational parameters listed will meet the V-band GSO protection criteria once the ITU EPFD software is available.[9]

Table 14 V-band Uplink (47.2-50.2 GHz and 50.4-51.4) EPFD Input Parameters

V-band Gateway Uplink EPFD Simulation Parameters	
Spectrum Band	47.2-50.2 GHz, 50.4-51.4 GHz
Service Type(s)	Gateway Uplink
Minimum Elevation Angle	35°
Alpha (GSO Avoidance) Angle	8°
Nco	16
Earth Station Spacing	250 km
Earth Station Density	0.000016 km^2 / user

[9] SN Space Systems has committed to meeting the requirements in No. 22.5L and No. 22.5M and will update their inputs as necessary once the ITU has distributed appropriate EPFD validation software for this spectrum band.

7.4 Sharing with NGSO Systems

SN Space Systems requests authority to operate in V-band spectrum, as well as Ku-band and Ka-band spectrum, for which the FCC has already authorized NGSO system operations in prior processing rounds. SN Space Systems also contemplates sharing these spectrum bands with additional systems authorized in this V-band and future Ku/Ka-band processing rounds.

The Constellation was designed to provide significant multiple coverage in the key target markets to facilitate spectrum sharing with co-frequency NGSO systems. Furthermore, SN Space Systems has conducted numerous simulations of spectrum sharing with key NGSO processing round participants in order to validate that its business case supports and its operational requirements are met in the context of capacity constraints resulting from avoiding inline interference events.

SN Space Systems is also requesting access to the NGSO MSS feeder link spectrum to support MSS services. SN Space Systems acknowledges that Iridium is currently operating MSS feeder links in the 19.4-19.6 GHz (space-to-Earth) and 29.1-29.3 GHz (Earth-to-space) bands. Iridium operates a small number of sites around the world and SN Space Systems will coordinate under applicable Commission rules to prevent harmful interference to Iridium feeder link sites.

7.4.1 Sharing with Other NGSO FSS Systems

Consistent with Commission rules, policies, and precedent, SN Space Systems intends to share spectrum with and avoid causing harmful interference to operational NGSO systems via coordination. In the absence of a coordination agreement, SN Space Systems may operate the Constellation in compliance with default spectrum sharing rules of Section 25.261 (vis-à-vis other NGSO operations authorized in the same processing round) or demonstrations of non-harmful interference approved by the Commission (vis-à-vis other NGSO operations authorized in a prior processing round).

As discussed in Exhibit 2 attached hereto, SN Space Systems has computed anticipated inline interference avoidance angles and used these avoidance angles to estimate the multiple coverage reduction impacts of avoiding inline interference events with other NGSO systems. Simulations were conducted between the SN Space Systems NGSO constellation and numerous systems licensed by the Commission or authorized to serve the U.S. market in Ku-band, Ka-band, and V-band frequencies.

For the purposes of estimating the potential impact on multiple coverage due to spectrum sharing, simulations were conducted between the Constellation and each examined system and included all spectrum bands in which the two systems would operate co-frequency, taking into account the declared number of co-frequency satellites serving a single location ("Nco") for each system. A discussion of the results of these simulations is included in Exhibit 2. Based upon spectrum sharing analyses conducted, SN Space Systems is confident that successful spectrum sharing, via coordination or otherwise, can be achieved with co-frequency NGSO operations.

In particular, the Constellation uses narrow, steerable and shapeable satellite spot beams for all primary spectrum bands and is designed to provide significant multiple coverage and enable communications with multiple satellites simultaneously. In addition, Constellation earth stations general use toroidal antennas with multiple feeds that focus on a narrow segment of the visible sky. These characteristics will enable the Constellation to provide quality broadband services to customers while efficiently sharing spectrum and orbital resources with other NGSO broadband systems.

7.4.2 Sharing with MSS Feeder Links in 19.4-19.6 GHz (space-Earth) and 29.1-29.5 GHz (Earth-space)

SN Space Systems and Iridium employ large (greater than 2m diameter) Ka-band antennas for communications in the MSS feeder link spectrum. Furthermore, both NGSO systems employ directional satellite antennas, which limit the potential for interference to situations where the systems have a feeder link earth stations within relatively close proximity of each other. SN Space Systems intends to select feeder link earth station sites that can ensure Iridium gateway earth station sites in Tempe, Arizona; Oahu, Hawaii; and Punta Arenas, Chile will not experience harmful interference.

SN Space Systems intends to engage in coordination with Iridium to agree to operational constraints that will ensure Iridium MSS feeder links are protected from harmful interference. Specifically, pursuant to Section 25.250(d), SN Space Systems will coordinate any feeder link site within 800 km of any MSS feeder link complex, including those operated by Iridium.

7.4.3 Sharing with Other Services

The following spectrum bands are either used by or are adjacent to TDRSS, the Radio Astronomy Service (RAS), or the Earth Exploration Satellite Service (EESS):

- 13.75-13.8 GHz (TT&C and gateway uplink): protection of TDRSS forward link-to-LEO)
- 14.0-14.2 GHz (user uplinks): protection of TDRSS facility in Guam, White Sands, NM and Blossom Point, MD
- 14.47-14.5 GHz (user uplinks): coordination with NSF RAS sites
- 42.5-43.5 GHz (gateway downlinks): adjacent to gateway V-band downlink
- 48.94-49.04 GHz (gateway uplinks): within gateway V-band uplink allocations
- 50.2-50.4 GHz (gateway uplinks): between gateway V-band uplink allocations
- 51.4-54.25 GHz (gateway uplinks): adjacent to gateway V-band uplink allocations

SN Space Systems will abide by the following commission regulations regarding protection of RAS and EESS:

- US113 – make every practical effort to avoid interference into RAS measurements in 14.47-14.5 GHz
- US133 – coordinate with NTIA to minimize harmful interference into TDRSS in 14.0-14.2 GHz, coordinate with NSF to minimize harmful interference into RAS in 14.47-14.5 GHz
- US156 – limit unwanted emissions in 50.2-50.4 GHz
- US211 - take all practical steps to avoid interference into RAS in 42.5-43.5 GHz
- US337 – coordinate with NTIA on a case-by-case basis to minimize interference into TDRSS from gateway and TT&C earth stations operating in 13.75-13.8 GHz
- US342 – take all practical steps to avoid interference into RAS in 42.5-43.5 GHz

SN Space Systems will also abide by PFD and EIRP density limits described in relevant ITU footnotes, resolutions, and recommendations, including:

- 5.504B
- ITU-R M.1643-0
- 5.551H
- 5.551I
- Resolution 743 (Region 2)
- ITU-R S.1586-1
- ITU-R RA.1631
- 5.555
- 5.555B

Pursuant to Section 25.202(j), gateway earth station uplink transmissions in the 49.7-50.9 GHz band will ensure that unwanted emission in the 50.2-50.4 GHz band does not exceed -20 dBW/200MHz.

7.4.4 Sharing with U.S. Government Networks

There are a variety of Federal allocations in the Ku-band, Ka-band and V-band spectrum used by the Constellation. SN Space Systems is fully committed to successful coordination with all U.S. government operations in these bands. Based upon the sharing demonstrations provided for terrestrial, GSO and NGSO systems, SN Space Systems is confident that the technical characteristics and operational concepts of the Constellation will allow successful coordination with U.S. government operations. SN Space Systems will notify the Commission upon completion of coordination with the U.S. Government.

8 Orbital Debris Mitigation / Satellite End-of-Life Plan

8.1 Orbital Debris Mitigation

Although the operational requirements for the Constellation are well-understood and many design elements are nearing completion, the detailed satellite bus design and components selection is ongoing. Accordingly, an overview of SN Space Systems' 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. A full orbital debris showing, including analysis using NASA's Debris Assessment Software (DAS) or equivalent, will be submitted once SN Space Systems' orbital debris mitigation and satellite end-of-life plans has been reviewed and accepted by the United Kingdom.

8.1.1 Debris Release

SN Space Systems does not intend to release debris during the planned course of operations of the Constellation and will design the satellites to limit the amount of debris released due to unplanned events during normal operations.

SN Space Systems is cognizant of the potential for its satellites to become a source of debris in the unlikely event of a collision with space debris or meteoroids. Such a collision has both the potential to generate more space debris and to render a SN Space Systems satellite inoperable, increasing the chance of it colliding with other satellites or space debris. To address these concerns, SN Space Systems will incorporate design features such as: redundancy, separation of components, and shielding into the satellite design. Propellant tanks are designed to suffer impact penetration without causing an explosive rupture. Batteries are shielded, incorporate vent before burst mechanisms, and have isolation features to prevent cascading failure of battery cells.

SN Space Systems will continue to review the satellite design and on-orbit operations throughout the spacecraft design finalization and manufacturing process and will make adjustments and improvements as appropriate to minimize the probability that its spacecraft will become a source of debris due to a collision or otherwise.

8.1.2 Accidental Explosions

SN Space Systems is designing its satellites in a manner that limits the probability of accidental explosion. The key areas examined for this purpose are potential rupture of propellant tanks and batteries.

The basic propulsion design (including a dual-wall shielding effect from the bus walls), propulsion subsystem component construction, preflight verification through both proof testing and analysis, and quality standards will be employed to ensure a very low risk of tank failure. A burst disk ensures that sudden failure of propulsion containment cannot overpressure and fragment the spacecraft.

The batteries will include protection circuits to prevent against overcharge and undercharge conditions. The batteries will include a pressure relief burst disk to assure vent before burst to prevent the potential for explosive rupture under failure condition. Furthermore, the battery subsystem will be composed of smaller, individually packaged cells with sufficiently small size, mass, and potential energy to contain most debris if any cell does explosively rupture due to a cascading fault situation.

The battery and the propulsion subsystems will be instrumented with fault detection, isolation, and recovery to continually monitor and preclude conditions that could result in the remote possibility of energetic discharge and subsequent generation of debris. Through this process, SN Space Systems will assess and limit the possibility of accidental explosions during all phases of mission operations. Following the end of mission, SN Space Systems will passivate all satellites once they have been moved into their final orbit. Satellite passivation will include using all remaining propellant to minimize orbit altitude, thereby decreasing the remaining orbital lifetime.

8.1.3 Collision Risk with Large Debris

SN Space Systems takes seriously the responsibility of deploying large numbers of satellites into space and intends to exceed best practices to ensure the safety of space. SN Space Systems has carefully assessed and limited the probability of its system becoming a source of debris by collision with large debris or other operational space stations.

SN Space Systems will maintain the accuracy of its orbital parameters at a level that will allow operations with sufficient spacing to minimize the risk of conjunction with adjacent and crossing satellites in the Constellation and other NGSO systems. Under Section 25.114(d)(A)(5) of the Commission's rules, SN Space Systems certifies that upon receipt of a space situational awareness conjunction warning, it will review and take appropriate steps to assess the collision risk and mitigate the collision risk if necessary. Appropriate mitigation steps include 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.

The SN Space Systems satellites measure >10 cm in the smallest dimension, excluding deployable components, and therefore will be trackable in accordance with Section 25.114(d)(14)(v) of the Commission's rules. SN Space Systems will employ active tracking and GNSS capabilities for onboard positional and navigation information.

SN Space Systems will register with the 18th Space Control Squadron or its successor entity prior to deployment. SN Space Systems commits to sharing information about initial deployment, ephemeris, planned maneuvers, etc. with the 18th Space Control Squadron or successor entity, other entities that engage in space situational awareness or space traffic management functions, and/or other operators in accordance with Section 25.114(d)(v)(A-C) of the Commission's rules. SN Space Systems will maintain the following orbital tolerances in accordance with Section 25.114(d)(iv)(4):

- Apogee – 3 km
- Perigee – 3 km
- Inclination – 0.06 degree
- RAAN – 0.03 degree

The propulsion system onboard can respond quickly as needed, allowing SN Space Systems to coordinate in advance and respond to conjunction risks, whether with debris or another active spacecraft. SN Space Systems will engage with operators of other NGSO systems to ensure safe and coordinated space operations.

The SN Space Systems orbit selection process included the evaluation of existing/planned NGSO systems to determine and avoid orbit shells with a higher potential of being congested.

8.2 Post-Mission Disposal

Each satellite in the Constellation is designed for a useful lifetime of approximately five years. SN Space Systems intends to dispose of satellites through atmospheric re-entry at end-of-life. SN Space Systems intends to comply with Section 4.6 and 4.7 of NASA Technical Standard 8719.14A with respect to this re-entry process. In particular, SN Space Systems anticipates that its satellites will reenter the Earth's atmosphere within approximately one year following mission completion, which far less than the current NASA guidance of 25 years.

Upon mission completion, the spacecraft apogee and perigee will be lowered to a maximum of 400km[10] but the perigee will continue to be lowered until either the propellant is exhausted, or the attitude control system's ("ACS") control authority is exceeded by the atmospheric drag conditions. If propellant remains as the ACS control authority reaches its limit, the excess propellant will be vented. After all propellant is consumed, SN Space Systems will passivate its satellites by de-spinning reaction wheels, drawing batteries down, and powering down the satellite. During the ensuing months, the denser atmosphere will rapidly lower the satellite's perigee until its eventual atmospheric demise.

[10] This orbit altitude is intended to ensure positive control of end-of-life satellites until they are fully below the orbit of the International Space Station. From there, all remaining propellant will be expended to minimize the remaining time on orbit.

CERTIFICATION OF PERSON RESPONSIBLE FOR PREPARING TECHNICAL INFORMATION

I hereby certify that I am the technically qualified person responsible for preparation of the information contained in this Petition, 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 Petition and that it is complete and accurate to the best of my knowledge and belief.

/s/

Ninh Phuoc Quang Le

Chief Engineer

EXHIBIT 1

This Exhibit illustrates the beam projections for each type of beam from the Schedule S. It should be noted that the .GXT files provided in the Schedule S reflect a sub-satellite point of 0N78W (in Ecuador) because the GIMS used to create these contour diagrams must use a GSO orbital position[1] and a nadir beam over this region provides reasonable visual context to understand the size and scale of each contour. However, for this Exhibit, the same beam projections were plotted over Washington, DC for additional visual context.

1. Gateway Transmit Beams

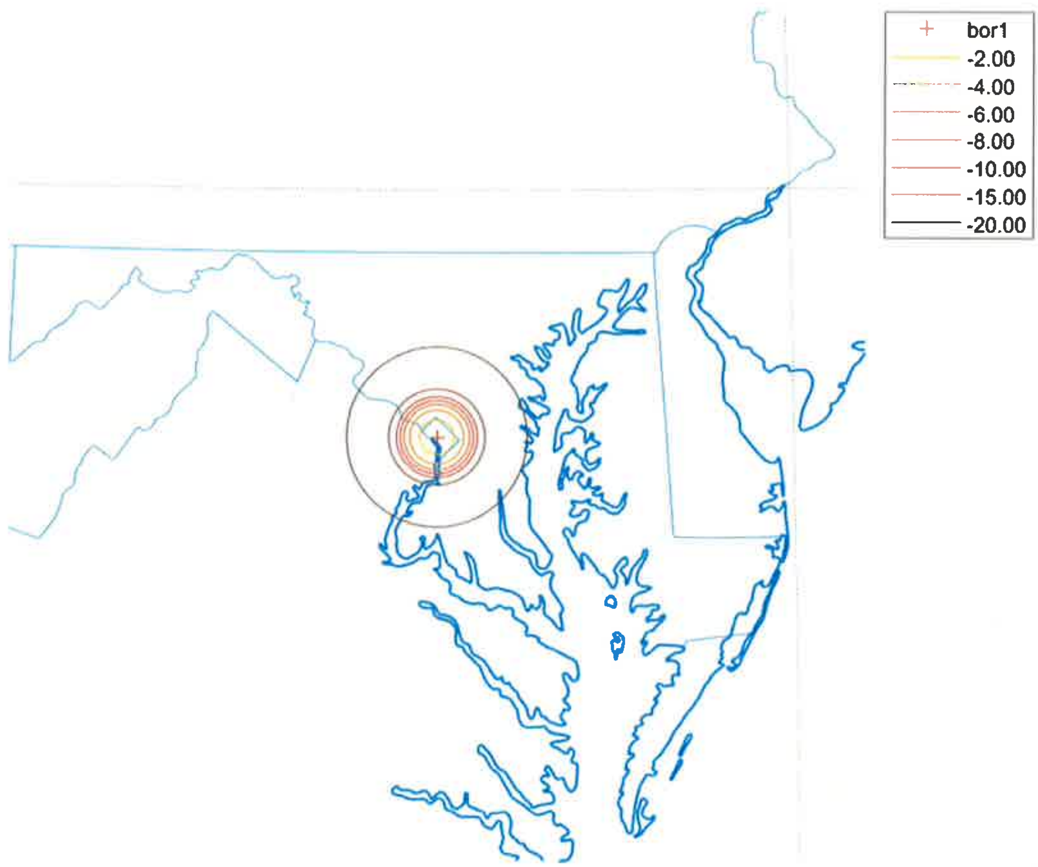

Figure 1 V-Band Transmit Satellite Gateway Beam Projection - Nadir Pointing

[1] Only the GSO beam projections in GIMS provide actual .GXT contours (versus images).

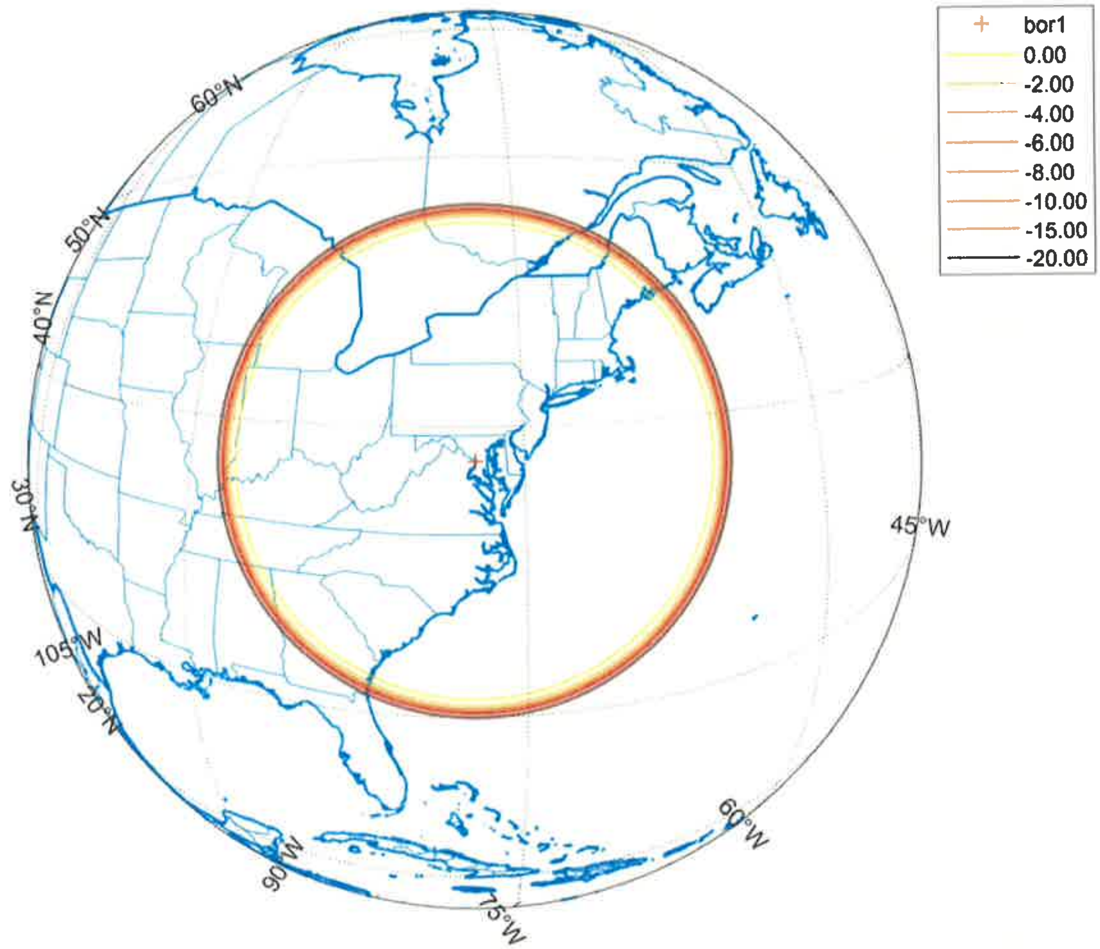

Figure 2 V-Band Transmit Satellite Gateway Beam Projection - Scan to All Locations

2. Gateway Receive Beams

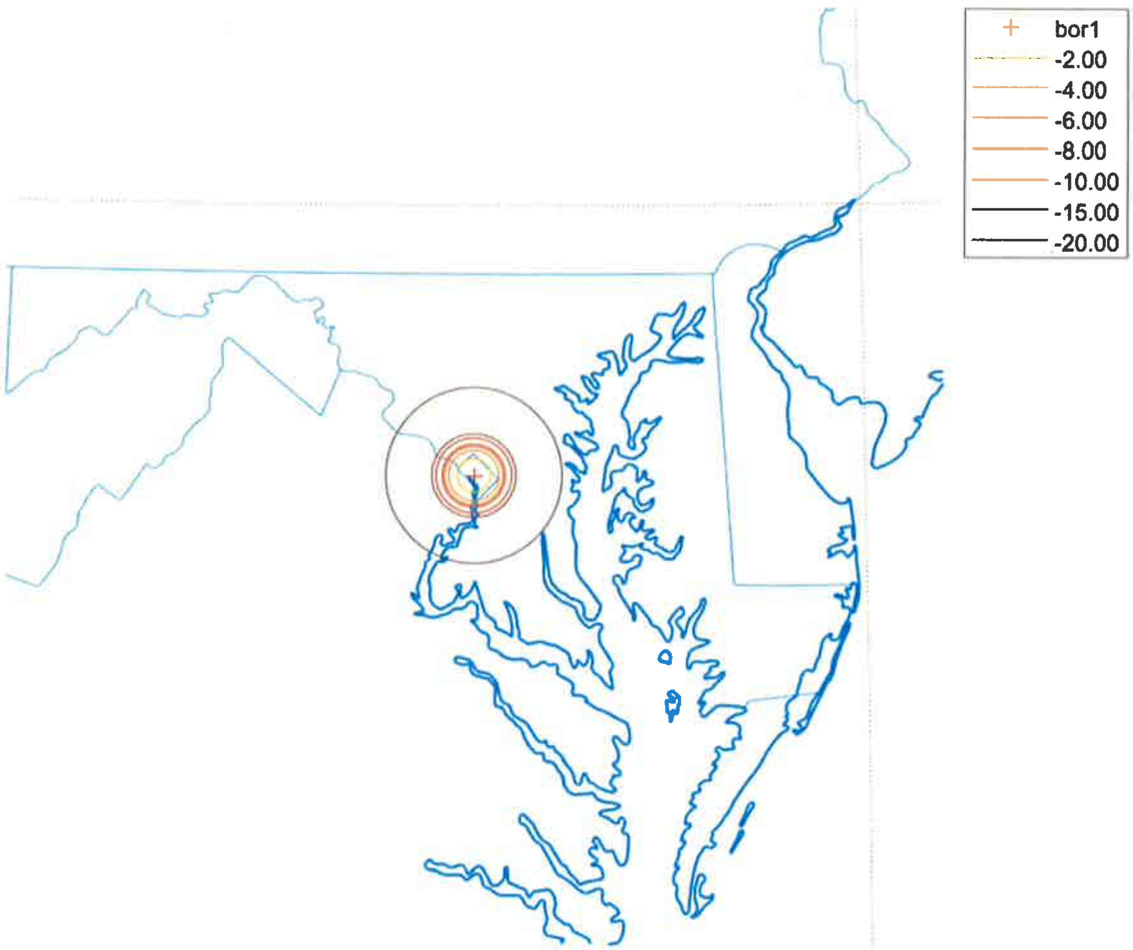

Figure 3 V-Band Receive Satellite Gateway Beam Projection - Nadir Pointing

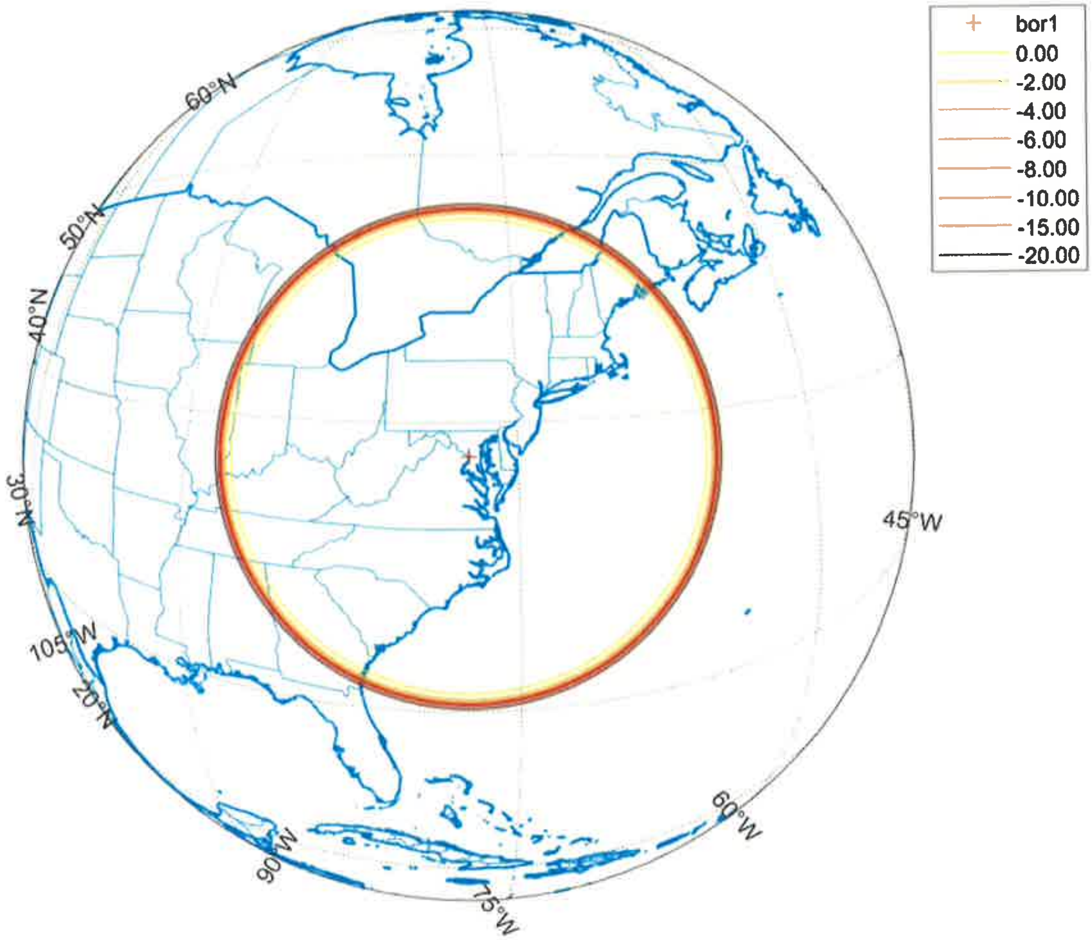

Figure 4 V-Band Receive Satellite Gateway Beam Projection - Scan to All Locations

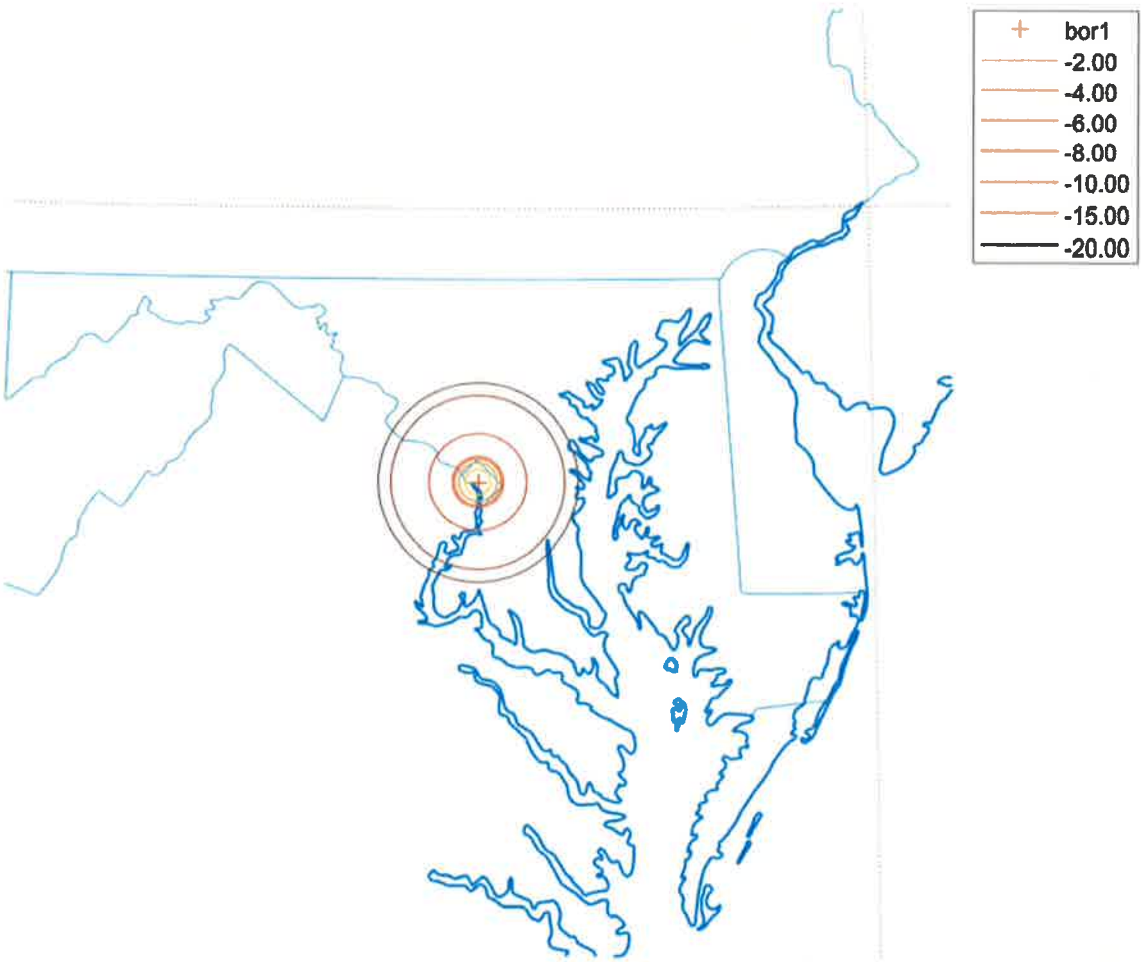

Figure 5 Ka-Band Receive Satellite Gateway Beam Projection - Nadir Pointing

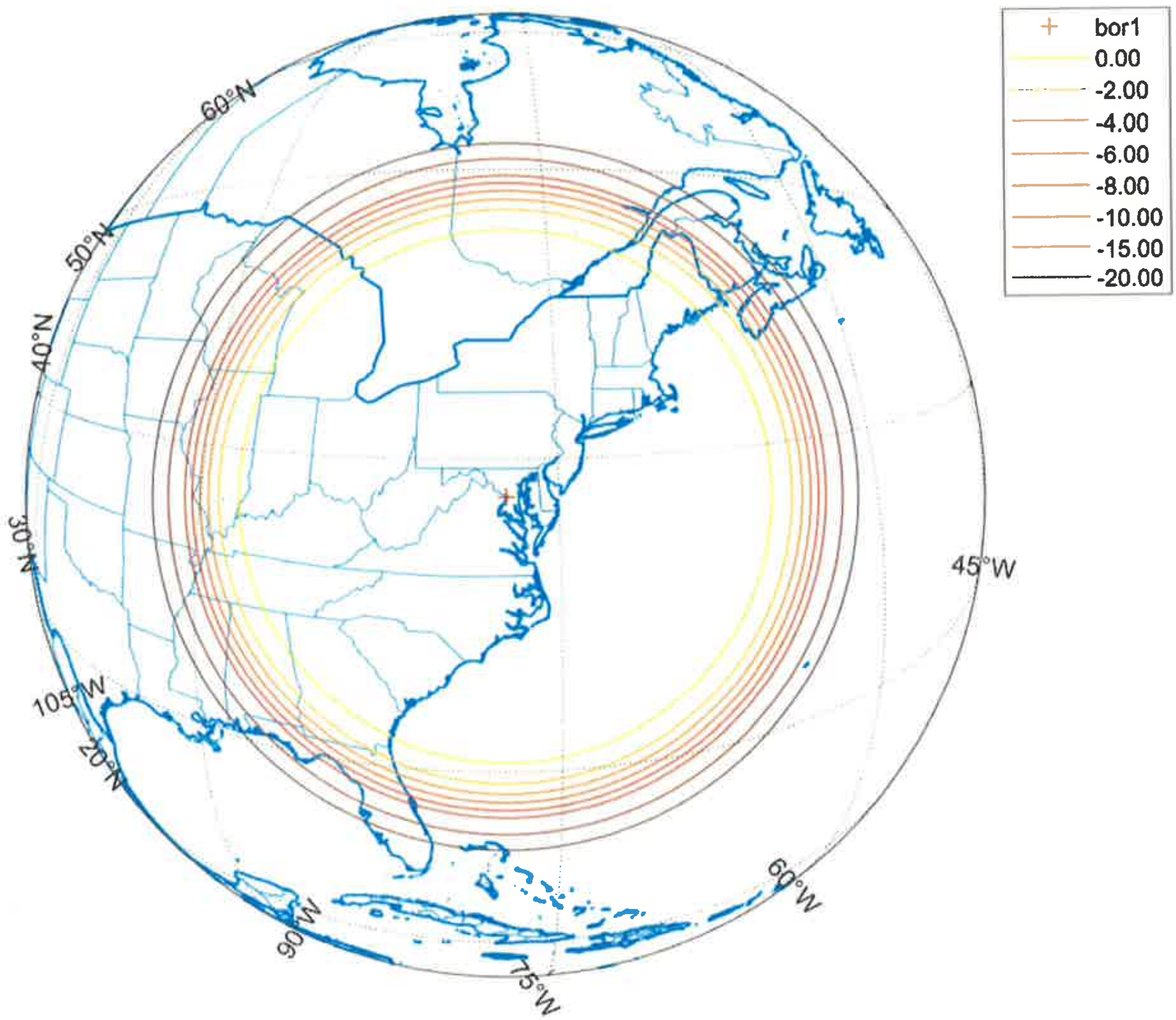

Figure 6 Ka-Band Receive Satellite Gateway Beam Projection - Scan to All Locations

3. User Transmit Beams

The user transmit beams are also employed for feeder link and primary TT&C space-to-Earth communications.

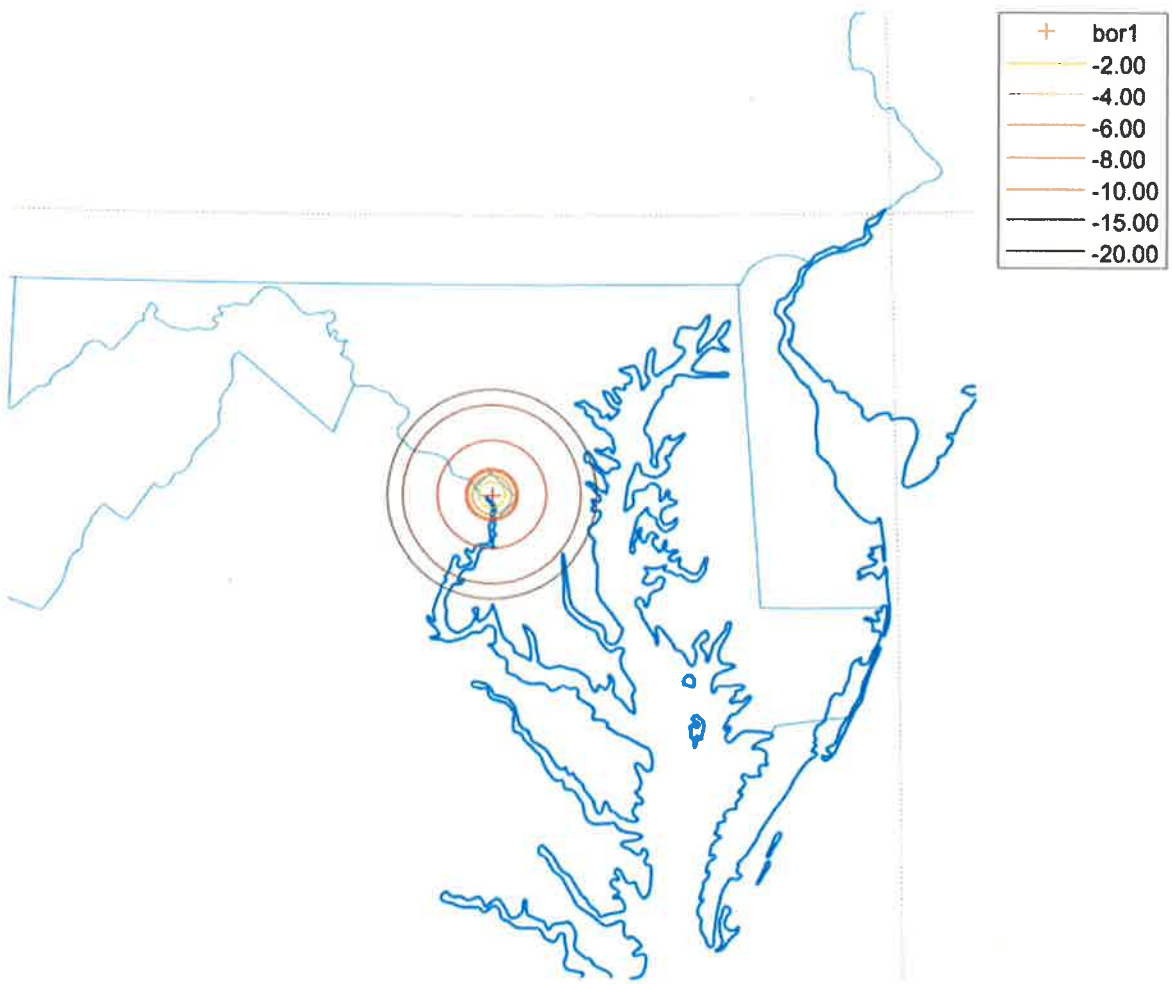

Figure 7 Ka-Band Transmit Satellite User Beam Projection - Nadir Pointing

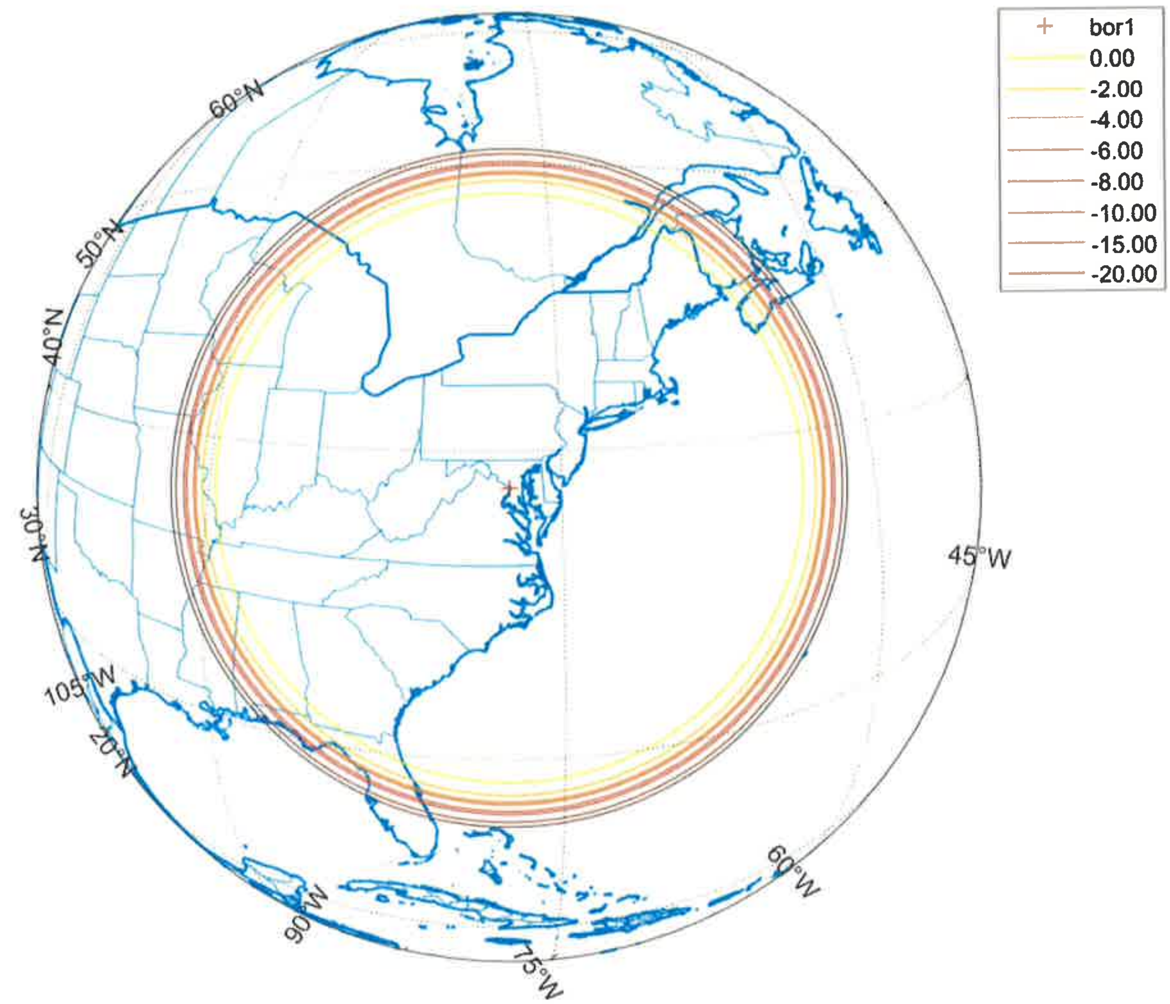

Figure 8 Ka-Band Transmit Satellite User Beam Projection - Scan to All Locations

4. User Receive Beams

The user receive beams are also employed for gateway and primary TT&C Earth-to-space communications.

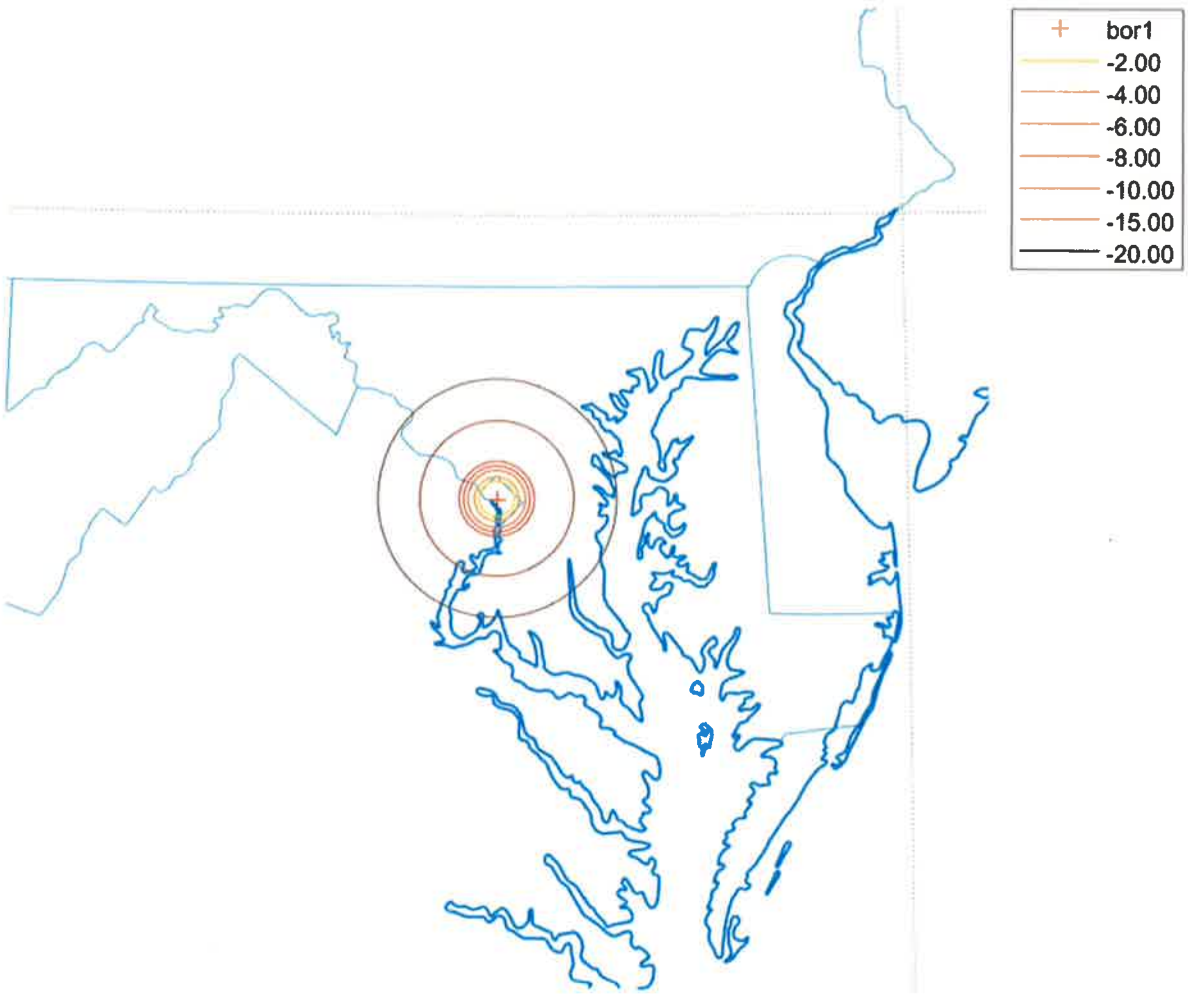

Figure 9 Ku-Band Receive Satellite User Beam Projection - Nadir Pointing

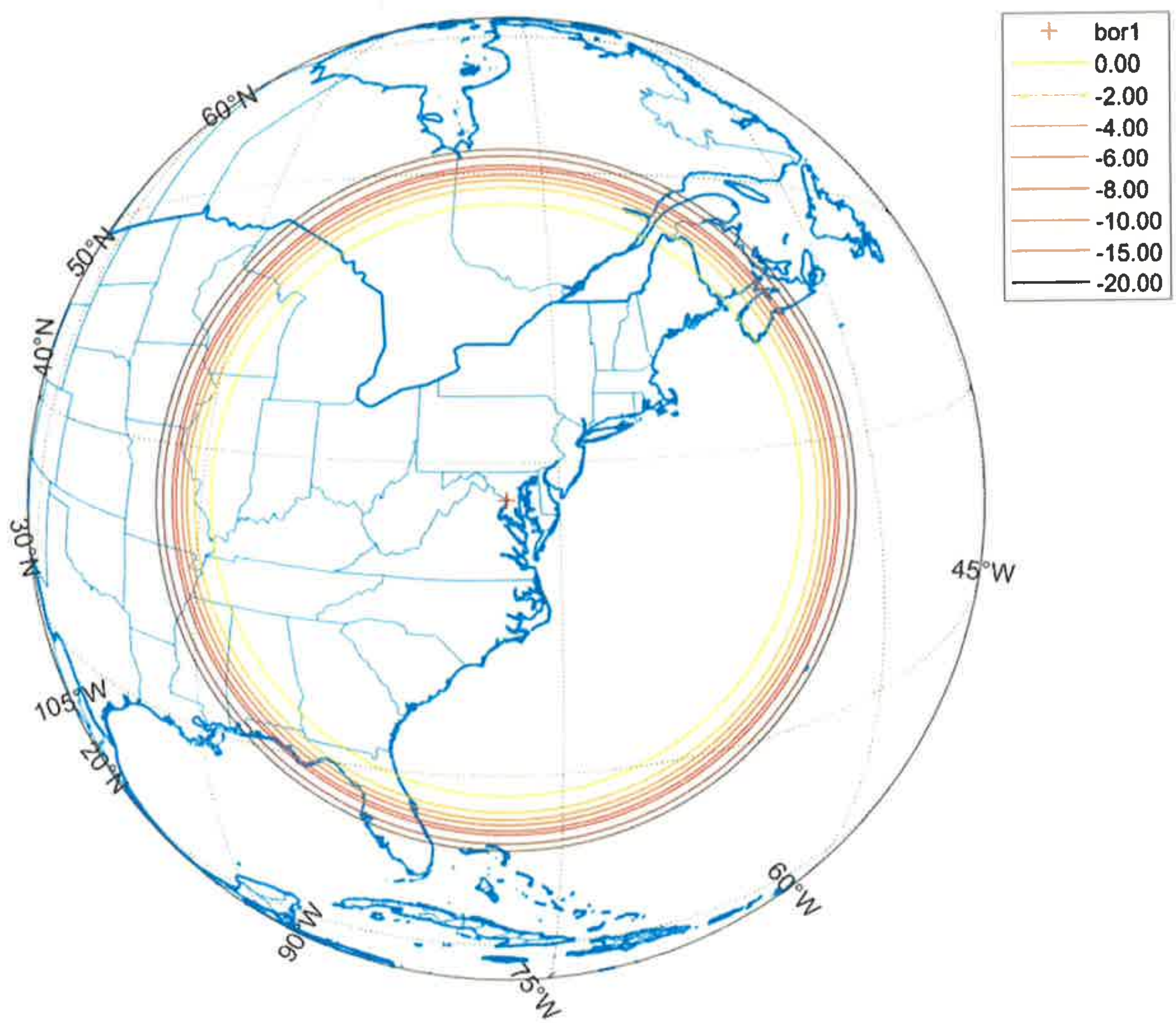

Figure 10 Ku-Band Receive Satellite User Beam Projection - Scan to All Locations

5. Backup TT&C Beams

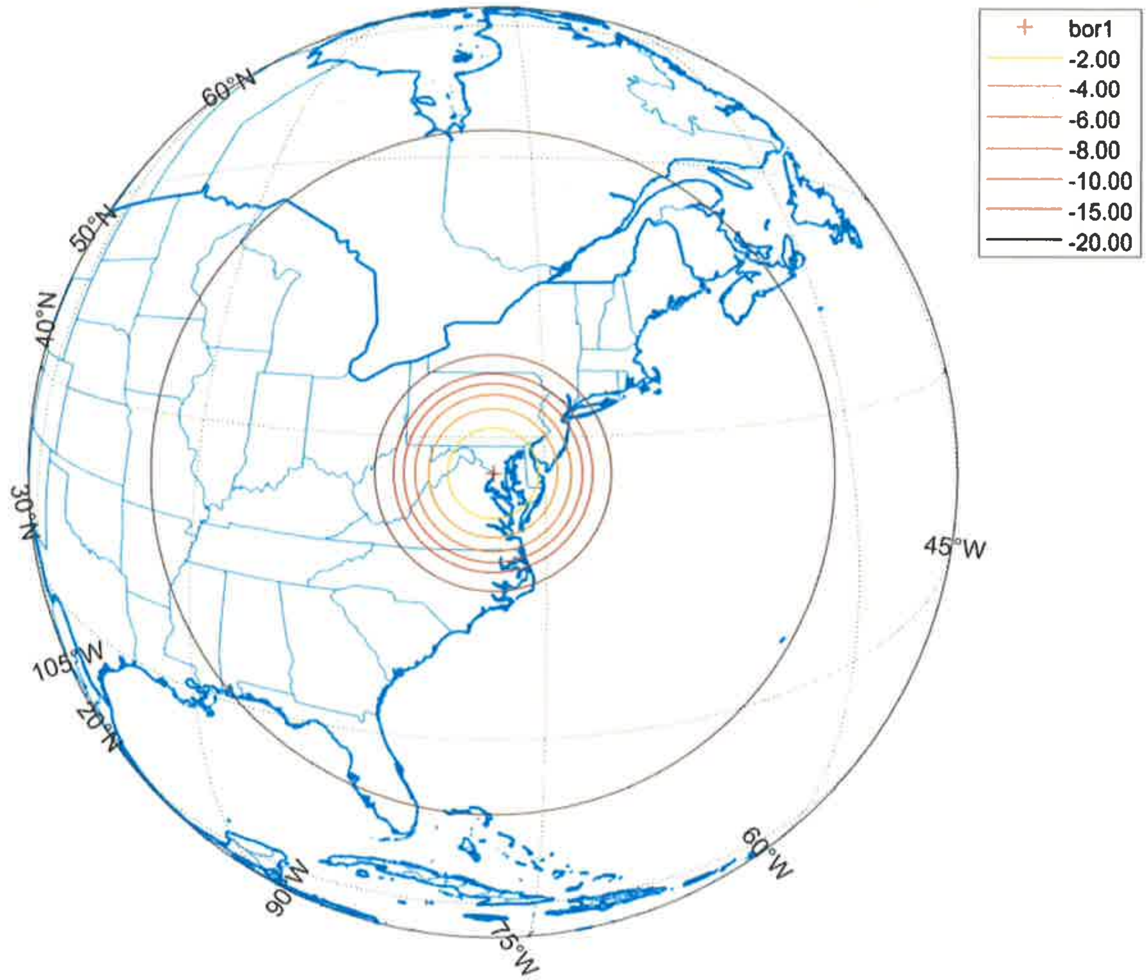

Figure 11 Satellite Receive Ku-band Backup TT&C - Nadir Beam Projection

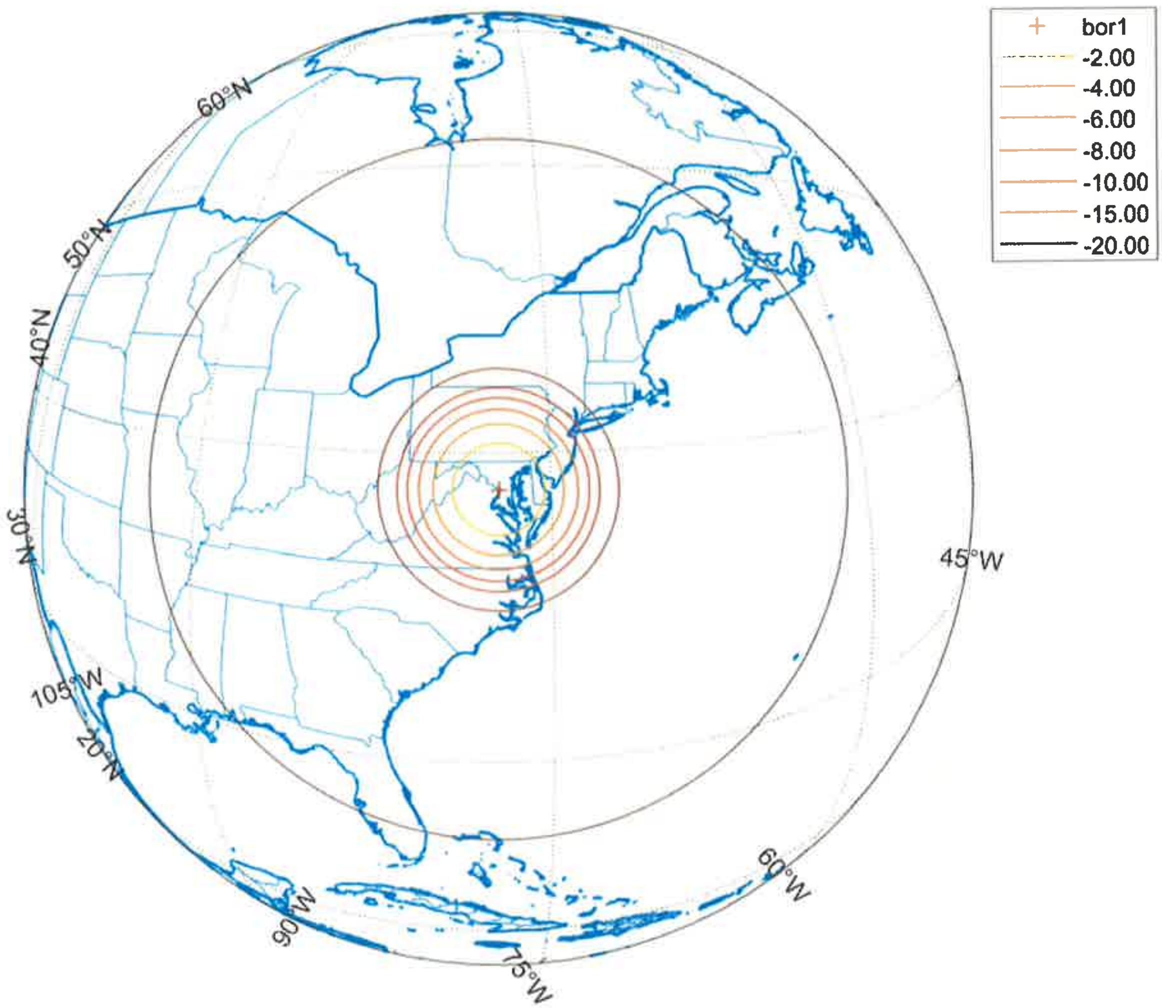

Figure 12 Satellite Transmit Ka-band Backup TT&C - Nadir Beam Projection

EXHIBIT 2

SN Space Systems will share spectrum with and avoid causing harmful interference to other operational NGSO systems via appropriate information sharing and good faith coordination. In the absence of a coordination agreement, may operate the Constellation in compliance with default spectrum sharing rules of Section 25.261 vis-à-vis other NGSO system operations authorized in the same processing round. In addition, with respect to NGSO operations authorized in a prior processing rounds, SN Space Systems understands that it would be possible to operate the Constellation consistent with a demonstration of non-interference approved by the Commission.

In the context of assessing the potential impact of spectrum sharing on the Constellation's multiple coverage characteristics (and thus on capacity and other performance characteristics), more conservative simulations were conducted between the Constellation and numerous co-frequency NGSO systems across a range of U.S. locations. These simulations considered both GSO-arc avoidance and avoidance of the other NGSO system's declared number of co-frequency satellites serving a single location ("Nco") so that inline events with the highest number of active satellites would be avoided. The simulations also assumed only Constellation satellites would avoid the other system's satellites to provide the worst-case potential reduction in multiple coverage that could be experienced by the Constellation.

In this way, SN Space Systems was able to evaluate extreme worst-case impacts of spectrum sharing on Constellation capacity, throughput, and service continuity. In all cases, even with these worst-case assumptions, SN Space Systems has concluded that the Constellation can effectively share spectrum with co-frequency NGSO FSS systems while providing robust satellite broadband service to customers.

SN Space Systems provides an overview of simulations with certain examined systems below. Simulations with these systems are highlighted as relevant examples given their size, frequency overlap, and orbital architecture. Spectrum sharing with smaller and less complex systems will have a less of an impact on the Constellation's multiple coverage characteristics.

1. Spectrum Sharing with SpaceX

Simulations were conducted between the Constellation and SpaceX's 4,408-satellite NGSO system.[1] The SpaceX system utilizes Ku-band spectrum for user links. The Constellation will operate co-frequency with SpaceX in the Ku-band uplink where both systems operate user uplink ubiquitously and the SpaceX system has declared an Nco of 1 for Ku-band user links.

The SpaceX system employs Ka-band spectrum for gateway links. The Constellation will operate Ka-band user downlinks co-frequency with SpaceX gateway downlinks and will operate Ka-band gateway uplinks co-frequency with SpaceX gateway uplinks. The potential for inline interference events on the Ka-band downlink should be limited to Constellation user terminals that are collocated or within proximity of a gateway earth station site. For the Ka-band uplink, inline interference events should be limited to cases where Constellation gateway earth stations are collocated or within proximity to SpaceX gateway earth station sites. SpaceX has declared an Nco of 8 for Ka-band gateway links.

SN Space Systems has simulated the effects of avoiding inline interference events with SpaceX. Simulations were conducted at multiple latitudes and possible avoidance angles. Preliminary calculations suggest that the inline avoidance angle for the Ku-band uplink should be approximately 6°, the inline avoidance angle for the Ka-band downlink should be approximately 3°, and the inline avoidance angle for the Ka-band uplink should be approximately 6°.[2]

As indicated below, on average, Constellation multiple coverage is reduced by approximately 5% when avoiding Ku-band uplink inline events by 6°. On average, Constellation multiple coverage is reduced by approximately 5% when avoiding Ka-band downlink inline events by 3°. On average, Constellation multiple coverage is reduced by approximately 10% when avoiding Ka-band uplink inline events by 6°.[3]

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[1] *See* Space Exploration Holdings LLC, File No. SAT-MOD-20200417-00037 (granted Apr. 27, 2021).

[2] These inline avoidance angles are estimates based on SN Space Systems' understanding of the respective systems' operational parameters and the Commission rules and policies. SN Space Systems expects that these avoidance angles will be refined in the context of coordination.

[3] Note that the multiple coverage reduction plots include 3°, 6°, and 10° avoidance angles to provide, among other things, a top-level sensitivity analysis associated with various avoidance angles. Please refer to the text with respect to the appropriate avoidance angle for each sharing scenario.

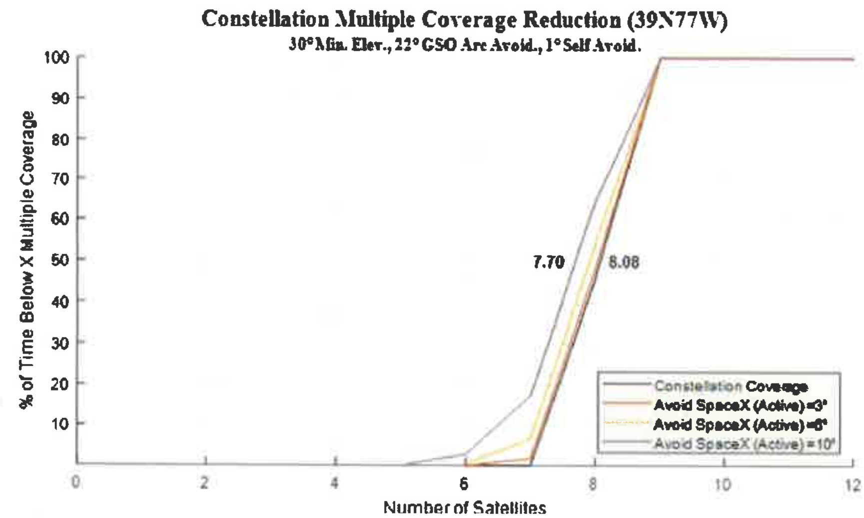

Figure 1 Ku-band Uplink (Constellation Users with SpaceX Users)

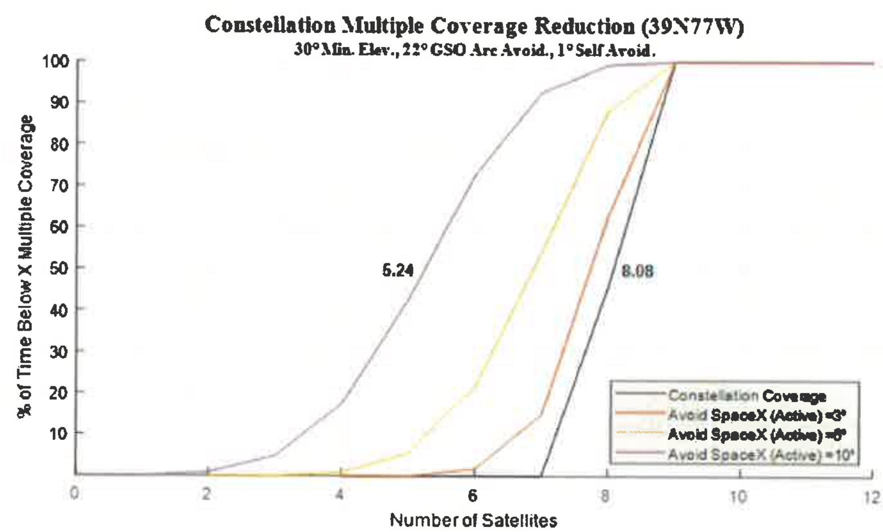

Figure 2 Ka-band Downlink (Constellation Users with SpaceX Gateways)

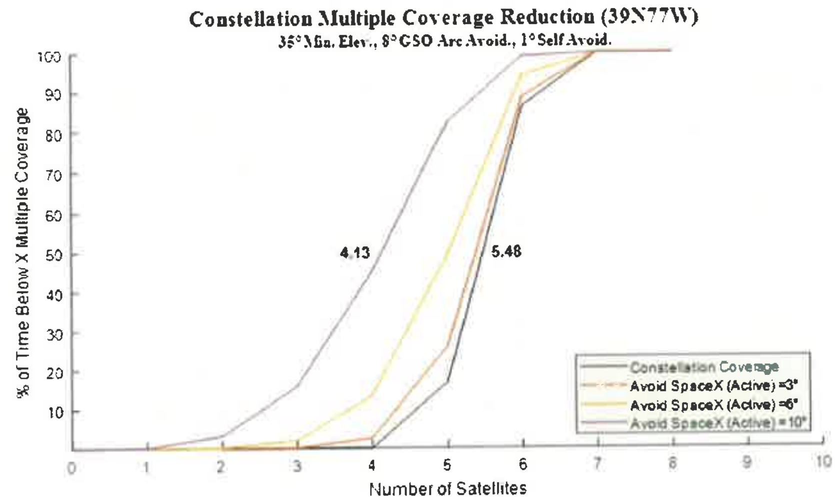

Figure 3 Ka-band Uplink (Constellation Gateways with SpaceX Gateways)

SpaceX also authorized to operate V-band gateway links on its 4,408 constellation and a separate NGSO system with V-band gateway and user links. SN Space Systems has examined the potential inline event avoidance angles in these bands and estimates that the Constellation would need to avoid inline interference events by no more than 3° to avoid causing harmful interference to SpaceX V-band operations. The multiple coverage degradation experienced by the Constellation resulting from avoiding inline interference events with SpaceX V-band links would be, on average, less than 5%.

2. Spectrum Sharing with Kuiper

Simulations were conducted between the Constellation and the authorized 3,236-satellite Kuiper system.[4] With limited exceptions, the Kuiper system operates user and gateway links in different Ka-band frequencies.[5] The Constellation will operate Ka-band gateway uplinks co-frequency with both Kuiper gateway and user uplinks. The Kuiper system has declared Nco=1 for Ka-band uplink user links and Nco=4 for Ka-band uplink gateway links.

The Constellation will operate Ka-band user downlinks co-frequency with Kuiper gateway and user links. In the Ka-band downlink spectrum that the Kuiper system uses for gateways, the

[4] *See* Kuiper Systems, LLC, File No. SAT-LOA-20190704-00057 (granted July 30, 2020).
[5] Any such shared gateway and user spectrum was evaluated by SN Space Systems using the most constraining sharing scenario.

potential for inline interference events should be limited to Constellation user terminals that are collocated or within proximity of a Kuiper gateway site. In the Ka-band downlink spectrum used by the Kuiper system for user links or both user and gateway links, inline interference events may occur anywhere.

SN Space Systems has simulated the effects of avoiding inline interference events with the Kuiper system at various latitudes and avoidance angles. Preliminary calculations suggest that the inline avoidance angle should be approximately 6° for Ka-band uplink spectrum (both for user and gateway uplinks),[6] 3° in spectrum Kuiper uses for gateway downlinks, and 10° in spectrum that Kuiper uses for user downlinks.[7]

As indicated below, on average, Constellation multiple coverage is reduced by approximately 5% when avoiding Ka-band uplink inline events by 6°. On average, Constellation multiple coverage is reduced by approximately 2% when avoiding Ka-band gateway downlink inline events by 3°. On average, Constellation multiple coverage is reduced by approximately 3% when avoiding Ka-band user downlink inline events by 10°.[8]

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[6] SN Space Systems conducted its Ka-band uplink simulation with an Nco of 4 for gateway uplinks (rather than Nco of 1 for user uplinks) as a conservative assumption. In addition, SN Space System notes that the Kuiper system's use of spectrum for gateway and user links may change over time (like that for all NGSO systems).

[7] These inline avoidance angles are estimates based on SN Space Systems' understanding of the respective systems' operational parameters and the Commission rules and policies. SN Space Systems expects that these avoidance angles will be refined in the context of coordination.

[8] Note that the following multiple coverage reduction plots include 3°, 6°, and 10° avoidance angles to provide, among other things, a top-level sensitivity analysis associated with various avoidance angles. Please refer to the text with respect to the appropriate avoidance angle for each sharing scenario.

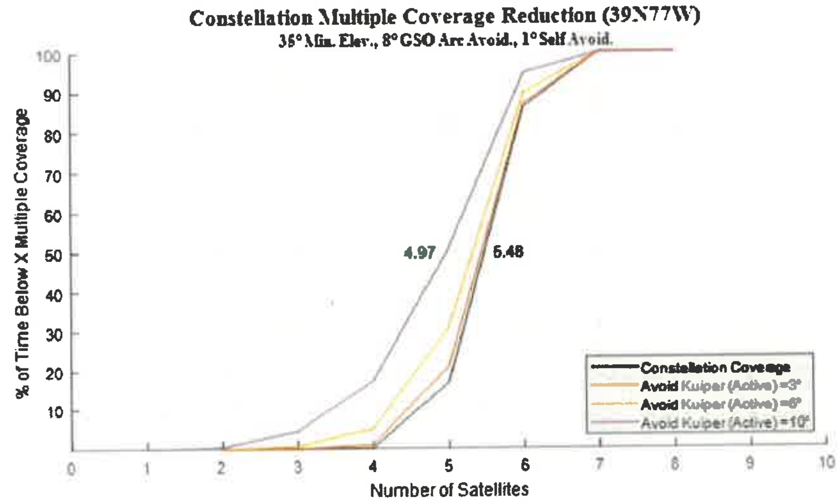

Figure 4 Ka-band Uplink (Constellation Gateways with Kuiper Gateways/Users)

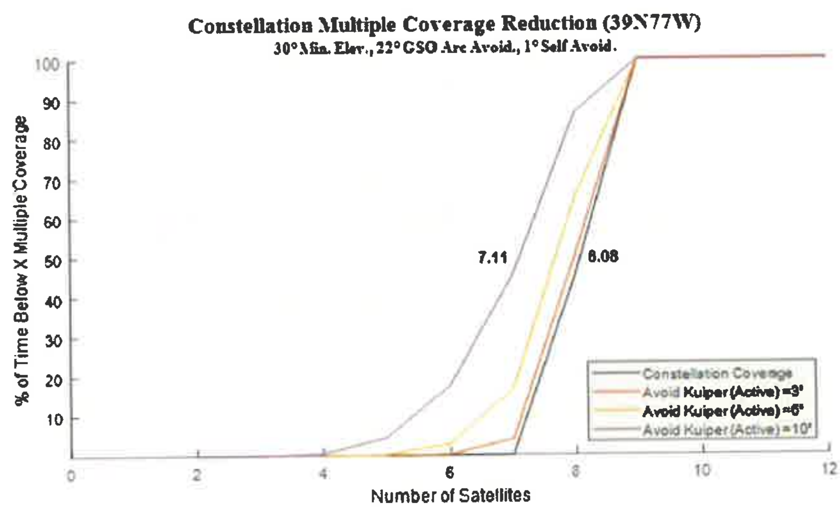

Figure 5 Ka-band Downlink (Constellation Users with Kuiper Gateways)

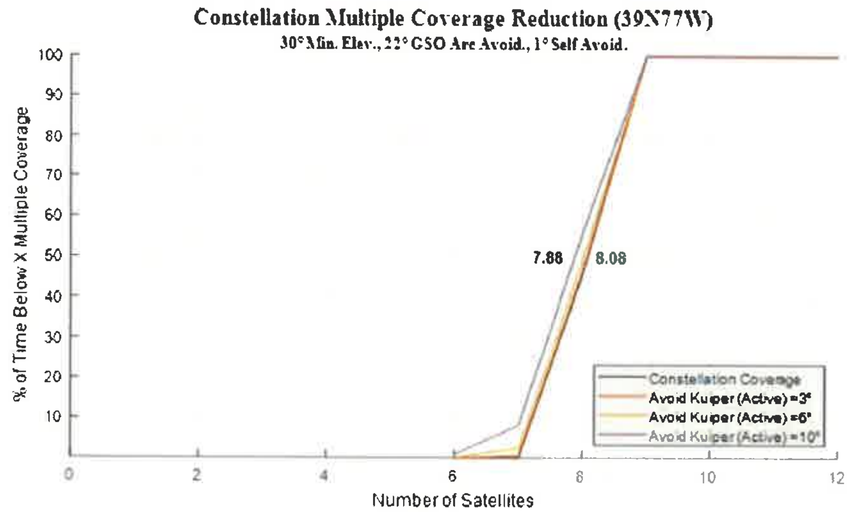

Figure 6 Ka-band Downlink (Constellation Users with Kuiper Users)

3. Spectrum Sharing with Mangata

The Mangata NGSO system consists of 567 medium-Earth orbit satellites and 224 highly elliptical orbit satellites.[9] The larger constellation size and unique orbital architecture suggests it is an important spectrum sharing scenario, especially because Mangata's request for authority to operate in V-band spectrum for gateway uplinks and downlinks is a subject of the current processing round in which SN Space Systems seeks to participate.

When sharing Ka-band and V-band spectrum with Mangata, multiple coverage simulations were conducted at various latitudes and avoidance angles. Preliminary calculations suggest that the inline avoidance angle should be approximately 6° in Ka-band gateway uplink spectrum and 3° in V-band gateway uplink and downlink spectrum, 6° in Ka-band gateway downlink spectrum, and 10° in Ka-band user downlink spectrum to be shared with Mangata.[10]

As indicated below, on average, Constellation multiple coverage is reduced by approximately 2% when avoiding Ka-band uplink gateway inline events by 6° and approximately 1% when avoiding V-band uplink/downlink gateway inline events by 3°. On average, Constellation

[9] *See* Mangata Networks LLC, File No. SAT-PDR-20200526-00054 (filed May 26, 2020).

[10] These inline avoidance angles are estimates based on SN Space Systems' understanding of the respective systems' operational parameters and the Commission rules and policies. SN Space Systems expects that these avoidance angles will be refined in the context of coordination.

multiple coverage is reduced by approximately 5% when avoiding Ka-band gateway downlink inline events by 6°. On average, Constellation multiple coverage is reduced by approximately 3% when avoiding Ka-band user downlink inline events by 10°.[11]

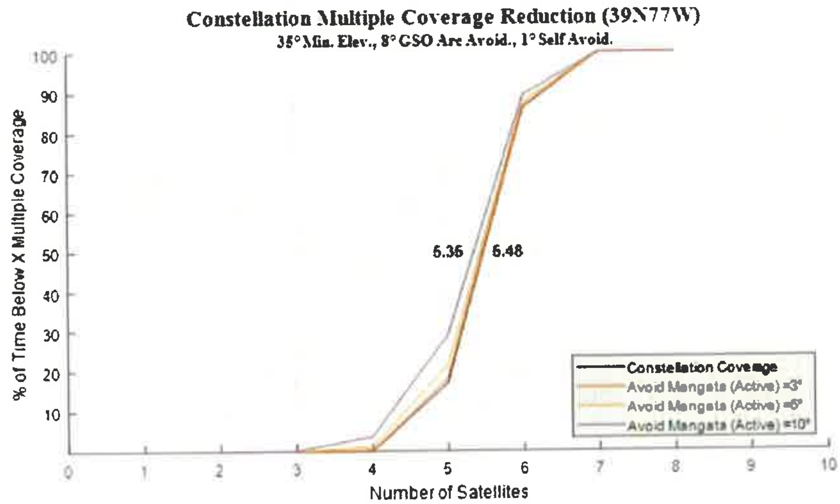

Figure 7 Ka-band Uplink and V-band Uplink/Downlink (Constellation Gateways with Mangata Gateways)

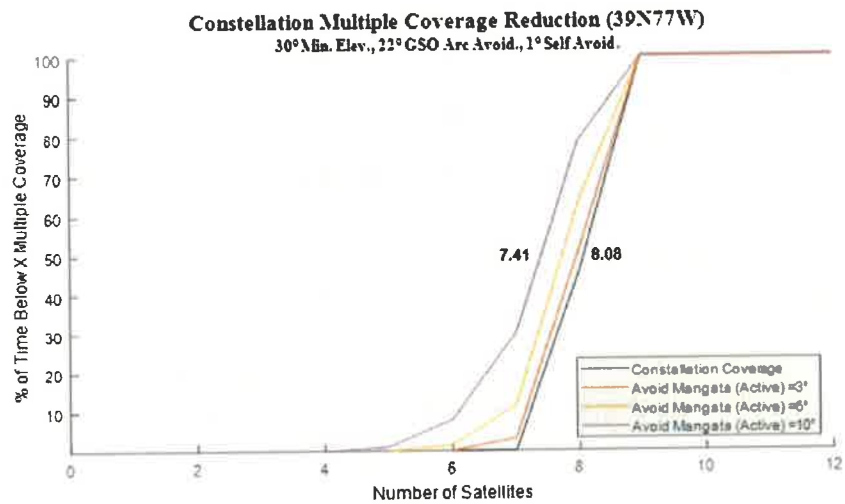

Figure 8 Ka-band Downlink (Constellation Users with Mangata Gateways)

[11] Note that the following multiple coverage reduction plots include 3°, 6°, and 10° avoidance angles to provide, among other things, a top-level sensitivity analysis associated with various avoidance angles. Please refer to the text with respect to the appropriate avoidance angle for each sharing scenario.

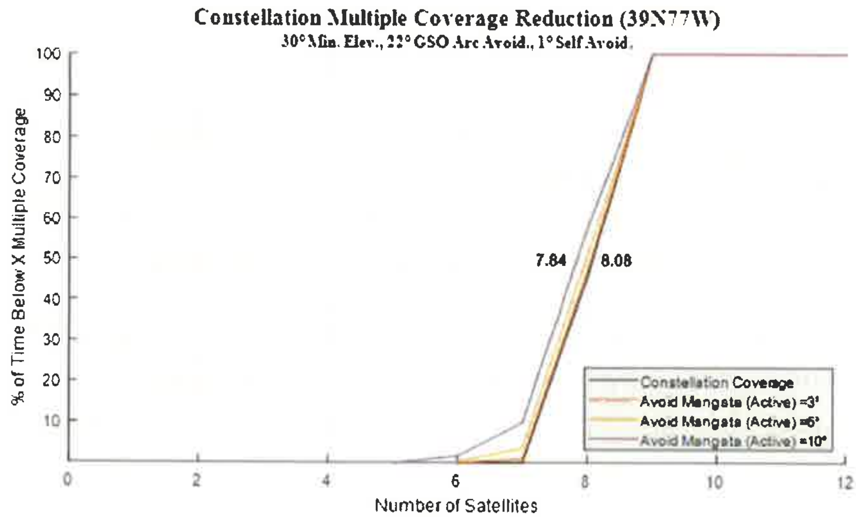

Figure 9 Ka-band Downlink (Constellation Users with Mangata Users)

4. Aggregate Effects of Spectrum Sharing with NGSO Systems

In addition to spectrum sharing with individual systems, SN Space Systems has examined the impact of spectrum sharing with multiple NGSO systems from prior processing rounds and the same processing round. At the outset, the inherent imprecision of the spectrum sharing environment should be noted, particularly given the uncertainty of authorized system implementation. As a result, SN Space Systems has considered a wide range of spectrum sharing scenarios and operational impacts and has concluded that the Constellation can effectively share spectrum while providing robust satellite broadband services regardless of additional NGSO system implementation.

In addition, although it has sought to examine worst-case condition in evaluating its business case and operational requirements, SN Space Systems believes that such assumptions will not actually be realized in the context of the dynamic spectrum environment among broadband NGSO systems. For example, good faith coordination and spectrum splitting among participants in the same processing round will mitigate worst-case assumptions considerably. Also, reduction in multiple coverage is not merely the sum of percentage losses caused by sharing with each individual NGSO system and it should not be assumed that reduction in multiple coverage translates directly into a reduction overall system capacity.

Furthermore, certain estimated reductions in the Constellation's multiple coverage are associated with sharing with gateway earth stations, which only applies within a limited geographic area. The limited scope of such affects must be considered, as well as potential mitigation (*e.g.*, via strategic location of Constellation teleports).

In addition, simulations suggest that the aggregate multiple coverage reduction impact of sharing with multiple systems does not combine linearly. As additional systems are examined, the incremental reduction is less than its individual, stand-alone impact as satellite tracks begin to cross and other systems are required to resolve inline interference events with each other. In this context, coordination and information sharing regarding active beam locations can greatly facilitate -- and reduce the impact -- of spectrum sharing.

SN Space Systems would also note that in bands shared among participants in the same processing round, Section 25.261 spectrum splitting may result in no reduction in multiple coverage even if an affected satellite may only operate on a fraction of available spectrum for a brief period of time. This mitigating factor must also be considered in accurately assessing the impact of spectrum sharing.

Finally, there may be areas in which a user terminal or gateway earth station can see more than the maximum of four satellites with which the toroidal antennas are designed to communicate simultaneously. In such circumstances, SN Space Systems' simulations may show a reduction in multiple coverage but there would be no actual impact on user or gateway communications.

In summary, SN Space Systems has conducted extensive NGSO-NGSO spectrum sharing analyses and believes that the potential reduction in multiple coverage and system capacity associated with sharing Ku-band, Ka-band, and V-band spectrum with other NGSO systems are acceptable under most reasonable NGSO deployment scenarios.