# MYRIOTA NON-GEOSTATIONARY SATELLITE SYSTEM

## ATTACHMENT A
## TECHNICAL INFORMATION TO SUPPLEMENT SCHEDULE S

### A.1 SCOPE AND PURPOSE

This attachment contains the information required under Part 25 of the Commission's rules that cannot be fully captured by the associated Schedule S.

### A.2 OVERALL DESCRIPTION

Myriota seeks access to the U.S. market for a non-voice, non-geostationary ("NVNG") satellite system of small satellites that will communicate with low-power NVNG modules and employ advanced signal processing to provide connectivity to a new generation of Internet of Things ("IoT") devices. Myriota will deliver global coverage by enabling transmissions directly from IoT devices to satellites in low-Earth orbit ("LEO"), which removes the need for intervening ground-based infrastructure. Myriota's LEO constellation will provide secure, low-cost communications for IoT devices anywhere on the planet for economical massive scale direct-to-orbit applications. As described in greater detail below, Myriota's NVNG system will provide this capability using a flexible and spectrum-efficient operating approach that will facilitate spectrum sharing with other authorized systems while still providing robust and innovative services for its customers.

***Orbital Parameters***

The Myriota non-geostationary orbit ("NGSO") satellite system consists of 26 satellites operating in 18 planes at an initial altitude of approximately 600 km.[1] Table A.2-1 below

[1] Myriota also seeks authority to communicate with follow-on satellites launched to replenish its constellation as satellites reach end of life.

summarizes the orbital parameters of this constellation.

| Altitude (km) | Inclination | Number of Planes | Satellites per Plane |
|---|---|---|---|
| 600 | 54° | 10 | 1 |
| 600 | 54° | 2 | 2 |
| 600 | 97.7° | 6 | 2 |

**Table A.2-1. Summary of Orbital Parameters**

Myriota's first three satellites, with a 3U cubesat form factor, will not have propulsive capability, and thus will not be able to actively maintain orbital parameters. These satellites will be launched via ride share into two of the 97.7 degree inclined orbital planes, and one near the 54 degree inclined orbital planes. After the initial three satellites, Myriota will continue with satellite rollout of a limited number of additional 3U satellites. Following this 3U phase, subsequent satellites launched will have propulsion capability, and will be larger with a 6U form factor. They will utilize dedicated launch precisely to the target inclination. As the constellation grows and is replenished, the added propulsion capability will be used to conduct orbital station keeping, plane phasing (utilizing the J2 perturbation), collision avoidance, and de-orbit maneuvers.

***Spectrum***

In the United States, Myriota will operate its NVNG system using the 399.9-400.05 MHz (Earth-to-space) and 400.15-401 MHz (space-to-Earth) frequency band. Both bands have been allocated to non-Federal MSS on a primary basis and have been specifically identified by the Commission as being available for NVNG MSS operations.[2] As illustrated in Figure A.2-1 below, Myriota's satellites can vary channel bandwidth with on-board processing across the entire range of both the uplink and downlink frequency bands authorized for its use. Accordingly, Myriota

[2] *See* 47 C.F.R. §§ 2.106, 25.202(a)(3). *See also* 47 C.F.R. § 2.106 n.US320 (the use of the 399.9-400.05 MHz and 400.15-401 MHz bands by the MSS is limited to NVNG satellite systems).

proposes to operate multiple channels within the requested uplink and downlink frequencies.

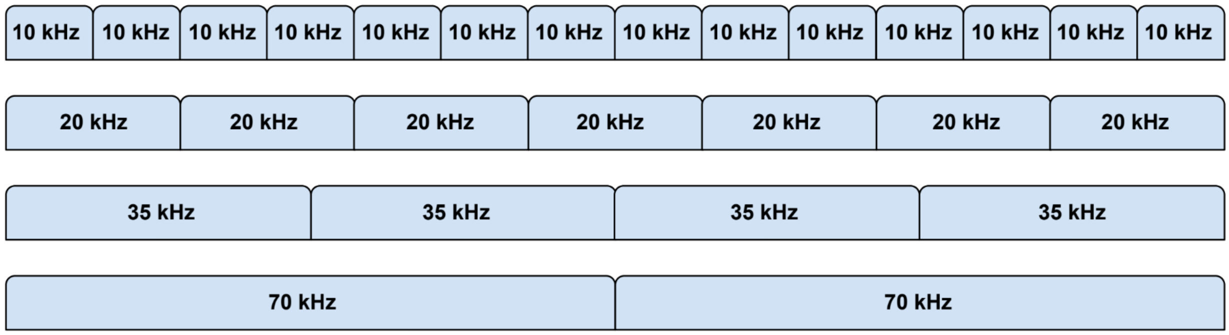


**Figure A.2-1. Illustration of Channel Variations**

Outside the U.S., Myriota will use additional spectrum to transmit both payload data and payload command and control information between its spacecraft and gateway earth stations. These transmissions will be performed in the 2025-2110 MHz band for uplinks, and in the 2200-2290 MHz and 8025-8400 MHz bands for downlinks. Myriota will also perform telemetry, tracking, and control ("TT&C") operations from locations outside the U.S. Myriota does not request market access with respect to these additional frequency bands at this time.

## A.3 PREDICTED SPACE STATION ANTENNA GAIN CONTOURS

All satellites in the Myriota NVNG constellation have been designed with the same transmit and receive antenna beams. These beams are fixed with respect to the satellite body. The spacecraft attitude is maneuverable, and the expected gain of the dipole antennas will be between -1.9 dBi and 2.15 dBi at nadir. The antenna gain contours for the beams of a representative space station, which are essentially the same for satellites operating in all planes within the constellation, are shown in Figure A.3-1 below and embedded in the associated Schedule S.

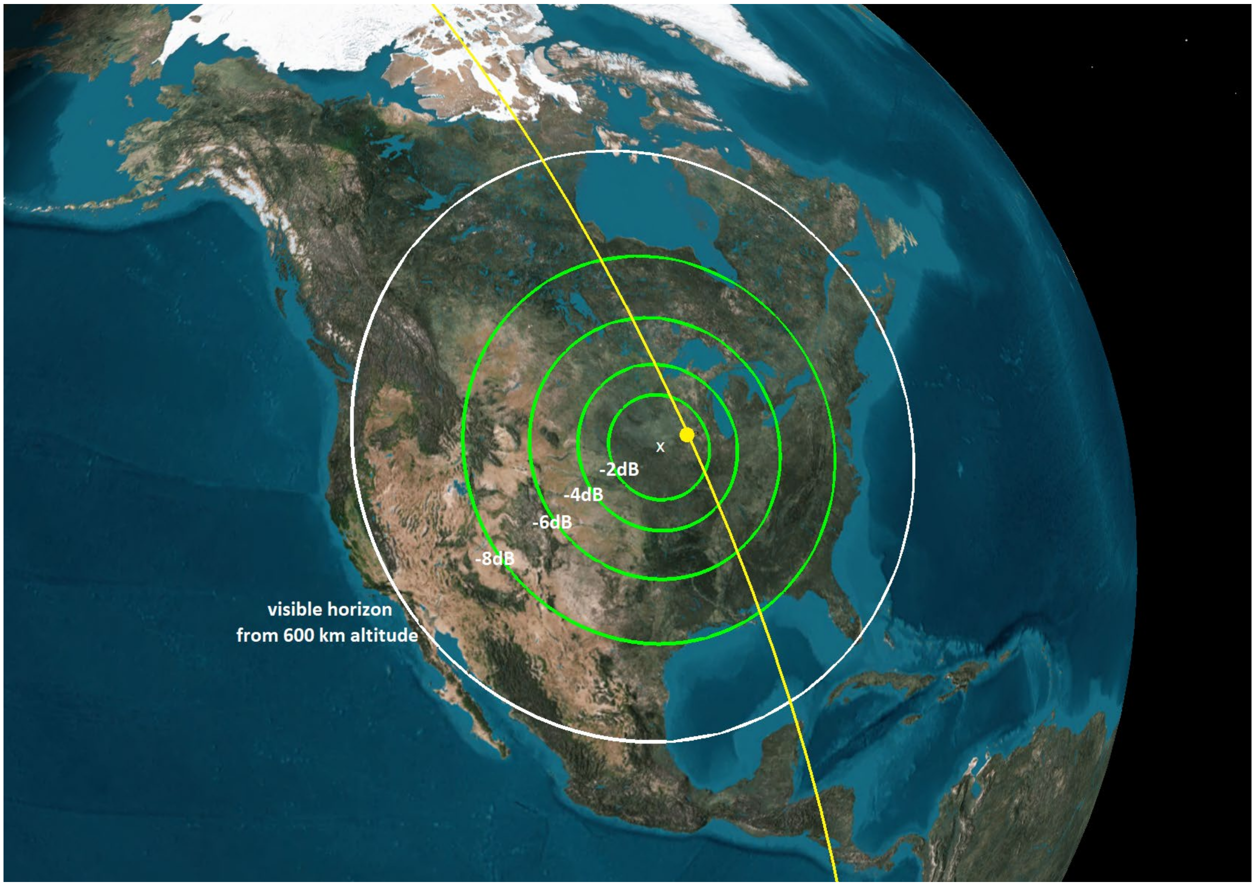


**Figure A.3-1. Representative Antenna Gain Contour Plot**

## A.4 TT&C CHARACTERISTICS

The Myriota TT&C operations communicate with spacecraft during pre-launch, transfer orbit, and on-station operations, as well as during spacecraft emergencies.[3] All TT&C communications will be conducted over authenticated and encrypted links for commanding, telemetry (mission related data), and customer data. During all phases of the mission, TT&C operations will use the following frequency bands:

- For space-to-Earth: 2200-2290 MHz.
- For Earth-to-space: 2025-2110 MHz.

[3] The information provided in this section complements that provided in the associated Schedule S and Technical Database.

As noted above, Myriota will conduct TT&C operations using ground station facilities located outside the U.S., and therefore does not seek authority for market access with respect to TT&C spectrum at this time.

### A.5 CESSATION OF EMISSIONS

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, as required by Section 25.207 of the Commission's rules.

### A.6 SPECTRUM SHARING ANALYSES

As discussed in Section A.2 above, the frequency ranges Myriota proposes to use in the U.S. have been designated by the Commission for use by commercial NVNG MSS systems. However, that spectrum is also shared with other services in the U.S. Table of Frequency Allocations. As required in Section 25.142 of the Commission's rules, Myriota below (1) demonstrates, based on existing system information publicly available at the Commission, that it will not cause unacceptable interference to any NVNG MSS system currently authorized to construct or operate, (2) provides the power flux-density ("PFD") produced by its system at the Earth's surface in the 400.15-401 MHz band to demonstrate that no further coordination with terrestrial systems is necessary, (3) describes the measures it would employ to protect the radio astronomy service in the 406.1-410 MHz band from harmful interference from unwanted emissions, and (4) demonstrates compliance with applicable emission limitations.[4]

As discussed below, Myriota has designed its NVNG system to achieve a high degree of flexibility and spectral efficiency in order to facilitate frequency sharing and to protect other

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[4] *See* 47 C.F.R. § 25.142(a)(1)-(3).

authorized satellite and terrestrial systems in compliance with U.S. and international regulations and under reasonable coordination arrangements. Applying these and other sharing mechanisms as described throughout this section, Myriota is confident that it can successfully coordinate its system with other authorized satellite and terrestrial networks.

### A.6.1 Spectrum Sharing with Respect to Other NVNG Satellite Systems

Myriota intends to operate its NVNG system in the U.S. using the 399.9-400.05 MHz uplink and 400.15-401 MHz downlink bands, which have been allocated for use by commercial NVNG MSS systems.[5] Section 25.142(a)(1) of the Commission's rules requires all NVNG applicants to file information demonstrating, on the basis of information publicly available at the Commission at the time of filing, that they will not cause unacceptable interference to any NVNG MSS system authorized to construct or operate. Below we provide a brief history of the Commission's NVNG licensing activity before addressing the situation in each band in which Myriota proposes to operate in the United States.

In the mid-1990's, the Commission conducted two NVNG processing rounds. As a result of a consensus spectrum use plan negotiated by the applicants in the second processing round, the Commission issued a total of five licenses for NVNG MSS systems, sometimes referred to as "Little LEO" systems.[6] The Commission did not authorize any NVNG system to operate in the 399.9-400.05 MHz band at that time (or in subsequent years). However, of these five NVNG licenses, three included authorization to operate in the 400.15-401 MHz band.

- ➢ System 1 was originally licensed to Leo One and covered 400.15-400.505 MHz and 400.645-401 MHz bands.

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5 *See* 47 C.F.R. §§ 2.106, 25.202(a)(3). *See also* 47 C.F.R. § 2.106 n.US320 (the use of the 399.9-400.05 MHz and 400.15-401 MHz bands by the MSS is limited to NVNG satellite systems).

6 *See Amendment of Part 25 of the Commission's Rules to Establish Rules and Policies Pertaining to the Second Processing Round of the Non-Voice, Non-Geostationary Mobile-Satellite Service*, 13 FCC Rcd. 9111 (1997) ("*Second NVNG Processing Round Order*").

- System 2 was originally licensed to Final Analysis and covered the entire 400.15-401 MHz band.

- System 5 was originally licensed to VITA, covered the 400.505-400.5977 MHz and 400.5983-400.645 MHz bands, and was required to timeshare with System 2.

By December 2005, all three of these licenses had been either surrendered by the licensee or cancelled for failure to meet applicable deployment milestones. Each time, the Commission issued a public notice stating that the licensee's spectrum would be available for new applicants on a first-come, first-served ("FCFS") basis.[7]

The only NVNG licensee to launch and operate a system authorized to provide service in the U.S. was Orbital Communications Corporation ("Orbcomm"), which originally was licensed to use spectrum in the 137-138 MHz (uplink) and 148-150 MHz (downlink) bands. However, in 2007, Orbcomm applied for the spectrum formerly authorized to System 1, which includes spectrum in the 400.15-401 MHz band. In support of its application, Orbcomm observed that "sufficient Little LEO spectrum remains available to license three other Little LEO systems after assigning System 1 frequencies to Orbcomm."[8] In granting that application, the Commission also authorized Orbcomm to operate temporarily in the remaining NVNG spectrum, on the condition that "Orbcomm must operate jointly in the Little LEO spectrum with any other licensees operating in the System 2, System 3, and VITA system segments under the plan adopted in the *Second Processing Round Report and Order* if and when an applicant is authorized to operate in any of those designated system segments."[9]

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[7] *See* Public Notice, 19 FCC Rcd. 4804 (2004) (Final Analysis cancellation); Public Notice, 19 FCC Rcd. 5368 (2004) (Leo One cancellation); Public Notice, 20 FCC Rcd. 20273 (2005) (VITA surrender).

[8] *See Orbcomm License Corp.*, 23 FCC Rcd. 4804, ¶ 10 (2008).

[9] *See id.* ¶ 11.

### A.6.1.1 400.15-401 MHz

As discussed above, the only operational NVNG system authorized by the Commission in this downlink band is licensed to Orbcomm. It has been authorized to use the 400.15-400.505 MHz and 400.645-401 MHz bands on an ongoing basis but must share the remaining NVNG spectrum in the band once another NVNG operator is authorized to use it. Ideally, Myriota would like access to operate downlink communications using 140 kHz bandwidth. Table A.6.1.1-1 below illustrates a channel plan arrangement for a contiguous 140 kHz spectrum assignment:

| Channel bandwidth (kHz) | Number of channels | Assigned bandwidth (kHz) | Required avg. duty cycle (%) |
|---|---|---|---|
| 10 | 14 | 140 | 10 |
| 20 | 7 | 140 | 10 |
| 35 | 4 | 140 | 10 |
| 70 | 2 | 140 | 10 |

**Table A.6.1.1-1. Illustration of Channel Plan for 140 kHz Assignment**

Nonetheless, Myriota could operate its constellation in the spectrum assigned to either System 2 or System 5 from the second processing round, both of which are currently available. Accordingly, Myriota could operate without causing unacceptable interference to Orbcomm.

Yet even in the absence of this legacy spectrum sharing plan, Myriota's system has the flexibility and spectral efficiency to be able to operate harmoniously with Orbcomm in this band. For example, Myriota's satellites can vary the bandwidth of their emissions through on-board processing, and dynamically control their emissions to accommodate sharing arrangements with other users of the band. Myriota downlink emissions can range in bandwidth between 10-140 kHz and operate within the entire 850 kHz MSS allocation or any portion thereof designated for their use. Myriota downlink emissions can employ frequency hopping to move throughout the assigned band, or operate with a defined channel plan, using either multiple contiguous channels or a fragmented channel arrangement. By combining the 10% duty cycle with the flexibility of the software defined radio on board its satellites, Myriota will be able to share spectrum by coordinating usage and/or time of operations. Myriota has contacted Orbcomm to organize a coordination meeting to discuss sharing arrangements of this band.

Myriota recognizes that Hiber Inc. has also filed an application seeking U.S. market access using this same spectrum band.[10] According to its application, Hiber intends to operate using 100 kHz bandwidth with a low duty cycle. Hiber contends that its system would be able to share this band and would not preclude entry by other NVNG systems in the future.[11] Since both Myriota and Hiber will only transmit for a small fraction of time, there is a very low probability of harmful interference between the systems even while sharing the same spectrum. As described above, the spectrally efficient and flexible software defined radio on board its satellites will enable Myriota to share with Hiber under a variety of possible arrangements. Myriota has already contacted Hiber to organize a coordination meeting.

**A.6.1.2 399.9-400.05 MHz**

The 399.9-400.05 MHz band has been allocated for use by NVNG systems for over a decade. However, the Commission has never issued an authorization to construct or operate a satellite system in this uplink band. Accordingly, there is no risk that granting Myriota's application could result in unacceptable interference to an authorized NVNG system, satisfying the requirement in Section 25.142(a)(1).

Yet even if this were not the case, Myriota's system would be able to share this band with

[10] *See* Petition for Declaratory Ruling, IBFS File No. SAT-PDR-20180910-00069 (Sep. 10, 2018) ("Hiber PDR").

[11] *See id.* at 7-8.

other NVNG systems without causing harmful interference. Both IoT modules and micro-gateways transmit only when a Myriota satellite is overhead, significantly reducing the times during which interference is even theoretically possible. All of Myriota's NVNG terrestrial stations in this band operate with less than 5 dBW EIRP. This would be within the limit currently proposed under Agenda Item 1.2 to be considered at the World Radio Conference later this year.[12] Myriota's IoT modules will operate with typical transmit duty cycle less than 0.02%, and occasionally with duty cycle of 0.5%. They employ frequency hopping across the intended band, with a narrow emission bandwidth of just 2 kHz. Myriota's micro-gateways will typically operate with transmit duty cycle less than 0.5% and occasionally up to 5%, with emission bandwidth ranging from 2-20 kHz. Since the micro-gateways are far less numerous than other devices communicating with Myriota satellites in this band and they remain within the EIRP limit under consideration internationally, their slightly higher duty cycle will have a negligible effect on the spectrum environment. These operating characteristics give Myriota the ability to share the entire 150 kHz range with other NVNG systems also operating in the 399.9-400.05 MHz band, as well as the ability to operate in any portion of the band designated for its use.

Here again, Myriota is aware that the Commission has received two other applications for authority to operate space stations in this band. One was the application by Hiber discussed above. The other was filed by Spire Global, Inc. ("Spire"), which proposes to operate back-up TT&C uplinks in this spectrum for its Earth Exploration Satellite Service ("EESS") system.[13] In response to a request

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12 *See* FEDERAL COMMUNICATIONS COMMISSION, DOCUMENT WAC/086, DRAFT PROPOSALS PRESENTED AT MARCH 11TH, 2019 MEETING OF THE WORLD RADIOCOMMUNICATION CONFERENCE ADVISORY COMMITTEE, AGENDA ITEM 1.2 (2019): to consider the in-band power limits for earth stations operating in the mobile-satellite service, meteorological-satellite-service, and Earth exploration-satellite service in the frequency bands 401-403 MHz and 399.9-400.05 MHz, in accordance with Resolution 765 (WRC-15).

13 The Commission deferred consideration of Spire's application with respect to this band. *See, e.g.,* Stamp Grant, IBFS File Nos. SAT-LOA-20151123-00078 and SAT-AMD-20180102-00001, at n.2 (Nov. 29, 2018).

for information from the Commission, Spire contends that because its use of this spectrum for back-up TT&C operations will be very infrequent and it is willing to turn off its earth station transmitter when the NVNG satellite of another operator is in view, its operations would not preclude use of this spectrum by other NVNG systems.[14] Thus, both Spire and Hiber contend that their systems can share the 399.9-400.05 MHz with other NVNG satellite systems, and Myriota shares the same belief. Myriota has contacted both Hiber and Spire to initiate discussion of potential sharing techniques.

### A.6.2 Spectrum Sharing with Respect to Terrestrial Networks

Section 25.142(a)(2) of the Commission's rules requires applicants for NVNG MSS authorizations to provide the PFD produced at the Earth's surface by each space station in the 400.15-401 MHz band, to allow determination of whether coordination with terrestrial services is required under any applicable footnote of the U.S. table of frequency allocations. In this case, the relevant footnote is 5.264, which provides that the PFD limit indicated in Annex 1 of Appendix 5 of the ITU Radio Regulations shall apply in this band.[15] That PFD limit is -125 $dBW/m^2/4$ kHz at the Earth's surface.[16]

In order to demonstrate compliance with this limit, Table A.6.2-1 below calculates the PFD for a satellite in Myriota's system, assuming operations at maximum power, at both its initial altitude and at the lowest altitude at which it will perform commercial operations.

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14 *See* Letter from Letter from Jonathan Rosenblatt to Jose P. Albuquerque, IBFS File Nos. SAT-LOA-20151123-00078, SAT-AMD-20161114-00107, and SAT-AMD-20180102-00001, at 5-6 (May 16, 2018) ("Spire Letter").

15 *See id.* § 2.106 n.5.264.

16 *See* ITU Radio Regulations, *Coordination thresholds for sharing between MSS (space-to-Earth) and terrestrial services in the same frequency bands and between non-GSO MSS feeder links (space-to-Earth) and terrestrial services in the same frequency bands and between RDSS (space-to-Earth) and terrestrial services in the same frequency bands*, Appendix 5, Annex 1, ¶ 1.1.1.

| | | |
|---|---|---|
| Satellite altitude [km] | 600 | 400 |
| Antenna Gain [dBi] | 2.15 | 2.15 |
| Maximum EIRP [dBW]<br>(for arbitrary bandwidth 80 kHz) | 14.5 | 11 |
| Maximum EIRP density [dBW/4 kHz] | 1.5 | -2 |
| Spreading loss [dB] | -126.555 | -123.033 |
| PFD [dB(W/$m^2$/4 kHz)] | -125.055 | -125.033 |

**Table A.6.2-1. Maximum PFD at the Surface of the Earth**

Because operations at 400 km illustrate a worst-case PFD, yet the value at this altitude is still lower than the limit incorporated into the Commission's rules, no coordination with terrestrial systems in the 400.15-401 MHz band is required. If multiple satellites are simultaneously active in a given area, Myriota's system is flexible enough to control emissions such that the aggregate PFD on the Earth's surface will comply for any given 4 kHz range. Myriota also has the ability to manage the satellites' PFD levels during all phases of the mission, because the satellite downlink transmit power is adjustable on-orbit, providing yet more assurance that its NVNG system will not cause harmful interference to terrestrial systems.

In addition, Myriota's satellites comply with the requirement set forth in Section 25.142(a)(3)(ii) of the Commission's rules that no signal received by satellites from sources outside of the system shall be retransmitted with a PFD level exceeding the limits discussed above. Signals received from terrestrial sources are demodulated and processed onboard the satellite. An appropriate response is then generated, modulated, and transmitted by the satellite. Unknown or incompatible signals received by a satellite are rejected and do not result in a transmission response, ensuring that signals originating from sources outside of the Myriota network will not be re-transmitted.

### A.6.3 Protection of Radio Astronomy in the 406.1-410 MHz Band

Section 25.142(a)(2) of the Commission's rules also directs applicants for NVNG authorizations to discuss the measures they would employ to protect the Radio Astronomy Service ("RAS") in the 406.1-410 MHz band from harmful interference from unwanted emissions.[17] Myriota appreciates the importance of protecting RAS sites worldwide against harmful interference. Indeed, Myriota has already held discussions with personnel in charge of protecting Australia's most significant and sensitive radio astronomy site at the Square Kilometre Array, operated by the Commonwealth Scientific and Industrial Research Organisation ("CSIRO"). From this experience, Myriota understands various techniques that can be employed to help mitigate interference threats concerning RAS operations, as discussed below. Myriota will continue its discussions with Australia's CSIRO, and will commence reaching out to the international RAS community, including relevant RAS contacts in the United States. Below we discuss considerations that would be applicable in the 406.1-410 MHz band.

In the 400.15-401 MHz downlink band, the theoretical worst-case Doppler effects will be ±10.5 kHz (as discussed below). These effects are insignificant relative to the frequency separation between the NVNG and RAS operations (*i.e.*, 5100 kHz separation between boundaries at 401 MHz and 406.1 MHz). As a result, Doppler effects will have no material impact on attenuation of the satellite signal in this band. RAS facilities are generally vulnerable to interference from satellite transmissions due to the high gain antennas used on many spacecraft, which tend to concentrate energy in a specific direction and can unintentionally target an RAS antenna. By contrast, Myriota's satellite emissions will be extremely low over the 406.1-410 MHz range. Over

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[17] *See* 47 C.F.R. § 25.142(a)(2). *But see id.* § 2.106 n.US74 ("In the band 406.1-410 MHz, the radio astronomy service shall be protected from unwanted emissions only to the extent that such radiation exceeds the level which would be present if the offending station were operating in compliance with the technical standards or criteria applicable to the service in which it operates").

any 4 kHz measured bandwidth in this range, the EIRP from a Myriota satellite emission will be attenuated at least 55 dB through front-end filtering compared to the emission at frequency of operation. This equates to a PFD value at the Earth's surface of less than -180 dBW/m$^2$/4kHz. Moreover, Myriota's downlink emissions will not be continuous over time, with duty cycle 10% or less. This reduces the average power received at the RAS site, and further reduces the probability of harmful interference.

Uplink transmissions from Myriota's NVNG terrestrial stations will occur over 399.9-400.05 MHz. RAS facilities have considerably lower antenna gain in the direction of all terrestrial transmitters (*i.e.*, at very low elevation angles). However, they may be susceptible to interference from terrestrial transmitters that are operating in close proximity. This is very unlikely to be the case for Myriota's NVNG terrestrial stations for several reasons. For example, Myriota NVNG terrestrial stations operate with EIRP less than 5 dBW over intended range 399.9-400.05 MHz, and emissions outside this range will be reduced by at least 40 dB over any 4 kHz measured bandwidth through front-end filtering compared to the emission at frequency of operation. Myriota will manage the deployment of its micro-gateways such that they avoid interference potential to RAS. Myriota's IoT modules will operate with a low duty cycle (typically less than 0.02%), which further reduces the average power received by a RAS facility. If a specific RAS site nonetheless experiences interference, Myriota can utilize its geofencing technology to prevent IoT modules from ever transmitting within certain distances of a given location. Myriota has employed this strategy to protect the Square Kilometer Array in Australia, and could apply it to other RAS sites as appropriate. Myriota can even send messages instructing specific NVNG terrestrial stations to cease transmission should interference concerns arise.

Accordingly, using such measures, Myriota will protect RAS facilities operating in the 406.1-410 MHz band from harmful interference from unwanted emissions.

### A.6.4 Compliance with Emission Limits

Section 25.142(a)(3) requires applicants for NVNG authorizations to show that their space stations will not exceed the emission limitations specified in Sections 25.202(f)(1)-(3), as calculated for a fixed point on the Earth's surface in the plane of the space station's orbit, considering the worst-case frequency tolerance of all frequency determining components, and maximum positive and negative Doppler shift of both the uplink and downlink signals, taking into account system design.

For a satellite launched to an altitude of 600 km, the worst-case Doppler shift is 10.067 kHz, occurring at the upper limit of the 400.05-401 MHz downlink band. As shown in Table A.6.4-1 below, as these satellites gradually lose altitude over time, the Doppler shift increases slightly. To be conservative, assuming worst case Doppler shift of 10.5 kHz would comfortably accommodate any such difference in satellite altitude.

| **Satellite altitude** | **Transmit frequency** | **Doppler shift** |
|---|---|---|
| 600 km | 400.05 MHz | ± 10.043 kHz |
| | 401 MHz | ± 10.067 kHz |
| 400 km | 400.05 MHz | ± 10.285 kHz |
| | 401 MHz | ± 10.309 kHz |

**Table A.6.4-1. Doppler Shift at Various Altitudes**

Myriota's satellite hardware is being designed to conform with the emission limits of Section 25.202(f), for a range of possible emission bandwidths. Figure A.6.4-1 below shows the required emission mask necessary to conform to these emission limits, assuming an example emission bandwidth of 80 kHz, for both worst-case Doppler effects (shown in red) and without considering Doppler effects (shown in blue). Myriota's satellites will conform to these limits.

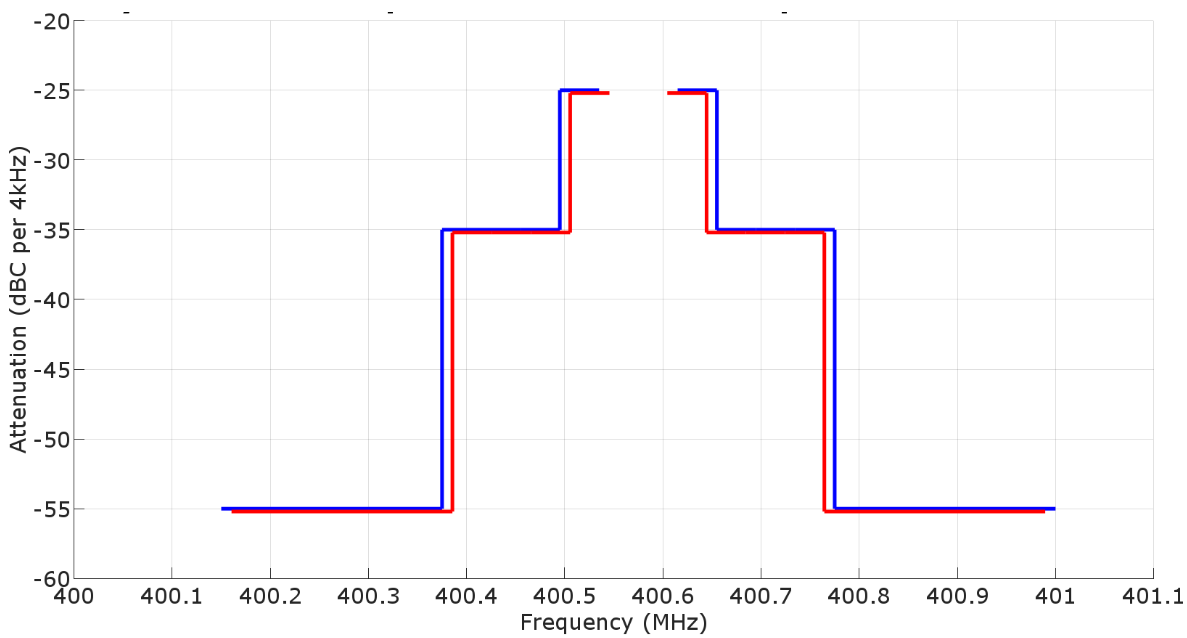


**Figure 8.6.4-1. Spectral Emission Limits**

### A.6.5 Spectrum Sharing with Respect to GSO Satellite Systems

Section 25.289 of the Commission's rules provides that an NGSO system licensee must not cause unacceptable interference to, or claim protection from, a GSO FSS or GSO BSS network.[18] However, there are no GSO satellite systems currently licensed by the Commission or granted U.S. market access in the bands at issue in this petition. Accordingly, there is no basis for concern with respect to potential interference to GSO satellite systems.

### A.6.6 Coordination with U.S. Government Networks

There are a variety of Federal allocations in the spectrum Myriota proposes to use for its NVNG operations in the U.S., including Space Research and Land Mobile Radio operations in

[18] *See* 47 C.F.R. § 25.289.

the 399.9-400.05 MHz band and a variety of meteorological radiosonde operations in the 400.15-401 MHz band.[19] Section 25.142(b)(2) of the Commission's rules notes these dual allocations, and the Commission's role as liaison with the National Telecommunications and Information Administration ("NTIA") to reach agreement with respect to achieving compatible operations between federal government users and commercial NVNG systems. Myriota's agile and spectrally-efficient system will facilitate coordination with federal spectrum users, and Myriota pledges to work with the Commission and NTIA to reach appropriate coordination agreements.

Myriota is also prepared to operate consistent with the requirements of Section 25.260 to protect Department of Defense ("DoD") operations in the 400.15-401 MHz band.[20] Myriota is capable of complying with the regulations regarding restriction of transmissions into the "protection area" of DoD satellites described in Section 25.260(a). In addition, as required under Section 25.260(b), Myriota will provide a point of contact that will be available twenty-four hours per day, seven days per week so that reports of harmful interference into DoD earth stations and other operational issues can be reported and resolved expeditiously.

In addition, each satellite will automatically turn off and cease satellite transmissions if, after 72 consecutive hours, no reset signal is received from a Myriota feeder link earth station and verified by the satellite. All satellites in Myriota's NVNG system will be capable of instantaneous shutdown on any sub-band upon command. Myriota's NVNG system will be able to change the frequency on which its satellites are operating within 125 minutes of receiving notification from a DoD required frequency change in the 400.15-401 MHz band, and Myriota

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[19] *See, e.g.,* NTIA OFFICE OF SPECTRUM MANAGEMENT, *Federal Government Spectrum Use Reports, 225 MHz – 7.125 GHz* (2015), https://www.ntia.doc.gov/page/federal-government-spectrum-use-reports-225-mhz-7125-ghz.

[20] *See* 47 C.F.R. § 25.260.

will use best efforts to reduce this implementation time to 90 minutes as it builds out additional feeder link earth stations.

### A.7 ITU FILINGS FOR MYRIOTA

The Myriota NVNG system will operate under network filings made on its behalf with the ITU by the Australian administration under the satellite network name MNSAT. A request for coordination of this filing was published in BR IFIC 2878 on September 4, 2018.

### A.8 ORBITAL DEBRIS MITIGATION

Myriota intends to incorporate the material objectives set forth in this PDR into the technical specifications established for design and operation of its NVNG system. Myriota will internally review orbit debris mitigation throughout design for the spacecraft, and incorporate these objectives, as appropriate, into its operational plans. Because this mitigation statement is necessarily forward looking, the process of designing, building, and testing may result in minor improvements to the parameters discussed herein. In addition, Myriota will continue to stay current with the Space Situational Awareness community and technology and, if appropriate, Myriota will modify this mitigation statement.

***Spacecraft Hardware Design***

Myriota has assessed and limited the amount of debris released in a planned manner during normal operations and does not intend to release debris during the planned course of operations of its NVNG system. Myriota is also aware of the possibility that its system could become a source of debris in the unlikely case of a collision with small debris or meteoroids that could either create jetsam or cause loss of control of the spacecraft and prevent post-mission disposal. Myriota is undertaking steps to address this possibility by incorporating redundancy, shielding, separation of components, and other physical characteristics into the satellites' design. Myriota will continue to review these aspects of on-orbit operations throughout the spacecraft design and manufacturing process and will make such adjustments and improvements as appropriate to assure that its spacecraft will not become a source of debris during operations or become derelict in space due to a collision.

***Minimizing Accidental Explosions***

Myriota is working with Tyvak-nanosatellite systems with the design of its spacecraft in a manner that limits the probability of accidental explosion. The Myriota satellite batteries will be equipped with protection circuitry. In addition, the low charges and small battery cells on the satellites' power system prevent a catastrophic failure, so that passivation at end of mission is not necessary to prevent an explosion large enough to release orbital debris. The propulsion system will be made safe at the end of mission, though the precise procedure for doing so will depend on the technology adopted.

***Safe Flight Profiles***

Through detailed and conscientious mission planning, Myriota has carefully assessed and limited the probability of its system becoming a source of debris by collisions with large debris or other operational space stations. Myriota is willing to engage with any operators of nearby constellations and other space stations to ensure safe and coordinated space operations. To this end, Myriota will utilize GNSS receivers to determine accurate spacecraft location ephemeris data to assist in assessing conjunction risks, and through cooperation with the Combined Space Operations Center and other spacecraft operators will conduct differential drag maneuver when required (using differential drag with its initial satellites or propulsion for those launched later).

Attached hereto is a preliminary Orbital Debris Assessment Report ("ODAR"), prepared with the use of NASA's Debris Assessment Software ("DAS"). For purposes of this report, Myriota considered its non-propulsive first-generation satellites, since the lack of propulsion presents a worse case for potential collisions.[21] As shown in that ODAR, DAS indicates that the probability of any Myriota satellite colliding with debris or meteoroids greater than 10 cm in diameter is less than 0.00000, whether the satellite is in the stowed or deployed configuration, assuming an initial altitude of 600 km. The ballistic coefficient of the 6U satellites will be similar, resulting in a less than 25-year lifetime. The upgraded satellites will use a combination of altitude increase maneuvers and the J2 perturbation to achieve the Right Ascension of the Ascending Node plane phasing. This makes it favorable that the launch altitude be less than constellation operating altitude. Accordingly, even assuming a worst-case of a satellite that is inoperable upon orbital injection, de-orbit and atmospheric demise would occur in much less than 25 years.

***Post-Mission Disposal***

Each satellite in Myriota's NVNG system is designed for a full capacity useful lifetime of at least three years under the most limited power generation conditions, and will be duty cycled beyond that date until system failure or orbital decay leads to atmospheric demise. After its mission is complete, each Myriota spacecraft will be reoriented to increase drag in order to hasten the atmospheric demise process. The spacecraft will begin to passivate itself by de-spinning reaction wheels and drawing batteries down to a safe level and powering down. Over the following months, the denser atmosphere will gradually lower the satellite's apogee until its eventual atmospheric demise. As suggested by the Commission,[22] Myriota intends to comply with Section 4.6 and 4.7 of NASA Technical Standard 8719.14A with respect to this re-entry process.

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21 *See, e.g., Mitigation of Orbital Debris in the New Space Age*, FCC 18-159, ¶ 26 (rel. Nov. 19, 2018) (with respect to collision risk, describing the Commission's "current licensing practice" as "consider[ing] this risk to be zero or near zero during the period of time in which the spacecraft is maneuverable").

22 *Mitigation of Orbital Debris*, 19 FCC Rcd. 11567, ¶ 88 (2004).

Under nominal conditions, Myriota would deploy its satellites at an altitude of approximately 600 km and continue to conduct commercial operations until they reach an altitude of approximately 400 km. In these circumstances, DAS analysis indicates that Myriota satellites will reenter the Earth's atmosphere within approximately 5.4 years after deployment, as illustrated in Figure A.8-1 below.

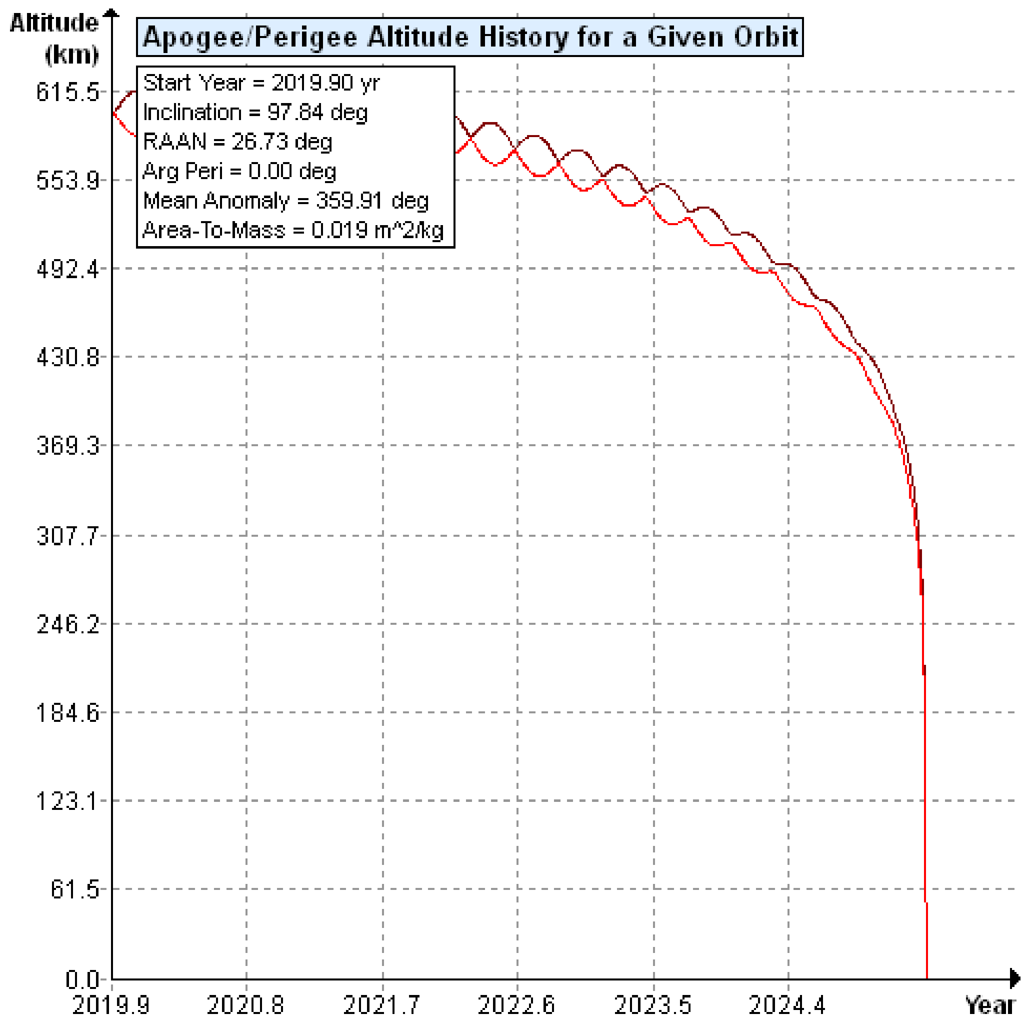


**Figure A.8-1. Projected Demise of Deployed Myriota Satellite from 600 km Altitude**

However, even if a satellite were launched to 600 km and immediately failed such that it remained in its stowed configuration, DAS indicates that it would have an expected orbital lifetime of 24.7

years – still less than the international standard of twenty-five years – as shown in Figure A.8-2 below.

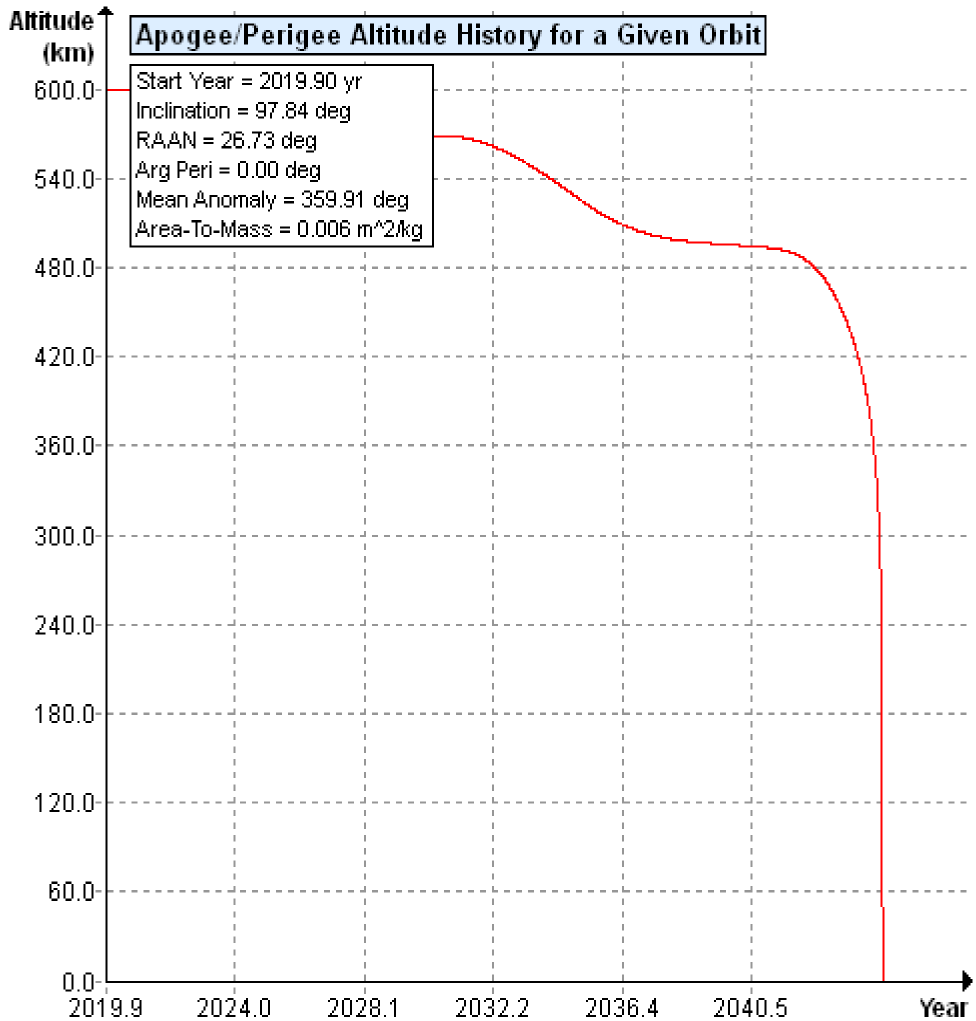


**Figure A.8-2. Projected Demise of Stowed Myriota Satellite from 600 km Altitude**

Myriota also conducted a preliminary re-entry risk analysis using DAS and the bill of materials of components with high melting temperatures. As modeled, DAS indicates the entire satellite will demise completely during uncontrolled re-entry with no material surviving to reach the Earth's surface. Accordingly, the risk of human casualty on the ground from Myriota satellites re-entering the atmosphere is zero.

Each satellite can be expected to spend less than a few weeks at altitudes below 480 km where there will be any risk of conjunction with ISS and other human spaceflight orbiting laboratories. As discussed above, Myriota will work with NASA and CSpOC in order to eliminate conjunction risks.

**ENGINEERING CERTIFICATION**

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/ *Dr. David Haley*

Dr. David Haley
Chief Technology Officer
MYRIOTA PTY. LTD.

March 27, 2019
Date