Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
	)	
AUDACY CORPORATION	)	
	)	
Application for Authority	)	
to Launch and Operate a	)	File No.
Non-Geostationary Medium	)	
Earth Orbit Satellite System	)	
in the Fixed- and Inter-Satellite Services	)	

APPLICATION

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APPLICATION

Audacy Corporation ("Audacy"), by its attorneys and pursuant to Sections 308 and 309 of the Communications Act of 1934, as amended, 47 U.S.C. §§ 308 and 309, hereby requests authority to launch and operate three satellites in medium Earth orbits ("MEO") in the fixed- and inter-satellite services ("FSS" and "ISS", respectively). Audacy herein refers to its proposed aggregate network of space- and Earth-based infrastructure as the "Network," individual satellites as "Relays," complementary ground stations as "Gateways," and spacecraft using the Network's communication services as "Users." Individual frequency bands, their proposed use by the Network, and their referred terms herein are listed in the table below.[1]

[1] As further described in Part V herein, Audacy seeks a waiver of the Commission's processing round requirements. In the alternative, Audacy submits this Application for consideration in conjunction with other applications involved in the OneWeb processing round and requests a waiver of the Commission's processing round requirements with respect to any frequencies not involved in any pending processing rounds. *See Cut-Off Established for Additional NGSO-Like Satellite Applications or Petitions for Operations in the 10.7-12.7 GHz, 14.0-14.5 GHz, 17.8-18.6 GHz, 18.8-19.3 GHz, 27.5-28.35 GHz, 28.35-29.1 GHz, and 29.5-30.0 GHz Bands*, Public Notice, DA 16-804 (rel. July 15, 2016) ("*OneWeb Petition PN*").

Frequency Band (GHz)	Herein referred to as	Allocation[2]	Network purpose
19.70-20.20	"K-band Downlink"	FSS Space-to-Earth	Off-nominal TT&C downlink
37.50-42.00	"V-band Downlink"		Primary downlink feeder
29.50-30.00	"K-band Uplink"	FSS Earth-to-Space	Off-nominal TT&C uplink
47.20-50.20 50.40-51.40	"V-band Uplink"		Primary uplink feeder
22.55-23.55 24.45-24.75 32.30-33.00	"K-band Crosslink"	ISS	Forward / return communication service
54.25-56.90 57.00-58.20 65.00-71.00	"V-band Crosslink"		Signal diversity and Network redundancy

Table 1: Audacy Network Proposed Frequency Bands

I. INTRODUCTION

Audacy's space-based data relay constellation will provide operators with always-on, seamless access to their non-geostationary ("NGSO") spacecraft. The model of continuous, low-latency (<1s) connectivity is similar to that of a terrestrial telecommunications provider. Users of the Network will include operators of Earth observation satellites seeking real-time photographic and video data, launch providers needing continuous telemetry from onboard sensors, and operators of large Low Earth Orbit ("LEO") constellations who require continuous command and control of every satellite, wherever they are in their orbit. Symmetric forward and return data rates will vary from gigabits to kilobits per second depending on User spacecraft capabilities. Audacy respectfully submits that after the launch of Audacy's Network, 'loss of signal' will

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2 FCC and ITU allocations. Not inclusive of all co-primary allocations and secondary allocations in Table of Frequency Allocations.

likely cease to be an industry-standard phrase.

With this Application, Audacy seeks Commission authority to provide continuous, high-speed, low-latency communications to NGSO spacecraft through the deployment and operation of three MEO Relays. The Network will provide communication services to and from Users using internationally allocated K-band ISS spectrum, and to and from Gateways using internationally allocated V-band FSS spectrum (K-band in off-nominal recovery situations). The architecture promotes highly efficient use of spectrum, employing extensive frequency reuse to provide communication to thousands of Users simultaneously.

Audacy anticipates successful coordination and shared use of spectrum with existing and planned space and terrestrial operators. Certain characteristics of the Network are more similar to a GSO than an NGSO system, including the high MEO orbit, small number of space and earth stations (three of each), and extremely narrow uplink and downlink beams among them. Further analysis of the Network's spectrum sharing capabilities can be found in Part VI of this narrative.

Audacy was launched in 2015 by a team of Stanford graduates, NASA award winners, and SpaceX veterans. The company was formed around a simple idea: to deliver anytime, seamless space connectivity that advances humanity to a new age of space commerce, exploration, and discovery. Combining nearly a century of industry experience, the Audacy team has completed the first two phases of its business and development plan on time and under budget.

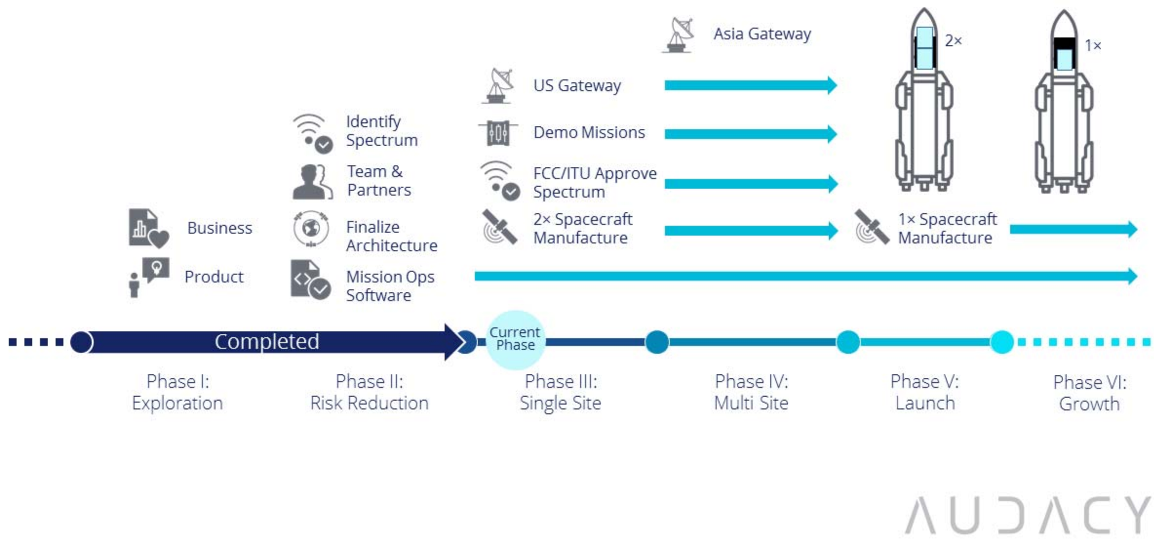

Figure I-1: Audacy Timeline and Roadmap

Audacy now seeks Commission authority to introduce new and much-needed communications capabilities to the satellite industry. Currently, individual satellite operators apply to the appropriate regulatory body for a transmission license to communicate between planned satellites and ground stations, and these applications are adjudicated on a case-by-case basis. Operators must then invest in earth station infrastructure, or rent third party facilities. By providing communication services to numerous spacecraft simultaneously, Audacy will ease the burden on not only regulatory authorities but also on operators themselves, who no longer need to build out extensive ground infrastructure to access to their spacecraft. Audacy will provide Users with standardized engineering documentation to help streamline the regulatory process and better enable administrations to approve and coordinate systems capable of communicating with Audacy Relays.

Audacy will advance the space industry and open up possibilities for transformative technologies across the value chain by opening up commercial access to 24/7 spacecraft communications. In addition to enabling new technologies such as real-time telerobotics and satellite servicing, Audacy's Network epitomizes the spectrally efficient use of crowded frequency bands.

A detailed description of the Network, including the narrative information required by Part 25 of the Commission's rules, is provided in Part III of this Application. Part IV of this Application describes the public interest benefits resulting from the Network's launch and operation. Waiver requests and their justifications are contained in Part V, and finally, Part VI describes the Network's spectrum sharing capabilities and analyses of interference with other users of the ISS and FSS spectrum. Given the significant need for continuous spacecraft communication, Audacy respectfully asks the Commission to expeditiously grant this Application.

II. THE PROPOSED NGSO NETWORK DOES NOT ENCUMBER TERRESTRIAL SPECTRUM USE

Granting Audacy an NGSO satellite license to operate the proposed Network will not affect the Commission's ongoing *Spectrum Frontiers* proceedings related to the development of next generation terrestrial broadband services in frequencies above 24 GHz.[3]

As discussed in greater detail above in Part I and below in Part III, Network Relays will offer inter-satellite backhaul service for commercial and scientific spacecraft. These inter-satellite communications occur hundreds of miles away from the surface of the Earth, with User

[3] *See Use of Spectrum Bands Above 24 GHz for Mobile Radio Services*, Notice of Proposed Rulemaking, 30 FCC Rcd 11878 (2015) ("*Spectrum Frontiers NPRM*"); *see also Use of Spectrum Bands Above 24 GHz for Mobile Radio Services*, Report and Order and Further Notice of Proposed Rulemaking, 31 FCC Rcd 8014, ¶ 5 (2016) ("*Spectrum Frontiers R&O and FNPRM*").

spacecraft employing antennas pointed away from the planet's surface towards overhead MEO Relays. Terrestrial communications present no meaningful threat of harmful interference to such services due to (i) the significant levels of naturally occurring attenuation and isolation between the ground and any potentially affected spacecraft receiver, and (ii) the orientation and highly directional qualities of both the terrestrial and space-based antennas.[4]

Inter-satellite communications with User spacecraft will be aggregated in space at the Relay before downlink to a single U.S.-based Gateway. From the U.S. Gateway, Audacy will deliver communications to customers via a cloud-based secure virtual private network. Similarly, terrestrial communications present no meaningful interference threat to Network Earth-to-space communications. The Relays will employ highly directional antennas with ample discrimination to avoid interference from terrestrial-based signals far below on the planet's surface. Audacy's sole U.S.-based Gateway[5] will employ large antennas, also with significant discrimination and low side lobes. The highly directional antennas at Audacy's U.S.-based Gateway will also always be pointed at high elevations (>5°) above any near-horizontal interfering terrestrial signals.

In the *Spectrum Frontiers R&O and FNPRM*, the Commission adopted rules to permit fixed and mobile terrestrial operation in the 37.5-38.5 GHz band but the Commission does not preclude satellite operators from expanding operations into the band.[6] In the 38.6-40.0 GHz band, gateway operations are allocated on a first-come, first-served basis entitling operators to

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[4] User inter-satellite antennas will generally not be oriented towards the planet's surface and Audacy would expect 5G antennas to be near-horizontal or employ some marginal downtilt in certain settings.

[5] The exact location of the U.S. Gateway will be provided to the Commission in Audacy's application for earth station authority.

[6] *See Spectrum Frontiers R&O and FNPRM*, 31 FCC at 8059, ¶ 112.

protections from terrestrial transmission subject to certain conditions.[7] The Commission also made the 64-71 GHz band available for use by unlicensed devices under part 15 of the Commission's rules.[8] The Commission has also sought additional comment on the following bands which overlap, in part, with Audacy's frequencies: 31.8-33.4; 47.2-50.2; and 50.4-52.6 GHz.[9] While some spectral overlap occurs between Audacy's proposed Network and the *Spectrum Frontiers* proceeding, Audacy respectfully submits that in granting the instant Application, the Commission will not encumber future terrestrial 5G licensees given the *de minimis* terrestrial contact and the need for Audacy to coordinate only one U.S. Gateway. Moreover, Audacy's Network alleviates spectrum-sharing concerns between terrestrial providers and Audacy's NGSO Users, because data for all Network Users is routed through only one discrete U.S. location as opposed to the vast number of individually coordinated gateways that would be required for continuous communication using a traditional ground-based model.

III. NARRATIVE INFORMATION REQUIRED BY PART 25

Part 25 of the Commission's rules require the following narrative responses for NGSO FSS/ISS satellite system applications, which are not provided in any other part of Form 312.[10]

A. § 25.111 ITU Publication Information

Audacy has already submitted to the Commission, and the Commission has provided to the International Telecommunication Union ("ITU"), the Advance Publication Information ("API") for all but three frequency bands used by the Network.[11] As part of this submission,

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7 *Id.*, 31 FCC at 8051-52, ¶ 93.

8 I*d.*, 31 FCC at 8064-65, ¶130.

9 I*d.*, 31 FCC at 8144 et seq., ¶ 369 *et seq.*

10 In Part V, Audacy separately requests waivers to certain rules under Part 25 of the Commission's rules and requests authority to operate on a secondary basis in the 29.5-30.0 and 32.0-33.0 GHz bands.

11 The Network's API filings were published by the ITU in BR/IFIC 2822 and BR/IFIC 2830 on June 21, 2016 and October 11, 2016, respectively.

Audacy assumed responsibility for any and all cost recovery fees associated with filings for the proposed system under ITU Council Decision 482 (modified 2008), as it may be modified or restated in the future.

Audacy will separately submit to the Commission appropriate ITU filings for the 19.7-20.2, 54.25-56.9, and 57-58.2 GHz bands referenced in this application to complete commencement of the frequency application process.[12]

B. § 25.114(c)(8) Maximum Power Flux Density Levels

Section 25.114(c)(8) of the Commission's rules requires applicants for FSS space station authorizations to provide the calculated maximum power flux density ("PFD") levels within each coverage area. Plots showing PFD values at all angles of arrival for all of Audacy's frequency bands are shown in Part VI of this application. It should be noted that the Network would always operate well below all ITU PFD limits. However, as discussed in Audacy's request for limited waiver of the Commission's limit in Part V of this application, in the 37.5-40 GHz band the Network's narrow downlink beams do discretely exceed the Commission's PFD limits for the angles of arrival between 5-7.5°, but fall well below the corresponding ITU limit (12 dB below).

C. § 25.114(d)(1) System Facilities, Operations and Services and How Uplink Frequency Bands Connect to Downlink Frequency Bands

Introduction

Space has rapidly commercialized over the last decade, and the average number of satellites launched each year between 2011-2015 increased 36% over the previous five years.[13] Contributing to this continued growth is the availability of financing sources willing to invest in

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[12] Given recent ITU procedural changes, Audacy anticipates making further ITU filings for these bands on or immediately after January 1, 2017.

[13] *See* 2016 State of the Satellite Industry Report, Satellite Industry Association (June 2016), *available at* http://www.sia.org/wp-content/uploads/2016/06/SSIR16-Pdf-Copy-for-Website-Compressed.pdf (last visited Nov. 12, 2016) ("*2016 Satellite Industry Report*").

these often capital-intensive ventures. In fact, in 2015, venture capitalists invested nearly $2 billion in commercial space companies, nearly doubling the amount invested in the previous 15 years combined.[14] As of December 31, 2015, operators from 59 countries have at least one satellite, for a total of 1,381 operational satellites on orbit.[15] This number has increased nearly 40% over the last five years, largely driven by small satellite growth in LEO, a core Network User segment.[16]

In addition, the National Space Policy of the United States advocates that a "robust and competitive commercial space sector is vital to continued progress in space."[17] As such, the United States is committed to "encouraging and facilitating the growth of a U.S. commercial space sector that supports U.S. needs, is globally competitive, and advances U.S. leadership in the generation of new markets and innovation-driven entrepreneurship."[18] The National Space Policy further encourages Federal departments and agencies to "purchase and use commercial space capabilities and services to the maximum practical extent" and to "actively explore the use of inventive, nontraditional arrangements for acquiring commercial space goods and services to meet United States Government requirements."[19] Audacy's Network provides valuable, innovative, and spectrally efficient services that meet the Federal Government's space technology goals and infrastructure needs.

Growth of the commercial space industry has tremendous positive implications for life on

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[14] See *VCs Invested More in Space Startups Last Year Than in the Previous 15 Years Combined,* Fortune.com, (2016), *available at* http://fortune.com/2016/02/22/vcs-invested-more-in-space-startups-last-year/ (last visited Nov. 12, 2016).

[15] *See 2016 Satellite Industry Report*.

[16] *See id.*

[17] National Space Policy of the United States, at 3 (June 28, 2010), *available at* https://www.whitehouse.gov/sites/default/files/national_space_policy_6-28-10.pdf.

[18] *Id.*

[19] *Id.* at 10.

Earth and the future of space exploration and should be encouraged. From a regulatory perspective, however, this growth presents a challenge. The reality is that radiofrequency spectrum is a finite resource that must be shared. Currently, individual satellite operators apply for transmit licenses on a case-by-case basis, and must then invest in their own earth stations or rent space/time on someone else's.

There are a number of implications to this status quo: spectrum is not being used efficiently, as transmission only occurs during the small fraction of the time when a spacecraft has line of sight to its operator's earth station(s). Orbital geometry and finite land area lead to significant spectral congestion at certain geographic locations. Operators of Earth observation satellites in polar or sun-synchronous orbits optimize earth station locations to maximize pass frequency and duration, leading to preferred locations in high latitudes such as Norway, Alaska, and Iceland. Due to the increasing number of Earth observation satellites in similar orbits, historically used for scientific missions rather than high-volume data streams, polar gateway overcrowding is becoming a significant problem creating a conflict between competing missions in these areas and bands.[20] Operators of satellites in equatorial orbits are seeing similar problems in equatorial regions including Hawaii and Malaysia.[21] With planned constellations numbering in the hundreds or even thousands of LEO spacecraft, it is clear that the problem of earth station overcrowding is only going to get worse.

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20 *See* Report to CORF from the NASA Office of Earth Science (May 14, 2003), *available at* http://sites.nationalacademies.org/cs/groups/bpasite/documents/webpage/bpa_048964.pdf (discussing "large number of new bandwidth-hungry missions" contributing to congestion in the X-Band, even in 2003); *see also* Planet Labs Inc. Grant, IBFS File No. SAT-MOD-2015802-00053 at 3 (granted Sept. 15, 2016) (declining to authorize use of the Maddock, ND and Keflavik, Iceland earth stations with satellites launched after June 15, 2016 due to failure to reach agreement with NASA, USGS and NOAA).

21 *See, e.g., The Importance of Spectrum and Orbit Efficient Use for Large Area and Developing Countries*, Marcos G. Castello Branco CPqD / Brazil (Vice-Chairman ITU-R Study Group 4) at 4 (May 9, 2009), *available at* http://www.itu.int/en/ITU-R/space/workshopEfficientUseGeneva/wseffuse09018.pdf.

Audacy's unique architecture addresses these challenges while dramatically improving operator connectivity and reducing necessary investment in earth station infrastructure in often remote and inhospitable locations.

Users of Audacy's space-based Network transmit and receive signals to Network Relays over ISS frequency bands, which are in turn relayed to only three Gateways worldwide. Accordingly, data for all Network Users is routed through only one discrete U.S. location as opposed to the vast number of individually coordinated gateways that would be required for continuous communication using a traditional ground-based model.

The Network also makes extensive use of well-proven cellular technology to optimize its use of internationally allocated spectrum. Terrestrial cellular technology divides the service area into discrete 'cells,' allocating each a separate frequency and polarization such that no adjacent cells are identical. Audacy's Network takes the same technology and applies it in space, reusing frequency hundreds of times across a single service area, increasing Network capacity without increasing allocated bandwidth to provide continuous communications services to thousands of simultaneous Users.

The Network's level of coverage and service is impossible to achieve using solely ground-based systems. Moreover, it eases earth station spectral congestion as well as the burden on operators to invest heavily in ground infrastructure to achieve even limited spacecraft access.

1. System Facilities, Operations, and Services System Overview

Audacy's Network will consist of three relay satellites in an advanced MEO configuration paired with three Gateways evenly longitudinally spaced around the Earth. The Network will provide NGSO operators with continuous, low-latency data communications with their spacecraft. The Relays' unique orbital placements result in serviceable link distances, comprehensive LEO fields of view, while avoiding interference with existing space and terrestrial systems.

Fast-moving User spacecraft have continuous line of sight to at least one Relay. Once transmitted to the nearest Relay, User spacecraft data is downlinked directly to a Network Gateway (or indirectly through a Relay ↔ Relay crosslink), and then routed terrestrially to customers using a cloud-based secure virtual private network. User operators can access their encrypted data anytime and anywhere through any Internet-enabled device.

Most operational spacecraft do not have radio frequency ("RF") electronics and antennas compatible with Network service signal characteristics. Audacy will work with spacecraft component manufacturers to make available Network-compatible User terminals that can be easily integrated onboard User spacecraft. Audacy will also provide reference design documents to operators who wish to design and build their own Network-compatible equipment.

As part of the Network's end-to-end data security, Audacy personnel will not have access to any User data. The Network is data-blind, accommodating streams varying from low-rate telemetry, tracking, command, to high-volume payload data, for any spacecraft orbiting below a 10,000 km altitude.

The entire Network including Relays, Gateways, and User services is managed, monitored, and controlled from Audacy Network Operations Centers ("NOCs") co-located with the Gateways. Figure III-1 provides an overview of the Network's facilities and connectivity.

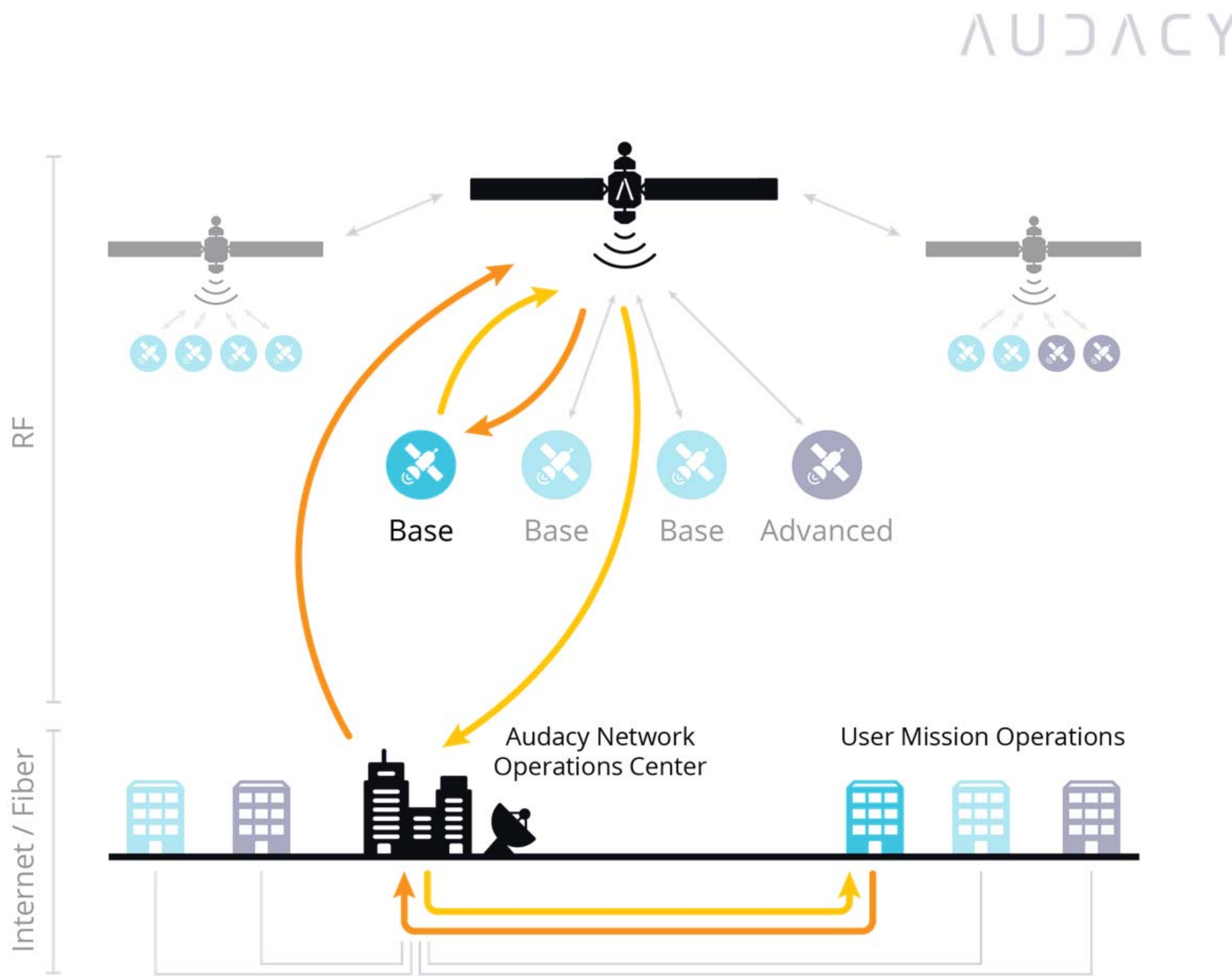

Figure III-1: Network Signal Chain from User Mission Operations to Spacecraft

The Network simplifies the complexities associated with satellite communications. Traditional ground station connectivity requires complex and costly infrastructure for a fraction of the uptime availability that the Network will provide. Mission operations are challenging when operators cannot communicate with their spacecraft for the majority of the time. Operators miss out on revenue opportunities due to the inability to downlink data when they want it. By using the Network, spacecraft operators of all sizes can focus on their missions while Audacy ensures customers get their data whenever they need it. Operators will simply integrate a

Network-compatible User terminal onto their spacecraft and, upon obtaining appropriate regulatory approvals, uplink and downlink to their spacecraft anytime through any Internet-enabled device.

a. Constellation

The Network's space segment will consist of three MEO Relays which relay data between Users (over ISS frequencies) and Gateways (over FSS frequencies). Audacy has carefully chosen the Relays' orbit to maximize LEO coverage while minimizing (i) Relay ↔ User link distance, (ii) the number of global Gateways required, (iii) Network operational complexity, and (iv) spectrum coordination with other systems. The Relays orbit in inclined circular planes spaced 120° around the Earth's spin axis. Their orbital period is 7 hours, 58 minutes, and 41 seconds (20,270 km radius, 13,890 km mean altitude), exactly three times the rotation rate of the Earth.

Not only is the Relay ↔ User link distance ⅓ of the distance to GSO (at least 8 dB less path loss in K_a-band), but the Relays' ground tracks (and therefore Gateway sky tracks) repeat on 24-hour cycles leading to reduced Network operational complexity.

Although there are no current GSO users of the Network's V-band primary uplink and downlink frequencies, Audacy is committed to eliminating interference with both current and future users of the bands proposed for use by the Network. For this reason, the Relays' orbits are 25° inclined to the equator in anticipation of future use of the V-band by GSO users. This inclination reduces the frequency of Relay ↔ GSO conjunctions, streamlining the coordination process with future spectrum users. The Network's frequency bands are described in more detail in Schedule S, as are the Network's spectrum-sharing capabilities in Part VI of this narrative.

b. Coverage and Services

The Relays' orbital configuration is designed to provide global line-of-sight visibility to all LEO spacecraft up to 1,500 km altitude. It should be stressed that Network Users will be space vehicles, and that no User terminals will be deployed for aviation, maritime, or other terrestrial use. Users will apply to the FCC or appropriate foreign regulatory bodies for authority to operate their spacecraft, identifying that they will be transmitting and receiving to and from Network Relays for real-time inter-satellite communications, and provide standardized engineering materials and documentation with respect to the frequency, antenna, and transmission characteristics to enable expedited regulatory treatment.

In order to increase Network uptime and robustness, link diversity, and reduce reliance on clear skies at Gateway locations, the Relays will each be capable of passing data amongst themselves through V-band inter-satellite links. These beams will have sufficient throughput capacity to provide Network redundancy and signal path diversity, so that the always-on communications services are not disrupted in the event of loss of signal at a single Gateway location.

The Network offers two types of bidirectional data relay services to Users. The "Base" service accommodates thousands of Users throughout a fixed cellular service area that extends up to 1,500 km altitude. Base forward and return data rates range from kilobits to tens of megabits per second depending on User spacecraft needs and RF capabilities. The "Advanced" service accommodates twelve Users anywhere up to 10,000 km altitude with symmetric data rates that vary from hundreds of megabits to several gigabits per second.

Exact User antenna configuration, concept of operations, and achievable data rates will vary depending upon User spacecraft power capabilities, size, and throughput needs, but the

Network is designed to ensure basic compatibility with even the smallest spacecraft. More capable User spacecraft will integrate terminals designed for multi-channel and dual-polarization operation, and thus achieve higher throughputs.

Both Gateway ↔ Relay and Relay ↔ User links will use advanced coding and modulation ("ACM") and adaptive power control to apply Network throughput capacity only where it is needed, optimizing spectral efficiency and eliminating interference events with other space and terrestrial spectrum users. In order to ensure continuous and efficient coverage, the NOCs will (i) dynamically allocate frequencies, polarizations, and transmit power to Gateway, User, and Relay RF terminals; and (ii) coordinate the continuous orbital motion of Network nodes and varying User demand across Relay fields of view. NOC's will also be able to remotely and immediately mute emission from Relays and Gateways should the need arise, for example in the unlikely case of unexpected or unwanted interference events.[22]

The Base Service

Each Relay's Base service payload will use advanced antenna technologies to generate hundreds of cellular spot beams across the Relay's field of view up to 1,500 km of altitude, efficiently sharing the ISS spectrum. Figure III-2 shows the representative Base coverage area of a single Relay situated above the Equator at -62.4° longitude, showing the narrow beams generated in a contiguous cellular pattern. Users in this Relay's gap in coverage between the inner circle and outer ring of cells will be served by adjacent Relays. Between them, the Relays have complete line of sight coverage of all LEO users up to 1,500 km altitude, and as low as Earth geometry permits. Figure III-3 shows how the Relays maintain complete LEO coverage

[22] Contact information for 24/7 NOC personnel will be provided to the Commission upon application for earth station authority for Audacy's U.S.-based Gateway; site selection for the Gateway has not concluded.

between them.

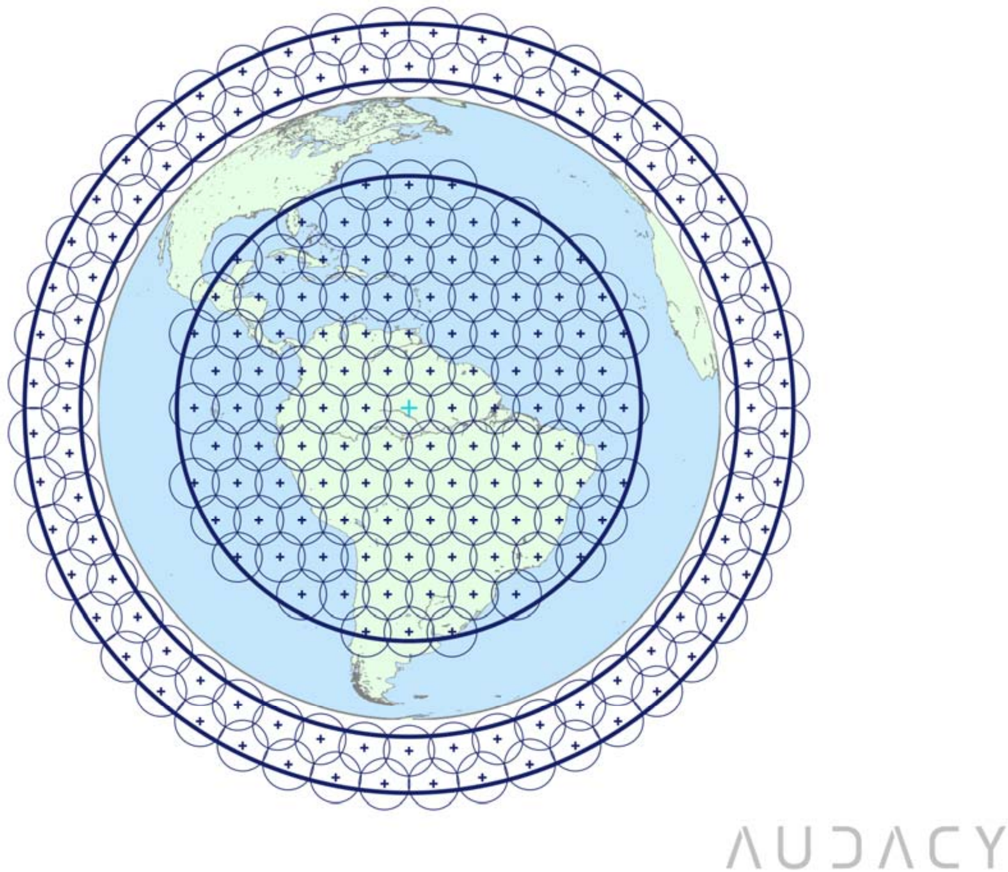

Figure III-2: Base service area of a single Relay at a representative location.

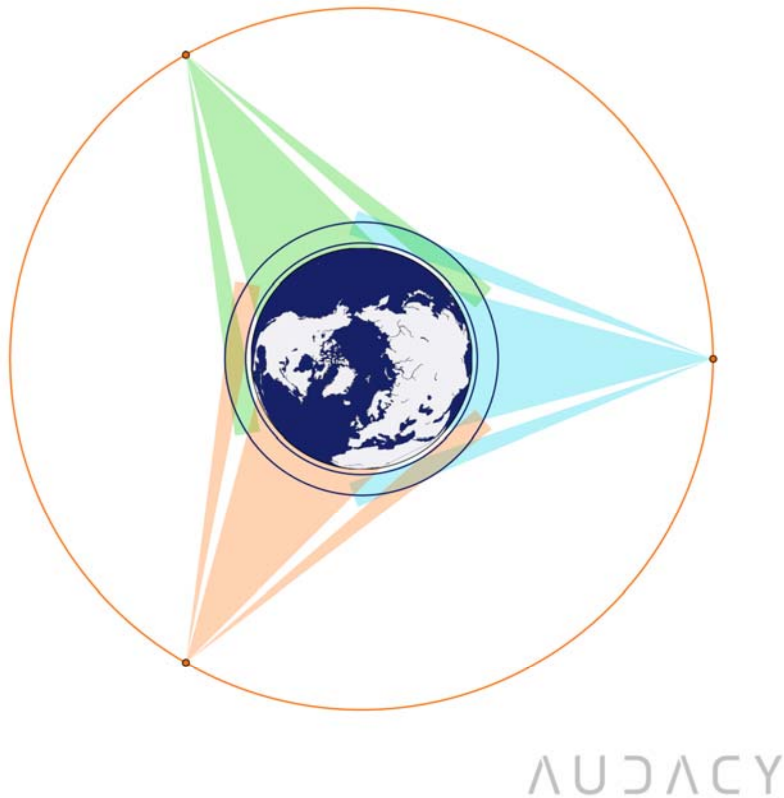

Figure III-3: Top-down view of Base service area, showing how the Relays provide complete coverage between them. (Equatorial orbit shown for clarity)

The User ↔ Relay links reuse the entire inter-satellite band numerous times in both forward and return directions across each Relay's coverage area. The low sidelobes of the payload spot beams enable extensive frequency reuse not only across each Relay's hundreds of cells, but also across multiple Users present simultaneously in a single cell. NOCs use knowledge of the Relays' and Users' orbits to map individual Users into Base service coverage cells so that User ↔ Relay data transfer can occur. NOCs ensure that Users are handed from cell to cell and Relay to Relay in a make-before-break approach as they progress along their orbit, resulting in seamless, high-speed communications anywhere in LEO.

A detailed discussion of the Network's efficient reuse of the ISS spectrum can be found in the narrative found in this Part III, covering Sections 25.114(d)(1)(B) and 25.210(f) of the Commission's rules, while beam characteristics and contours can be found in Schedule S. Frequency and polarization flexibility in the dynamically-reconfigurable Base payload ensures frequency isolation with other users of the ISS spectrum, which is discussed in more detail in Part VI of this narrative.

The Advanced Service

Each Relay's Advanced service payload will use high-gain, steerable (≤54° off nadir) antennas to provide high-speed, dedicated links to Users up to 10,000 km altitude. Figure III-4 shows example Advanced footprints from a single Relay situated above the Equator at -62.4° longitude, showing four narrow spot beams able to point independently anywhere within the Relay's field of view.

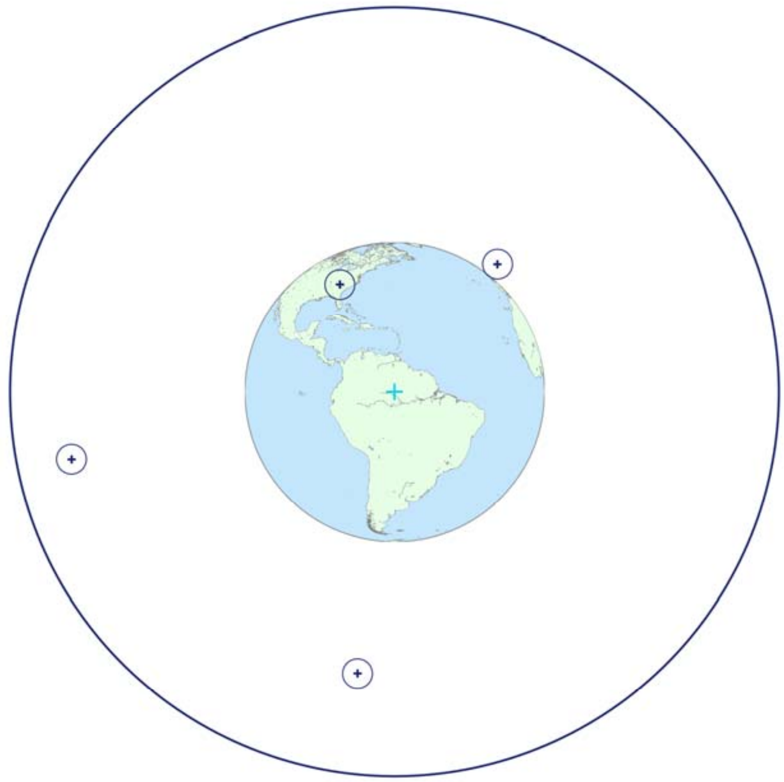

Figure III-4: View from a single Relay at a representative location, with Advanced service spot beams steered to representative points in the 10,000 km field of view.

The narrow beamwidth and low sidelobes of the Advanced spot beams, as well as the dynamically-reconfigurable nature of the Advanced payload ensures frequency isolation from other users operating in the ISS spectrum (*see* Part VI of this narrative). The orbital distribution of Users in each Relay's field of view means that the Advanced spot beams will rarely intersect the Earth, eliminating potential interference with terrestrial users of the same spectrum.

Sufficiently capable Advanced Users will integrate terminals designed for multi-channel and bi-polarization operation, allowing multiple Advanced spot beams to be trained simultaneously towards these Users, leading to higher throughput and make-before-break Relay handovers.

c. Ground Segment

As previously noted, the Network does not provide service to terrestrial end Users outside of the context of Part 25 of the Commission's rules; all User terminals will be deployed on spacecraft in NGSO orbits. The Network's ground segment consists only of the Gateway ↔ Relay bi-directional feeder links, operating in internationally allocated FSS spectrum. Audacy plans to construct three Gateways, evenly spaced around the globe, to achieve near-continuous line-of-sight access to all three Relays (and thus User access) simultaneously. Due to the Relay → Relay Crosslinks described above, the Network can maintain nominal service with only two operational Gateways. Audacy will apply separately to the Commission, and to the extent necessary, foreign regulators in relevant jurisdictions, for permission to operate each of the Gateways. Audacy may construct additional, remote Gateways as necessary to provide Network redundancy, robustness, and site diversity. Exact Gateway geographical locations are still being finalized, and Gateway locations shown in this application are for illustrative purposes only.

The Relays pass over a single Gateway in sequence: as one Relay is setting to the East of each Gateway, the next Relay is rising in the West. Each pass, during which Relays are elevated at least 5° above the Gateway's local horizon, lasts roughly four hours. As part of Audacy's commitment to eliminating interference events between the Network and terrestrial users of the FSS and ISS frequencies, neither Relay nor Gateway shall transmit when the Relay look angle elevation falls below 5° over the horizon. Each Gateway will have at least three identical parabolic, high-gain antennas: one to track the Relay currently overhead, and the other ready to pick up the next Relay when it rises 5° above the horizon. As far as orbital and geophysical geometries allow, this make-before-break approach eliminates Network outages during Gateway handovers, ensuring continuous control of each Network node.

The Relay ↔ Gateway links will operate within the FSS V-band spectrum, well separated from the Relay ↔ User ISS spectrum, and will use both frequency polarizations in both directions. The co-located NOCs not only use the Gateways as trunked feeder links for the uplink and downlink of User forward and return data, but also for command and monitoring of the Relays themselves through in-band TT&C links.

2. System Frequency Usage and Frequency Plans Frequency, Beam, and Channel Architecture

Table 2 below outlines the frequency bands proposed for Network use and their intended purpose. Complete beam information including EIRP, beamwidths, and gain pattern information is included in Schedule S.

Frequency Band (GHz)	Proposed Network Use
19.70-20.20	Off-nominal Downlink
37.50-42.00	Primary Downlink
29.50-30.00	Off-nominal Uplink
47.20-50.20 50.40-51.40	Primary Uplink
22.55-23.55 24.45-24.75 32.30-33.00	Relay → User Forward/Return
54.25-56.90 57.00-58.20 65.00-71.00	Relay → Relay Forward/Return

Table 2: Frequency bands and their proposed Network use.

The beam and channel designations in Schedule S and the following narrative follow the format below:

"G/A/B/R"	Node type (Gateway, Advanced User, Base User, or another Relay) with which Relay is communicating
"T/R"	Transmit or receive (with respect to the Relay)
"L/R"	Circular polarization
#	Alphanumeric ID (0-9-A-Z, TT&C listed first)

Table 3: Beam and channel format used in this Application and Schedule S.

For example, "GTL1" designates a left hand circular polarized Relay → Gateway (downlink) feeder beam as well as one of the channels associated with that beam. In the following diagrams beams are shown in blue, channels in green, and frequencies in GHz.

a. Relay → Gateway Communication Channels (GT--)

These channels will relay User return data (telemetry, payload data, etc.) from the Relays to the Gateways. Downlink beams will support primary channels up to 1.25 GHz and a single 500 MHz backup telemetry channel per polarization as shown in Figure III-5. The latter K-band channel will only be used for recovery telemetry in off-nominal situations where an omnidirectional backup to the high-gain Gateway antenna becomes necessary for Relay survival.

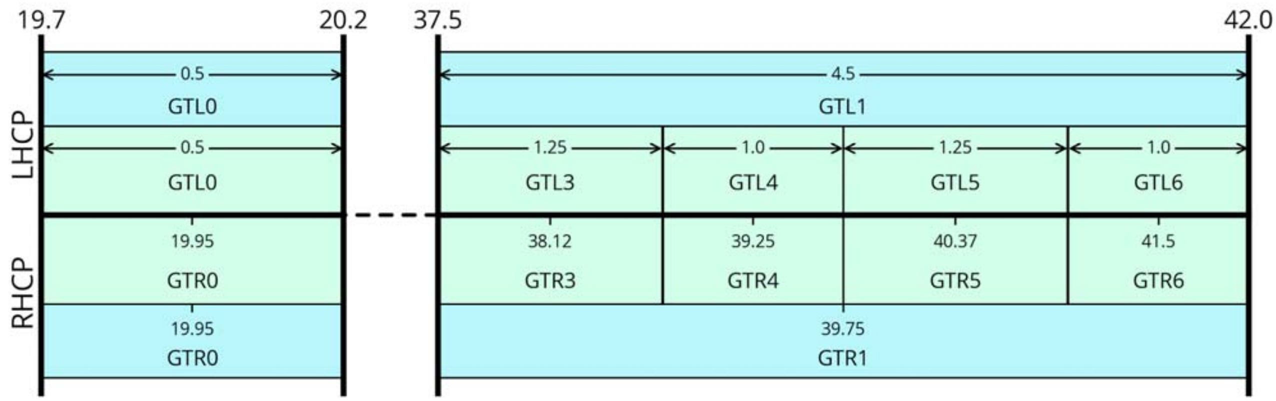

Figure III-5: Downlink beam and channel diagram.

b. Gateway → Relay Communication Channels (GR--)

These channels will relay User spacecraft forward data (command, payload data, software and FPGA updates, etc.) from the Gateways to the Relays. Uplink beams will support primary channels up to 1 GHz and a single 500 MHz backup command channel per polarization as shown in Figure III-6. The latter K-band channel will only be used for recovery commands and control in off-nominal situations where an omnidirectional backup to the high-gain Gateway antenna becomes necessary for Relay survival.

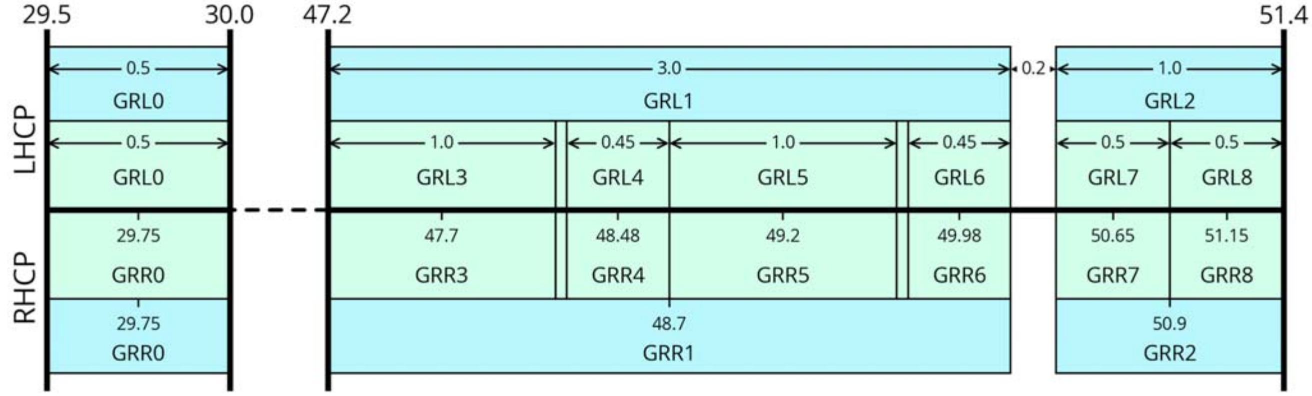

Figure III-6: Uplink beam and channel diagram.

c. Relay → Base User Inter-Satellite Channels (BT--)

These channels will relay Base User spacecraft forward data (command, payload data, software and FPGA updates, etc.) from the Relays to the Network's Base Users. Each beam supports up to seven channels per polarization as shown in Figure III-7, one for each 'color' in the Base service frequency reuse plan discussed in Audacy's response to Section 25.210(f) of the Commission's rules (Part III of this narrative).

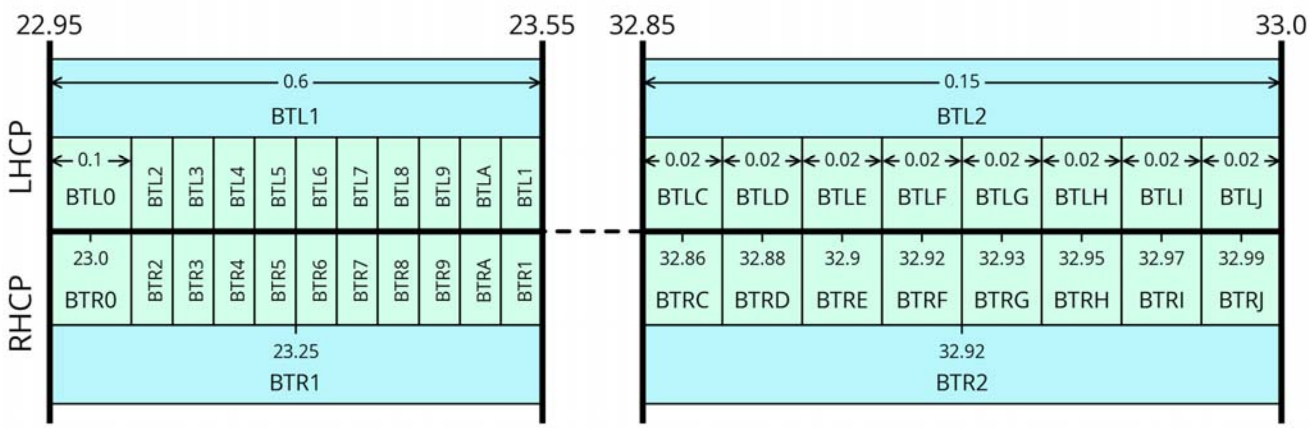

Figure III-7: Base forward beam and channel diagram.

d. **Base User → Relay Inter-Satellite Channels (BR--)**

These channels will relay Base User spacecraft return data (telemetry, payload data, etc.) from the Network's Base Users to the Relays. Each beam supports up to seven channels per polarization as shown in Figure III-8, one for each 'color' in the Base service frequency reuse plan discussed in Audacy's response to Section 25.210(f) of the Commission's rules (Part III).

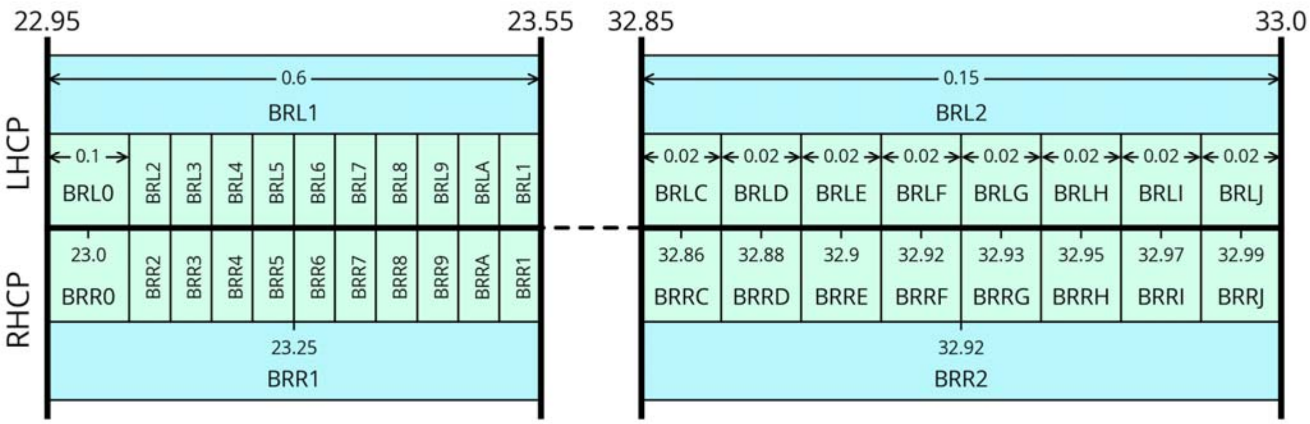

Figure III-8: Base return beam and channel diagram.

e. **Relay → Advanced User Inter-Satellite Channels (AT--)**

These channels will relay Advanced User spacecraft forward data (command, payload data, software and FPGA updates, etc.) from the Relays to the Network's Advanced Users. Advanced forward bandwidth will support one channel per beam, all isolated by frequency or polarization as shown in Figure III-9.

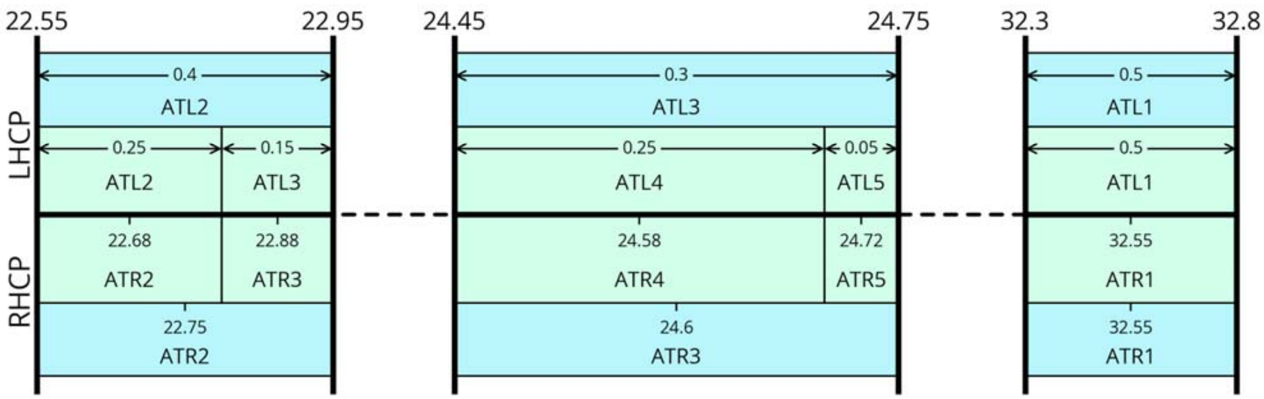

Figure III-9: Advanced forward beam and channel diagram.

f. Advanced User → Relay Inter-Satellite Channel (AR--)

These channels will relay Advanced User spacecraft return data (telemetry, payload data, etc.) from the Network's Advanced Users to the Relays. Advanced return bandwidth will support one channel per beam, all isolated by frequency or polarization as shown in Figure III-10.

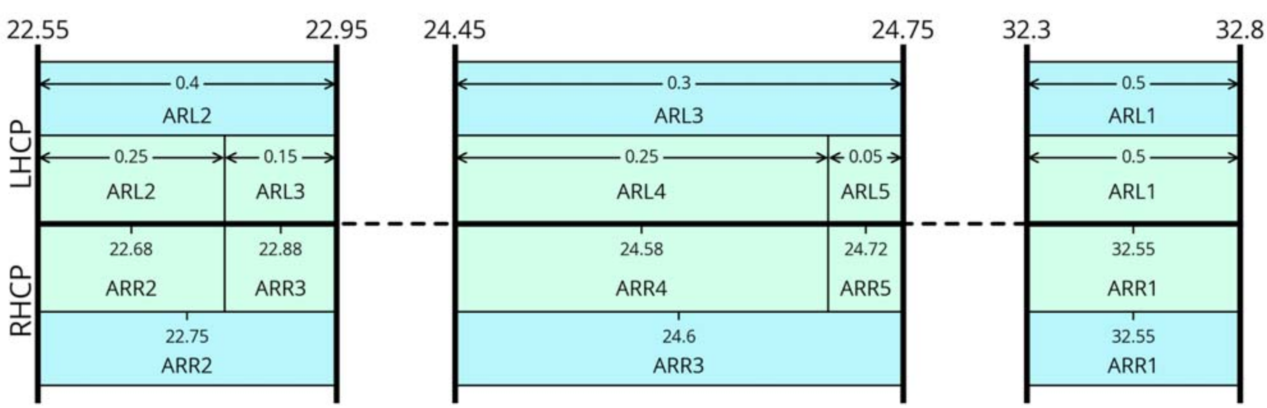

Figure III-10: Advanced return beam and channel diagram.

g. Relay → Relay Inter-Satellite Transmit Channel (RT--)

These channels will be used in place of the Relay ↔ Gateway links in cases where a Relay cannot establish a Gateway link. In this case, the Relay will transmit the return data of all Network Users (Base and Advanced) with which it is communicating. These data will be transmitted through the Relay → Relay channels and downlinked through the next Relay's Gateway link. A similar chain occurs in reverse with User uplink data.

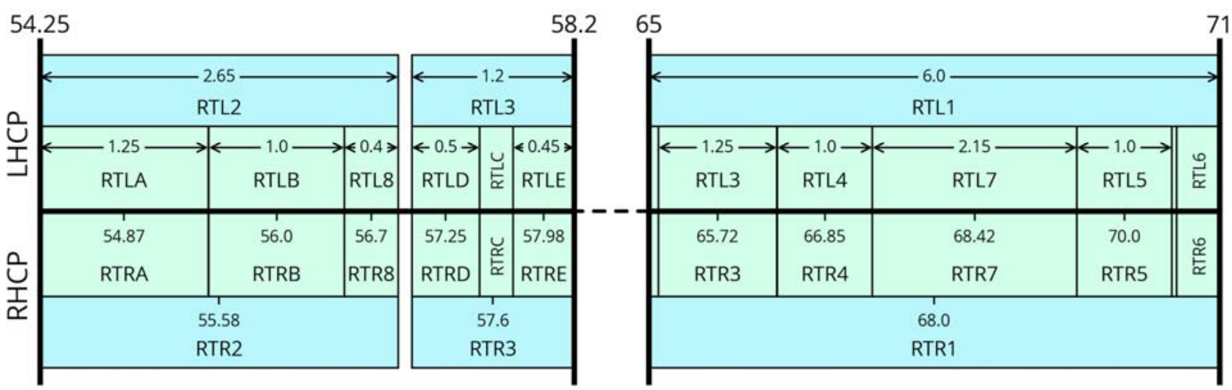

Figure III-11: Crosslink transmit beam and channel diagram.

h. Relay → Relay Inter-Satellite Receive Channel (RR--)

This carrier is the receiving end of the carrier described above in Part III.C.2.g.

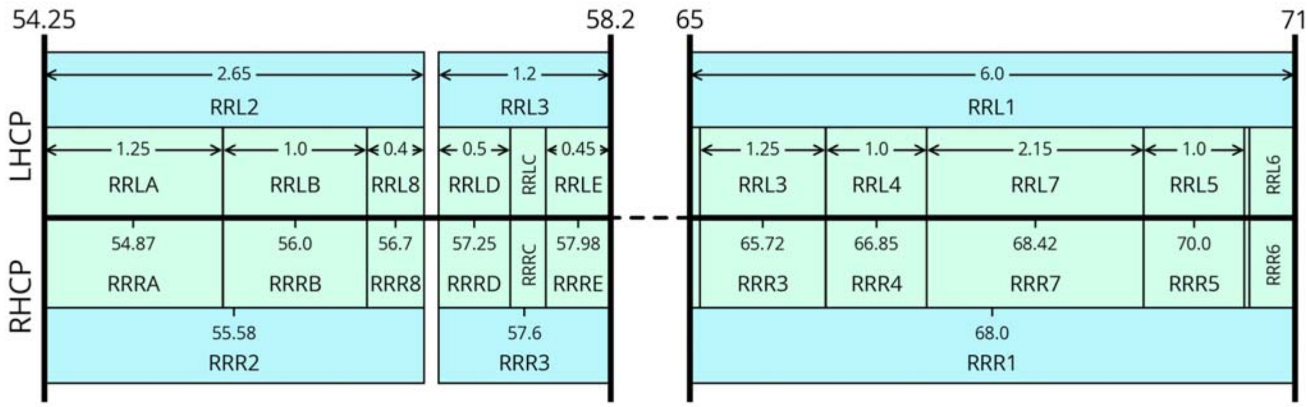

Figure III-12: Crosslink receive beam and channel diagram.

i. Uplink, Inter-Satellite, and Downlink Frequency Band Connectivity

The number of channels into which each Relay's Gateway beams are divided will vary with User demand. In situations where a Relay's Gateway link is unavailable, the Relay will substitute the Relay ↔ Relay inter-satellite link in its place to ensure successful coverage and transmission of data regardless of Gateway availability. Thus, the Relay ↔ Relay inter-satellite links must be capable of carrying the throughput of an entire Relay payload, while each Relay's Gateway links must be sized for the case where it must carry not only its own User data, but also those of its neighboring, Gateway-blind Relay.

The Relay payload dynamically connects uplink channels (whether directly from a Gateway or indirectly from a Relay → Relay link) to the appropriate Relay → User transmit channel, and User → Relay receive channels to the appropriate Relay → Gateway channel (or Relay → Relay channel if the Gateway is unavailable). In special cases, User → Relay channels can be connected directly to Relay → User channels for direct User ↔ User secure communication. In general, any receive channel may be connected to any transmit channel to maximize Network versatility and efficiency, according to the connectivity described in

Schedule S and illustrated in Figure III-13.

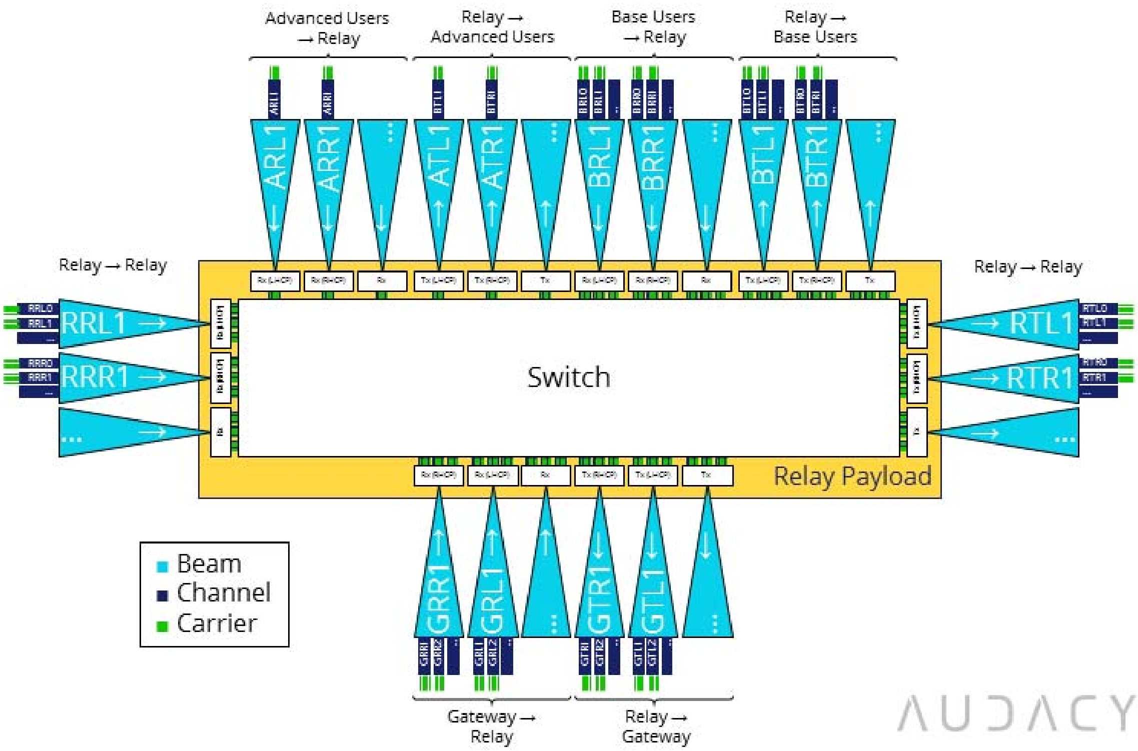

Figure III-13: Payload switching representation.

The Network will dynamically allocate bandwidth and capacity according to varying User numbers and data demand. The relative motion of both the Relays and Users will be accounted for to ensure seamless User handovers between Relay beams and between Relays themselves, and efficient capacity allocation for individual users throughout the Network service area.

D. § 25.114(d)(14) Mitigation of Orbital Debris (including § 25.283)

Audacy anticipates making a final Relay manufacturer selection shortly after receipt of an FCC grant of authority for the Network. The design of the Relays is based around the expected characteristics of 3-axis stabilized spacecraft buses available from major U.S. and international suppliers. These suppliers all have decades of experience in large spacecraft construction, and Audacy anticipates that the strategies employed by the Network will be similar and successful in eliminating harmful orbital debris regardless of the selected manufacturer.

The strategies employed by the Network to mitigate orbital debris are outlined below.

1. Control of Debris Released During Normal Operation

During deployment, normal MEO operation, and disposal, the Relays will generate no LEO debris with an orbital lifetime greater than 25 years, and no debris with the potential of traversing GEO. Audacy's protection of these two congested orbits is compliant with Requirement 4.3 of NASA's Process for Limiting Orbital Debris.[23] Each Relay will utilize appropriate shielding and design techniques to prevent debris generation in the MEO space environment.

Audacy will reduce the probability of debris generation from collisions with small objects and meteoroids by employing appropriate debris blankets, bumper shielding, and critical component redundancy. The Relays will also be all-electric (no bi-propellant or hypergolic fuels onboard), which greatly reduces the chance of ejecting debris while thrusting compared to chemical propulsion. The all-electric system eliminates the use of volatile fuels from traditional chemical thrusters, which could cause accidental explosions or release debris from the spacecraft.

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[23] *See Process for Limiting Orbital Debris (Revision A with Change 1 of 5/25/2012)*, NASA Technical Standards Program, 12/08/2011, NASA document number NASA-STD-8719.14, *available at* https://standards.nasa.gov/standard/nasa/nasa-std-871914 (last visited Nov. 12, 2016) ("*NASA's Process for Limiting Orbital Debris*").

2. Minimizing Debris Generated by Accidental Explosion

Audacy will take appropriate steps to minimize the chance of debris generation due to accidental explosion, including limiting the onboard stored energy sources to the following components:

- 2 × Pressurized Xenon Fuel Tanks
- 4 × Reaction Wheel Assemblies
- Lithium Ion Batteries
- Thermal Control System

The pressurized fuel tanks, reaction wheel assemblies, and batteries will all be space qualified hardware designed to prevent damage by environmental hazards including radiation, debris, and electrical anomalies, by adhering to appropriate safety and regulatory standards. The thermal control system will also use space-qualified hardware which will mitigate explosive reactions to damage, and adhere to all applicable regulations. The propulsion system onboard is all-electric and uses inert Xenon gas which does not contain stored chemical energy. Each component will be continually monitored for off-nominal behavior and to mitigate potential problems before they occur.

Audacy will work extensively with the Relay spacecraft manufacturer to ensure compliance with Requirement 4.4-1 of the Process for Limiting Orbital Debris.[24] Audacy is confident that the integrated probability of explosion for all credible failure modes of each spacecraft and launch vehicle will be significantly smaller than the value of 0.001 recommended by NASA.[25]

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24 *See id.* at 27.

25 *Id.*

At the end-of-mission, Audacy's spacecraft will transfer to a storage orbit and deplete all stored energy. The reaction wheels will be de-spun, the thermal control system will be deactivated, the batteries will be depleted and left in a permanent discharge state, and the pressurized Xenon tanks will be vented to remove all propellant and fully depressurize the system with fuel line valves permanently open. The all-electric propulsion system enables fuel to be vented at the end-of-mission without requiring a full burn or leading to significant safety concerns. These end-of-life passivation measures ensure that the Relays are compliant with Requirement 4.4-2 of the Process for Limiting Orbital Debris.[26]

3. Selection of Safe Flight Profile and Operational Configuration

Based on the United Nations Technical Report on Space Debris[27] and studies into the mass distribution of Earth-orbiting debris,[28] Audacy has estimated the probabilities of collision with various sizes of debris. The collision probabilities for objects 0.1-1.0 cm, 1.0-10 cm, and >10 cm are estimated to be less than 10^{-4}, 10^{-6}, and 10^{-7}, respectively for each of the three Relays over their anticipated 15-year lifetime. These results assume a launch into a geostationary transfer orbit followed by a low-thrust transfer to the final MEO orbit over a period of several months. Due to the overwhelmingly higher density of debris in LEO than MEO, the probability of a Relay colliding with debris of any size drops to negligible levels ($<10^{-8}$) in the event the Relays are launched directly into their final MEO orbits. The small number of Relays (three) in the Network and the MEO orbit into which they will be placed significantly minimizes the

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26 *Id.*

27 *See* Technical Report on Space Debris, Text of the Report adopted by the Scientific and Technical Subcommittee of the United Nations Committee on the Peaceful uses of Outer Space. New York, 1999. Publication number A/AC.105/720, *available at* https://www.orbitaldebris.jsc.nasa.gov/library/un_report_on_space_debris99.pdf (last visited Nov. 12, 2016).

28 *See* J.-C. Liou , *A Parametric Study on Using Active Debris Removal for LEO Environment Remediation*, NASA Johnson Space Center (2011), *available at* https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20100033207.pdf (last visited Nov. 12, 2016).

chances of debris collision.

The Relay's unique MEO placement is practically uninhabited by operational spacecraft. The Relays will not only be 35,000 km apart, but 22,000 km from GSO and 6,000 km from the GPS, BeiDou, Galileo, and GLONASS satellite navigation constellations. Audacy has analyzed debris throughout the MEO region using United States Strategic Command's databases of space objects. Only a small number of objects pass near the Relays' final orbits, both minimizing the chances of a close approach and allowing straightforward propagation and maneuver planning if necessary. The Relays' position in MEO has a low local mass density of debris and thus is a far safer alternative to LEO for avoiding collisions. During mission operations, the NOCs will monitor all space objects through the U.S. Space Catalog and will perform any necessary collision avoidance maneuvers for a collision probability greater than 10^{-4}. These probabilities of catastrophic collision are well below the value of 0.01 required by NASA according to Requirement 4.5-2 of the Process for Limiting Orbital Debris.[29]

At the end of the Relays' mission life, they will be transferred to a disposal orbit at least 200 km from their original orbit. During the final orbit transfer and post mission deactivation, debris will be continually monitored to avoid collisions.

In accordance with Requirement 4.5-2,[30] each Relay will be equipped with appropriate shielding including debris blankets and bumper shields to prevent loss of control in the event of a collision with small objects that could prevent implementation of the end-of-life disposal plan.

A catastrophic loss of control during the Relay's operational lifetime would of course prevent a transfer to its intended disposal orbit at its end of life. However, even in this worst-case

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[29] *See NASA's Process for Limiting Orbital Debris* at 32.

[30] *See id.*

scenario, the Relay will still be located in an acceptable disposal orbit according to Requirement 4.3.[31]

4. Post-Mission Disposal of Space Structures

The Relays' MEO placement does not require an end-of-life disposal maneuver to remain compliant with Requirement 4.3.[32] Nevertheless, each Relay will reserve approximately ten kg of Xenon propellant for a month-long, low-thrust transfer into a disposal orbit 200 km from its operational orbit. This maneuver would significantly reduce the risk of collisions with future space users of the Relays' MEO orbit.

E. § 25.164(b) Construction Milestones

Audacy acknowledges its obligation to place the Relays in assigned orbits and initiate operation in accordance with the proposed FCC authorization sought in this application no later than six years after the grant of the license.[33] As discussed above in Part III.C, the Relays will utilize three-axis stabilized platforms available from existing and established spacecraft manufacturers, all of which are compatible with multiple launch vehicles. Given the availability of existing satellite platforms and launch vehicles and the need to launch only three spacecraft, Audacy estimates that the six-year milestone to bring the Network into operation under the FCC's rules provides Audacy with sufficient time to complete design, construction, launch, and operation of the Relays.

F. § 25.202(j) 50.2-50.4 GHz Out-of-Band Emissions Limits

Audacy confirms that the Network will comply with the out-of-band emission limits applicable to the 50.2-50.4 GHz band. As described earlier in this narrative, the Network's

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[31] *Id.* at 21.

[32] *Id.*

[33] *See* 47 C.F.R. § 25.164(b).

primary uplink will use the 47.2-50.2 GHz and 50.4-51.4 GHz bands adjacent to the 50.2-50.4 band, which is allocated to the Earth exploration-satellite and space research services (both passive). The Commission's rules state that emissions into this band shall not exceed -20 dBW/200 MHz, except into earth stations with gain greater than 57 dBi. Audacy will comply fully with these regulations.[34]

G. § 25.207 Cessation of Emissions

As discussed above in Audacy's response to Section 25.114(d) of the Commission's rules, Audacy's NOCs will be able to remotely and immediately cease emissions from any or all of the Network Relays and Gateways.

H. § 25.210(f) Frequency Reuse

Although § 25.210(f) of the Commission's rules does not specifically apply to the Network (of the frequency bands the rule identifies, the Network only uses 29.5-30.0 GHz for a TT&C link to which the rule does not apply), Audacy is including this section out of an abundance of caution and to better inform the Commission on the Network's frequency-reuse capabilities.

As described in Audacy's response to § 25.114(d)(1)(i) of the Commission's rules, the Network uses three narrow feeder beams to transfer all User data between the three Relays and the Gateways. These feeder links will use up to 4 GHz of internationally allocated FSS spectrum in each direction and in both circular polarizations (LHCP and RHCP), split into numerous channels to ensure the most efficient possible use of bandwidth.

The Relay ↔ Advanced User ISS service is configured similarly to the Relay ↔ Gateway feeder links: very few narrow beams utilizing both polarizations for high-speed links.

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[34] A more detailed discussion of the Network's spectrum-sharing capabilities can be found in Part VI of this narrative.

The Relay ↔ Base User service serves a very wide field of view ($r_{\oplus}$ + 1,500 km) containing a vast number of individual Users, making efficient frequency reuse essential for Network functionality and performance. As described in Audacy's response to § 25.114(d)(1)(i) of the Commission's rules, the Relay ↔ Base User service uses up to 2 GHz of internationally allocated ISS spectrum in each direction and in both circular polarizations. Each Relay will generate hundreds of contiguous spot beams within its field of view, utilizing comprehensive frequency reuse to provide data services to the hundreds of Users within its service area. The frequency reuse plan employs both circular polarizations and uses the frequency plan described in Audacy's response to § 25.114(d)(1)(i) of the Commission's rules and Schedule S.

The full bandwidth will be adaptively used by the Network in both circular polarizations and would be divided into the narrower channels defined in Schedule S, one for each 'color' in the reuse pattern. The entire internationally allocated ISS spectrum will be reused hundreds of times across each Relay's coverage area. Figure III-14 shows example 3-, 4-, and 7-color frequency reuse schemes that the Network may employ to achieve extremely high spectral efficiency. The specific reuse pattern, polarization, and timing of each cell will depend on a range of factors including the distribution of User traffic and data demand across each Relay's field of view as well as over time. The dynamic adaptability of the Relay payloads and the Network as a whole ensures optimum frequency reuse and spectral efficiency, reusing the available ISS bandwidth many times in full compliance with the emissions restrictions and beam characteristics laid out in this narrative and Schedule S.

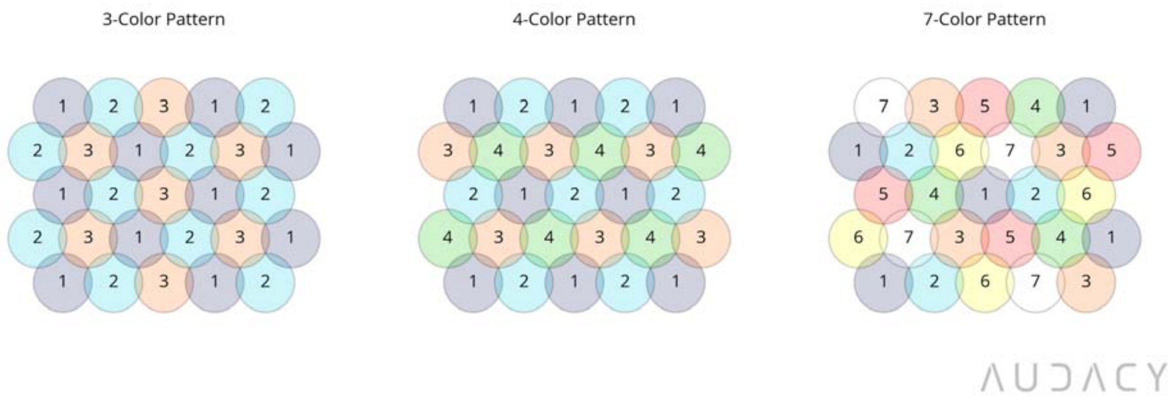

Figure III-14: Example frequency reuse "color patterns."

IV. PUBLIC INTEREST BENEFITS

Audacy respectfully submits that grant of this Application will serve the public interest, convenience and necessity. As demands for access to finite, valuable radiofrequency spectrum continue to grow among operators of wireless communications systems, the Commission is challenged to determine the most efficient spectrum utilization scheme, balancing the public interest benefits of promoting new technologies and innovation with the prevention of harmful interference into incumbent systems.[35]

A sea change in the commercial space and satellite industry has complicated the Commission's balancing equation. Until recently, most commercial space networks were easily coordinated GSOs with 2° spacing obligations and highly directional antennas, or mobile satellite systems using exclusive spectrum for end user communications. Technological advances

[35] *See Spectrum Efficiency Metrics,* White Paper, FCC Technology Advisory Council, at 2 (Dec. 2011), *available at* https://transition.fcc.gov/bureaus/oet/tac/tacdocs/SpectrumEfficiencyMetricsV1-12-20-11.docx.

facilitating less expensive and more compact spacecraft, competition among diverse launch providers, coupled with a growing demand for new space-based commercial services (*e.g.*, imaging) have created an unprecedented surge in new satellite operators and a commensurately intense demand for spectrum.

Finding spectrum for these new systems has become a critical problem that already threatens to hinder innovation. The polar orbits employed by many of these systems, which minimize the number of orbital passes needed to downlink data collected from imaging and other store-and-forward spacecraft, have already experienced such congestion that ground stations at northern polar sites are impractical or impossible to coordinate.[36] Use of mid-latitude orbits, where coordination will also become increasingly challenging as larger networks are deployed, is cost-prohibitive for LEO operators because it necessitates many more ground stations for up- and downlink operations.

Audacy's Network alleviates the looming spectrum crisis affecting space-to-Earth communications by allowing thousands of space network operators to trunk their communications through Audacy Gateways and Relays, thereby reducing costs and fostering spectral efficiency by eliminating the need for individual uplink and downlink frequencies for each system.

The Network will allow existing commercial and government spacecraft operators to simplify operations with seamless TT&C, enhance their service offerings, and unlock new revenue opportunities with access to real-time space communications. For example, Earth

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[36] *See* Report to CORF from the NASA Office of Earth Science (May 14, 2003), *available at* http://sites.nationalacademies.org/cs/groups/bpasite/documents/webpage/bpa_048964.pdf (discussing "large number of new bandwidth-hungry missions" contributing to congestion in the X-Band, even in 2003); *see also* Planet Labs Inc. Grant, IBFS File No. SAT-MOD-2015802-00053 at 3 (granted Sept. 15, 2016) (declining to authorize use of the Maddock, ND and Keflavik, Iceland earth stations with satellites launched after June 15, 2016 due to failure to reach agreement with NASA, USGS and NOAA).

observation operators using the Network will be able to downlink data and imagery in real time (<1s latency).[37] In addition to these immediate benefits of a commercial data relay system, there are endless technologies and new solutions that Audacy could enable. Audacy will advance the space industry and open up possibilities for transformative technologies across the value chain, from telerobotics to space debris collection.

The Network will also immediately promote the democratization of space. Many new and innovative satellite systems are anticipated to "create large data sets, and those data sets yield insight into corporate policy and industrial activity around the globe, including corporate supply chains, oil production, or shipping and maritime activity."[38] With the current *status quo*, entrants to the satellite industry struggle to access space because of three main barriers: Regulation, Infrastructure, and Costs. The Network significantly reduces these burdens on operators while promoting spectral efficiency and fostering innovation.

- **Regulation**: Operators using the Network will obtain approval from the appropriate regulatory bodies to communicate on Network ISS links without the need for their own uplink and downlink frequencies and associated FSS coordination. This streamlines mission planning and promotes efficient use of spectrum.
- **Infrastructure:** The Network is a 'plug and play' communications solution. Operators with a Network-compatible terminal on their spacecraft can easily schedule communications with their satellite at any time through Audacy's online

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[37] Real-time downlink is facilitated because the Earth observation spacecraft will always be able to communicate with a higher altitude Relay, as opposed to storing data and waiting to pass over a ground station to initiate downlink communications.

[38] *See VCs Invested More in Space Startups Last Year Than in the Previous 15 Years Combined,* Fortune.com, (2016), *available at* http://fortune.com/2016/02/22/vcs-invested-more-in-space-startups-last-year/ (last visited Nov. 12, 2016).

portal. This enables universities, researchers, and startups with little or no communications knowledge to seamlessly command and downlink from their payload. This democratization of space is in line with the Commission's goals to "facilitate greater investment and further innovation in the satellite industry as well as more rapid deployment of new satellite services to the public"[39] and "afford more operational flexibility for satellite licensees", per recent FCC rule changes.[40]

- **Cost**: The Network reduces barriers to entry to the satellite industry by eliminating the need to construct, operate, and maintain operationally complex ground infrastructure, which in many instances must be staffed 24/7 and operated in extreme environments. The Network is an innovative, scalable solution that reduces startup costs and fosters spectral efficiency by eliminating the need for separate uplink and downlink frequencies. With no required capital investment in communications infrastructure, operators can use Network communications services at any time and only when they need it. In addition to these significant savings on capital costs, Audacy also enables new revenue opportunities for operators who can now downlink and sell more data or address new markets with real-time data access.

Audacy's application of cellular technology in space furthers the FCC's "mission-

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[39] *In the Matter of Comprehensive Review of Licensing and Operating Rules for Satellite Services*, IB Docket No. 12-267, Report and Order, 28 FCC Rcd 12403, 12508 (2013).

[40] *Id.* at 12405. *See also In the Matter of Comprehensive Review of Licensing and Operating Rules for Satellite Services, IB Docket No. 12-267, Second Report and Order*, 30 FCC Rcd 14713 (2015).

critical" goal of "making sure that scarce spectrum is used in the most efficient way."[41] The Network takes well-proven, terrestrial cellular technology and applies it in space. Cellular technology divides the service area into spot beams, each assigned a separate frequency and polarization in a repeating pattern so that no adjacent cells are identical. This allows for the optimum use of scarce frequency, as spectrum can be reused hundreds of times across a single service area, increasing the capacity of the network without increasing allocated bandwidth.

The Network's multiple access techniques allow hundreds of users to share the allocated ISS bandwidth, just as hundreds of cellphone users simultaneously share a single terrestrial cell tower. These advanced multiple access schemes enable the Network to efficiently provide large numbers of users with maximum throughput using the limited available ISS spectrum.

Instead of using a single link protocol across all users and for all conditions, the Network will employ ACM techniques that dynamically alter each link's characteristics to optimize client throughput and reliability according to prevailing channel conditions. By altering the modulation from binary phase-shift-keying (BPSK) to 32-state amplitude- and phase-shift keying (32-APSK), for example, an RF link can transfer far more data. A typical link using ACM achieves the greatest possible capacity more than 99.9% of the time.

Lastly, it is important to note that Audacy is not seeking exclusive use of the frequencies set forth in the application and will not preclude additional entry by either GSO or NGSO applicants in the bands. Audacy's spectrum sharing approach is outlined in detail in Part VI of this narrative. In sum, grant of the instant Application serves the public interest.

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[41] Remarks of Chairman Tom Wheeler, 19th Annual Satellite Leadership Dinner (March 7, 2016), *available at* https://apps.fcc.gov/edocs_public/attachmatch/DOC-338135A1.pdf (last visited Nov. 12, 2016).

V. REQUESTED WAIVERS & SECONDARY USE REQUESTS

A. The Waiver Standard

The Commission may grant waivers "on its own motion or on petition if good cause therefor is shown."[42] "Good cause" has been interpreted to exist when the facts of a particular case make strict compliance inconsistent with the public interest and when the relief requested will not undermine the policy objective of the rule in question. To prevail, a petitioner must demonstrate that application of the involved rule would be inequitable, unduly burdensome, or contrary to the public interest. The Commission may also take into account considerations of "hardship, equity, or more effective implementation of overall policy" on an individual basis.[43] The courts have likewise found that "a general rule, deemed valid because its overall objectives are in the public interest, may not be in the 'public interest' if extended to an applicant who proposes a new service that will not undermine the policy, served by the rule that has been adjudged in the public interest."[44] Waivers are appropriate if "special circumstances warrant a deviation from the general rule and such deviation will serve the public interest."[45]

The waivers sought in the instant Application will not undermine the policy objective of the involved rules – namely, protecting incumbent spectrum users and not precluding operation of later-filed NGSO FSS systems – and will further the public interest by alleviating the ongoing spectrum crisis hindering the ability of innovative space-based systems from communicating with terrestrial infrastructure by promoting shared spectrum use among current and future NGSO

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42 47 C.F.R. §1.3.

43 *WAIT Radio v. FCC*, 418 F.2d 1153, 1159 (D.C. Cir. 1969) ("*WAIT Radio*").

44 *Id.*, 418 F.2d at 1157.

45 *Northeast Cellular Telephone Co. v. FCC*, 897 F.2d 1164, 1166 (D.C. Cir. 1990) (citing *WAIT Radio*, 418 F.2d at 1159) (explaining the necessary criteria to establish good cause for a waiver).

operations. The shared use of spectrum resources and promotion of innovative new services will benefit other NGSO operators and American consumers, as further discussed below.

B. Waiver of § 25.145(c) Geographic Coverage Requirements

Section 25.145(c) of the Commission's rules requires FSS NGSO systems operating in the 18.3-20.2 GHz and 28.35-30.0 GHz bands to provide service coverage (i) to all locations as far north as 70° latitude and as far south as 55° latitude for at least 75% of every 24-hour period and (ii) on a continuous basis throughout the fifty states, Puerto Rico and the U.S. Virgin Islands.[46] To the extent necessary, Audacy requests a waiver, to the extent necessary, of Section 25.145(c)'s K_a-band geographic coverage requirements. The Commission has previously granted such waivers based on limitations and constraints of NGSO operators' system design.[47] As described in Part III above, the Network will employ the 19.7-20.2 GHz and 29.5-30.0 GHz bands only in off-nominal, emergency situations and will not be used to provide service coverage. Moreover, as described in Part VI herein, the Network has been carefully designed to eliminate harmful interference to other users during both nominal and off-nominal situations. Frequencies and polarizations can be dynamically modified as necessary to accommodate existing and planned users of the spectrum and do not impede access to the spectrum. As such, good cause exists to grant Audacy's requested waiver.

C. Waiver of § 25.156(d)(4)

Audacy requests a waiver, to the extent necessary, of Section 25.165(d)(4), which provides that "Applications for feeder-link authority or inter-satellite link authority will be

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46 *See* 47 C.F.R. § 25.145(c).

47 *See Authorization of O3b Limited,* IBFS File Nos. SAT-LOI-20141029-00118 and D-SAT-AMD-20150115-00004 (Call Sign S2935) (granted Jan. 22, 2015).

treated like an application separate from its associated service band."[48] This rule was adopted to address circumstances where applicants applied for authority to use feeder links or inter-satellite links before frequencies were allocated for such use and, as such, to apply different application processing procedures to each type of link.[49] Applicants seeking to operate feeder links or inter-satellite links prior to an allocation were considered under a first-come, first-served procedure, while processing rounds were initiated for frequencies that had been allocated for a proposed service with already established service rules.[50]

Audacy's Network does not contemplate providing traditional service links to terrestrial end users. Moreover, in the case of Audacy's Network, all frequencies requested for feeder links and inter-satellite service links have been allocated for the requested operations in the U.S. Table of Frequency Allocations and should therefore be considered as a single application by the Commission. As such, good cause exists to grant Audacy's requested waiver.

D. Waiver of § 25.156(d)(5)

To the extent required, Audacy seeks a waiver of Section 25.156(d)(5) of the Commission's rules. Section 25.165(d)(5) provides that "where the Commission has not adopted frequency-band specific service rules, the Commission will not consider NGSO-like applications after it has granted a GSO-like application" and vice versa "until the Commission establishes NGSO/GSO sharing criteria for that frequency band."[51] Audacy does not believe there are currently any commercial satellite systems operating in bands addressed in this Application for

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[48] 47 C.F.R. § 2.156(d)(4).

[49] *See In the Matter of Amendment of the Commission's Space Station Licensing Rules and Policies; Mitigation of Orbital Debris*, IB Docket Nos. 02-34, 02-54, First Report and Order and Further Notice of Proposed Rulemaking, 18 FCC Rcd 10760, 10810-12 (2003); *In the Matter of Amendment of the Commission's Space Station Licensing Rules and Policies; 2000 Biennial Regulatory Review*, IB Docket Nos. 02-34, 00-248, Notice of Proposed Rulemaking and First Report and Order, 17 FCC Rcd 3847, 3859-61 (2002).

[50] *Id.*

[51] 47 C.F.R. § 2.156(d)(5).

which the Commission has not adopted service rules or sharing criteria, but requests a waiver out of an abundance of caution, to permit operation of the Network in these bands.

E. Waiver of § 25.157

Pursuant to Section 25.157(c) of the Commission's rules, space station applications for authority to launch and operate U.S.-licensed "NGSO-like" systems are evaluated under a "processing round" mechanism.[52] The Commission has waived the processing round requirement, however, when such authorization would "not preclude additional entry."[53] For the reasons set forth below and in Part VI, Audacy respectfully requests a waiver of the Commission's processing round requirement and authority to utilize the full range of radiofrequency bands as proposed in the instant application. In the alternative, and as discussed in greater detail below, Audacy urges the Commission to include its Network solely in processing rounds already in process or contemplated by the Commission, and waive the requirement for bands proposed in Audacy's application that do not overlap with already proposed NGSO-like systems.

The Audacy Network's ability to share frequencies with existing and future NGSO networks operating co-channel in the same radiofrequency bands will *not* preclude additional entry by future NGSO systems. First, the Audacy Network consists of only three Relay satellites in an advanced MEO configuration communicating with no more than three complementary Gateway earth stations.[54] This network architecture more closely resembles a GSO system and

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52 *See* 47 C.F.R. § 25.157(c), (e).

53 *See also Northrop Grumman Space & Missions Systems Corporation*, File No. SAT-LOA-19970904-00080 et al., DA 09-428, Order and Authorization, 24 FCC Rcd 2330, 2342, at ¶ 29, 34 (Int'l Bur. 2009) ("*Northrop Grumman Order*"); *see also Space Imaging, LLC*, IB Docket No. 02-34, Declaratory Order & Order & Authorization, 20 FCC Rcd 11964, ¶¶ 10, 11 (Int'l Bur. 2005) ("*Space Imaging Order*").

54 Audacy has carefully chosen the Relays' orbit to ensure complete line-of-sight coverage of User LEO spacecraft while minimizing Relay ↔ User link distance, the number of global Gateways required, and Network operational complexity.

ensures angular separation between Audacy communications links (FSS and ISS) and the links of other NGSO systems employing alternative orbits, including large LEO constellations. Second, the Network employs advanced RF technologies, including adaptive power control, very localized beams (<0.5°), and precise pointing. Moreover, the flexibility of the Network design, particularly that of the Relay RF payload, allows for dynamic modification of frequencies and polarizations on an as-needed basis to accommodate existing and planned users of the spectrum. In aggregate, this architecture ensures the Network is capable of deconflicting and eliminating in-line interference events with other satellite networks, present and future.

Grant of Audacy's waiver request would be consistent with the Commission's recent decision to waive the processing round for another NGSO network, which similarly employs a MEO configuration.[55] Audacy's Network, however, enjoys meaningful operational and technological advantages that improve Audacy's ability to avoid in-line incidence of interference and ensure radiofrequency spectrum is preserved for future NGSO networks. Most significantly, the already authorized network provides broadband connectivity to terrestrial end users, which involves a large volume of earth stations that can mispoint and must be coordinated with terrestrial services. Audacy's Network involves a total of three Gateway earth stations (only one planned U.S.-based Gateway), and no other satellite-based terrestrial infrastructure.

Given that the instant waiver supports the policy objective of the processing round - to preserve opportunities for competitive market entry[56] - and will further the public interest by

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[55] *See Application of O3b Limited to Operate a Gateway Earth Station with a Non-U.S. Licenses, Non-Geostationary Orbit K_a-band Space Station System*, FCC File No. SES-LIC- 20100723-00952, Radio Station Authorization, at 4, Condition 90043 (granted Sept. 25, 2012) (noting that O3b Limited will employ satellite diversity at low to medium latitudes, which will enable it to share spectrum with other NGSO FSS systems. At higher latitudes, O3b Limited will employ a band segmentation approach to accommodate other systems if interference occurs). *See also Northrop Grumman Order*, 24 FCC Rcd at 2342, at ¶¶ 31-33; *Space Imaging Order*, 20 FCC Rcd 11964, ¶¶ 10, 11.

[56] *Space Imaging Order*, 20 FCC Rcd 11964, ¶¶ 10, 11.

allowing Audacy to provide valuable and innovative services that promote efficient use of spectrum without the additional delay caused by subjecting the Network to a subsequent processing round, Audacy urges prompt grant of this waiver request for the entire range of radiofrequency spectrum proposed for the Network.

1. Alternative Request for Waiver of Section 25.157(c) Processing Round Requirement

Certain radiofrequency bands proposed for Audacy's Network overlap with bands contemplated by other NGSO networks for which the Commission has already initiated processing rounds. Specifically:

- On July 15, 2016, the Commission released a Public Notice establishing a processing round for NGSO-like applications competing with the lead application filed by WorldVu Satellites Limited, d/b/a OneWeb.[57] The *OneWeb Petition PN* established a November 15, 2016 filing deadline for additional applications and petitions for operation in the following frequency bands: 10.7-12.7 GHz, 14.0-14.5 GHz, 17.8-18.6 GHz, 18.8-19.3 GHz, 27.5-28.35 GHz, 28.35-29.1 GHz, and 29.5-30.0 GHz.[58] The *OneWeb Petition PN* frequencies that overlap with the Audacy Network include only the 29.5-30.0 GHz band.

- On November 1, 2016, the Commission released a Public Notice establishing a processing round for NGSO-like applications competing with the lead application filed by The Boeing Company.[59] The *Boeing Application PN* established a March 1, 2017 filing deadline for additional applications and petitions for operation in the following frequency bands: 37.5-40.0, 40.0-42.0, 47.2-50.2, and 50.4-51.4 GHz, all of which overlap with proposed Audacy Network frequency bands.

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57 *Cut-Off Established for Additional NGSO-Like Satellite Applications or Petitions for Operations in the 10.7-12.7 GHz, 14.0-14.5 GHz, 17.8-18.6 GHz, 18.8-19.3 GHz, 27.5-28.35 GHz, 28.35-29.1 GHz, and 29.5-30.0 GHz Bands*, Public Notice, DA 16-804 (rel. July 15, 2016) ("*OneWeb Petition PN*").

58 *OneWeb did not seek FCC authorization for 19.7-20.2 GHz because this band would not be used from U.S. territories. See WorldVu Satellites Limited, Petition for a Declaratory Ruling Granting Access to the U.S. Market for the OneWeb System*, Petition for Declaratory Ruling of OneWeb Ltd., SAT-LOI-2016428-00041, at 8 (filed April 28, 2016) ("*OneWeb Petition*").

59 *See Cut-Off Established for Additional NGSO-Like Satellite Applications or Petitions for Operations in the 37.5-40.0 GHz, 40.0-42.0 GHz, 47.2-50.2 GHz and 50.4-51.4 GHz Bands*, Public Notice, DA 16-1244 (rel. Nov. 1, 2016) ("*Boeing Application PN*").

Audacy can coordinate and deconflict with both WorldVu and Boeing, and requests that the Commission waive its participation in these ongoing processing rounds pursuant to the above waiver request for Section 25.157(c). Audacy's Network overlaps very discretely with these systems solely for FSS uplink and downlink communications. Accordingly, coordination with these networks will only involve resolving conflicts associated with Audacy's three Relays and three complementary Gateways. As discussed above in the immediately preceding waiver request and below in Part VI, such coordination does not present logistical or technical obstacles. Nevertheless, to the extent that inclusion in these active processing rounds is required, Audacy requests a narrower, discrete waiver of the Section 25.157(c) processing round requirement with respect to the remaining bands that are not involved in an existing processing round, namely the 19.7-20.2, 22.55-23.55, 24.45-24.75, 32.3-33, and 65-71 GHz bands. No basis exists for delaying action on Audacy's Network to undertake a processing round given that future NGSO systems will not be precluded from use of any of the frequency bands assigned to the Network.

2. Waiver of Section 25.157(e) Band Segmentation Rules

To the extent necessary under the current rules, in the event that Audacy's Network is included in a processing round, Audacy urges the Commission to waive band segmentation requirements in Section 25.257(e) to Audacy's Network. The FCC's processing round rules provide that, in the event of insufficient spectrum for qualified applicants, the available spectrum will be divided equally.[60] Processing rounds involving fewer than three applicants will not allocate more than one third of the available spectrum to reserve spectrum available for future processing rounds.[61]

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[60] 47 C.F.R. § 25.157(e)(1).

[61] 47 C.F.R. § 25.157(e)(2)-(3).

On August 16, 2016 the FCC released a decision that ends band segmentation for NGSO systems, finding that the "three-licensee presumption" is overly restrictive for its intended goals of "(1) accelerating the reassignment of spectrum to other satellite licensees, in order to expedite the provision of satellite services to customers; and (2) creating opportunities for competitive entry to the extent possible."[62] The Commission therefore determined that "the three-licensee presumption" would be removed from the band segmentation rules given that "having fewer than three licensees in a band does not necessarily indicate a harmful lack of competition."[63] The rules revised in the *Second Order on Reconsideration* will go into effect on November 30, 2016.[64]

The Commission has granted NGSO systems "access to an entire frequency bands when doing so would not preclude additional entry," and in those instances "have treated NGSO systems under a first-come, first-served approach and have not instituted a processing round."[65] As discussed above and in Part VI of this Application, the design of the Network will accommodate any current and future systems and limit interference events between NGSO systems in the selected frequency bands, promoting efficient use of spectrum. Audacy seeks application of the updated rule reflecting the Commission's current position on band segmentation to the extent such rule is not already in place at the time of license grant.

F. Waiver of 18 GHz Band Plan

The U.S. Table of Frequency Allocations designates the 19.7-20.2 GHz band as co-primary for Federal and non-Federal space-to-Earth FSS services.[66] In its 1996 *K_a Band Order*,

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62 *Amendment of the Commission's Space Station Licensing Rules*, Second Order on Reconsideration, IB Docket No. 02-34, 31 FCC Rcd 9398 9401-03, ¶¶ 7, 10 (2016) ("*Second Order on Reconsideration*").

63 *Id.*, 31 FCC Rcd at 9403, ¶ 10.

64 *See* 81 Fed. Reg. 75,338 (Oct. 31, 2016).

65 *Northrop Grumman Order*, 24 FCC Rcd at 2343, ¶ 34.

66 47 C.F.R. § 2.106.

the Commission designated the band for "GSO conventional downlink pairing" but determined that it would not "preclude the authorized use of these bands by other satellite applications on a secondary basis to the primary satellite application designated in the band."[67] Subsequently, however, in the 2000 *18 GHz Band Order*, the Commission eliminated the secondary designation, concluding that "secondary use of the 18 GHz band is not viable because it would unreasonably inhibit ubiquitous deployment of these services and limit the use of spectrum by primary users of the bands."[68] The Commission confirmed this conclusion on reconsideration, stating that removing secondary operations would lessen the potential for harmful interference to the primary services, though the Commission ultimately noted that the record was insufficient to determine "whether and how NGSO/FSS systems can operate on a secondary basis in GSO/FSS primary bands."[69]

The Commission will grant a waiver for non-conforming uses "when there is little potential interference into any service authorized under the U.S. Table of Frequency Allocations and when the non-conforming operator accepts any interference from authorized services."[70] Waivers have been granted for non-conforming NGSO/FSS operations on a no interference basis

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[67] *Rulemaking to amend Parts 1, 2, 21, and 25 of the Commission's Rules to Redesignate the 27.5-29.5 GHz Frequency Band to reallocate the 29.5-30 GHz Frequency Band to Establish Rules and Policies for Local* Multipoint Distribution Service and for Fixed Satellite Services, CC Docket No. 92-297, Report and Order 11 FCC Rcd 19005, 19036 (1996) ("*K_a Band Order*").

[68] *Redesignation of the 17.7-19.7 GHz Frequency Band, Blanket Licensing of Satellite Earth Stations in the 17.7-20.2 GHz and 27.5-30.0 GHz Frequency Bands, and the Allocation of Additional Spectrum in the 17.3-17.8 GHz and 24.75-25.25 GHz Frequency Bands for the Broadcast Satellite Service Use*, Report and Order, 15 FCC Rcd 13430, 13456-57 (2000) ("*18 GHz Band Order*").

[69] *Redesignation of the 17.7-19.7 GHz Frequency Band, Blanket Licensing of Satellite Earth Stations in the 17.7-20.2 GHz and the 27.5-30.0 GHz Frequency Bands, and the Allocation of Additional Spectrum in the 17.3-17.8 GHz and 24.75-25.25 GHz Frequency Bands for Broadcast Satellite Service Use*, First Order on Reconsideration, 16 FCC Rcd 19808, 19822 (2001).

[70] *In the Matter of Inmarsat Mobile Networks, Inc., Application to Operate a Fixed-Satellite Service Gateway Earth Station Facility in Lino Lakes, Minnesota with the Inmarsat-5 F2 Space Station*, Order and Authorization and Declaratory Ruling, 30 FCC Rcd 2770, 2777 (Int'l Bur. 2015) (citing *Fugro-Chance, Inc.*, Order and Authorization, 10 FCC Rcd 2860, 2860 (Int'l Bur. 1995)).

in the 19.7-20.2 GHz band where applicants have demonstrated that a system's operations meet the EPFD limits in Article 22, Tables 22-1C and 22-4B of the ITU Radio Regulations.[71] As the Commission has noted in these cases, "the ITU considers a NGSO FSS system that meets these EPFD limits to have fulfilled its obligations under Article 22.2 with respect to any GSO FSS network, and any interference by the NGSO FSS system into the GSO FSS network is acceptable."[72]

Audacy requests a waiver of the 18 GHz Band plan to utilize the 19.7-20.2 GHz band on a non-conforming, no interference basis, for downlink operations between its Relays and Gateways. Audacy will comply with the EPFD limits set forth in Article 22 of the ITU-RR and will not cause harmful interference to any existing operations in the band.

Moreover, Audacy will coordinate with Federal incumbents in accordance with footnote US334 of the U.S. Table of Frequency Allocations to protect any Federal operations in the band. A detailed discussion of the Network's spectrum sharing mechanisms, including protection of National Science Foundation ("NSF") radio astronomy operations, NASA solar system research, and Federal and military space operations can be found in Part VI of this narrative.

To summarize that discussion, Audacy confirms that it will coordinate with Federal, NSF, NASA, and military operators on a case-by-case basis to ensure that the Network does not introduce harmful interference into these incumbent systems. Audacy anticipates that the Network's GSO-like characteristics, including small number of space stations (3), earth stations (3), and the narrow (<0.5°) primary FSS beams, will ensure that the coordination process is streamlined and straightforward.

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71 *See In the Matter of contactMEO Communications, LLC for Authority to Launch and Operate a Non-Geostationary Orbit Fixed-Satellite System in the K_a-band Frequencies, Order and Authorization*, 21 FCC Rcd 4035, 4045 (Int'l Bur. 2006) ("*contactMEO Order*"); *Northrop Grumman Order*, 24 FCC Rcd at 2355.

72 *contactMEO Order*, 21 FCC Rcd at 4045.

Audacy further commits to cease operations in the 19.7-20.2 GHz band in the event of harmful interference to any GSO operation and will accept interference from any GSO FSS operations of Federal operations in the band.

G. Waiver of 25.202(a)(1) for 50.4-51.4 GHz Band

Audacy's Network will use the 50.4-51.4 GHz band for uplink operations between its Gateways and space stations on a non-conforming basis. The U.S. Table of Allocations identifies the 50.4-51.4 GHz band as co-primary for Federal and non-Federal Fixed, FSS, Mobile, and MSS services.[73] The Federal Spectrum Use Summary identifies NASA and military agencies as using the band for "research and development of radar-target cross sections."[74]

Part 25 of the Commission's rules does not presently include a satellite allocation in the 50.4-51.4 GHz band,[75] and in 1998 the Commission designated the 50.4-51.4 GHz band as primary for wireless services, noting that "designations are generally needed where bands are allocated to more than one service and sharing between these services may be difficult."[76] However, in the interim period only one wireless license has been granted in this band and that license expired in 2001.[77] Moreover, the Commission is currently seeking comment on means to accommodate sharing between terrestrial and satellite operations in the 50.4-51.4 GHz band in

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73 47 C.F.R. § 2.106.

74 Federal Spectrum Use Summary, 30 MHz – 3000 GHz, National Telecommunications and Information Administration, Office of Spectrum Management (Jun. 21, 2010), *available at* https://www.ntia.doc.gov/files/ntia/Spectrum_Use_Summary_Master-06212010.pdf ("*Federal Spectrum Use Summary 2010*").

75 *See* 47 C.F.R. § 25.202(a)(1).

76 *Allocation and Designation of Spectrum for Fixed-Satellite Services in the 37.5-38.5 GHz, 40.5-41.5 GHz and 48.2-50.2 GHz Frequency Bands; Allocation of Spectrum to Upgrade Fixed and Mobile Allocations in the 40.5-42.5 GHz Frequency Band; Allocation of Spectrum in the 46.9-47.0 GHz Frequency Band for Wireless Services; and Allocation of Spectrum in the 37.0- 38.0 GHz and 40.0-40.5 GHz for Government Operations*, Report and Order and Further Notice of Proposed Rulemaking, 13 FCC Rcd 24649, 24650 n. 3 (1998).

77 Search of FCC Universal Licensing System conducted on September 7, 2016 (Call Sign WNVZ641).

the *Spectrum Frontiers Proceeding*.[78] Audacy maintains that this band is ideal for uplink NGSO FSS operations and authorization would further the Commission's objective. Furthermore, the Audacy Network will only involve one discrete U.S. Gateway, with a total three total Gateways, thus, promoting efficient use of spectrum and preventing valuable spectrum from lying fallow.

Audacy commits to coordinating with Federal users in the band to avoid instances of harmful interference that cannot be remedied. A detailed discussion of the mechanisms the Network will employ to eliminate harmful uplink interference with Federal space systems is described in Part VI of this narrative.

H. Waiver of Footnote 5.556A GSO-only limitation for ISS allocations in 54.25-56.9 and 57-58.2 GHz bands

Use of the 54.25-58.2 GHz band is shared on a co-equal basis between U.S. Government and non-Government operations for Earth exploration-satellite service ("EESS") (passive), fixed, mobile, space research (passive) and inter-satellite services.[79] Footnote 5.556A of the Table of Frequency allocations restricts use of the 54.25-56.9 GHz, 57-58.2 GHz bands to GSO systems solely for the purpose of protecting EESS services in the band.[80] Specifically, to ensure protection for EESS systems, Footnote 5.556A provides that for GSO systems operating space-to-Earth communications "the single-entry power flux-density at all altitudes from 0 km to 1000 km above the Earth's surface produced by a station in the inter-satellite service, for all conditions

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78 *See Use of Spectrum Bands Above 24 GHz for Mobile Radio Services, et al.*, GN Docket No. 14-177 et al., Report and Order and Further Notice of Proposed Rulemaking, FCC 16-89, ¶ 421 (rel. July 14, 2016).

79 47 C.F.R. § 2.106.

80 *See Rulemaking to Amend Parts 1, 2, 21, and 25 of the Commission's Rules to Redesignate the 29.7-29.6 GHz Frequency Band, to Reallocate the 29.5-30 GHz Frequency Band, to Establish Rules and Policies for Local Multipoint Distribution Service and for Fixed Satellite Services*, CC Docket No. 92-297, Third Report and Order, 12 FCC Rcd 22310, 22331-32, ¶ 53 (1997) ("*Third FSS R&O*").

and for all methods of modulation, shall not exceed -147 dB(W/(m^2 · 100 MHz)) for all angles of arrival."[81]

Audacy requests a waiver of the GSO-only limitation in this band and requests to use 54.25-56.9 GHz, 57-58.2 GHz bands on a non-conforming, no interference basis to provide inter-satellite services between its three Relays.

As discussed in greater detail in Part VI of this narrative addressing the Network's protection of planned users in this band, the Relays' inclined orbits result in a maximum of two geostationary conjunctions per orbit, the Network will employ only three narrow (<1°) beams in this band (between the Relays), and these beams are directed away from Earth. Moreover, Audacy's Network will comply with the PFD limits set forth in Footnote S5.556A. In sum, these characteristics make Audacy's Relays much more akin to a GSO system with respect to EESS operations as opposed to a large-scale LEO network intended to provide broadband service to terrestrial-based end users. While Audacy understands that the U.S. Government has existing and planned ISS systems in the 56.9-57 GHz band segment,[82] it is unaware of any existing systems in the 54.25-56.9 GHz, 57-58.2 GHz bands and therefore does not anticipate creating a risk for harmful interference for any incumbent user or existing EESS system. Similarly, Audacy is not aware of any current non-government EESS or other GSO operations in this band, but will coordinate with any individual operators on a case-by-case basis to ensure no harmful interference occurs into existing and planned GSO systems.

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[81] 47 C.F.R. § 2.106, n. S5.556A. *See also Amendment of Part 2 of the Commission's Rules to Allocate Additional Spectrum to the Inter-Satellite, Fixed, and Mobile Services and to Permit Unlicensed Devices to Use Certain Segments in the 50.2-50.4 GHz and 51.4-71.0 GHz Bands*, ET Docket No. 99-261, Report and Order, 15 FCC Rcd 25264, 25284 (2000); ITU-R Recommendation RS. 1279: Spectrum Sharing Between Spaceborne Passive Sensors and Inter-Satellite Links in the Range 50.2-29.3 GHz (1997), *available at* http://www.itu.int/dms_pubrec/itu-r/rec/rs/R-REC-RS.1279-0-199710-I!!PDF-E.pdf (last visited Nov. 12, 2016).

[82] *Third FSS R&O*, 12 FCC Rcd at 22331.

I. Waiver of 25.114(c)(8) and 25.208(r) Power Flux Density Limits

Section 25.114(c)(8) of the Commission's rules requires space station applicants to provide the maximum PFD limits within each coverage area and energy dispersal bandwidth, if any, needed for compliance with Section 25.208.[83] Section 25.208(r) provides for maximum PFD limits for angles of arrival between 5-25° above the horizontal plane of "-132 + 0.75(δ-5) dB(W/m^2) in any 1 MHz band" under assumed free space conditions and "-120 + 0.75(δ-5) dB(W/m^2) in any 1 MHz band" during periods when power is raised to compensate for rain-fade conditions at the FSS earth station.[84]

As illustrated in Figure III-5 in Part V.I of this application, Audacy's use of the 37.5-40 GHz band will slightly exceed the FCC PFD limits described above for the angles of arrival between 5-7.5°, and Audacy therefore requests a waiver for this slight deviation. These levels fall well below the less stringent PFD limits of -120 + 0.75(δ-5) dB(W/m^2) "for all conditions and for all methods of modulation" adopted by the ITU for this band.[85] The Commission has recognized that higher PFD levels are at times necessary to maintain adequate satellite performance and has permitted PFD limits to exceed the FCC-prescribed levels "on a case-by-case" basis[86] and currently has pending a proposal to establish specific criteria for evaluating

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83 47 C.F.R. § 2.114(c)(8).

84 47 C.F.R. §§ 2.208(r)(1), (r)(2).

85 ITU-RR, Table 21-4.

86 *Northrop Grumman Order*, 24 FCC Rcd at 2345-46; *Allocation and Designation of Spectrum for Fixed-Satellite Services in the 37.5-38.5 GHz, 40.5-41.5 GHz and 48.2-50.2 GHz Frequency Bands; Allocation of Spectrum to Upgrade Fixed and Mobile Allocations in the 40.5-42.5 GHz Frequency Band; Allocation of Spectrum in the 46.9-47.0 GHz Frequency Band for Wireless Services; and Allocation of Spectrum in the 37.0-38.0 GHz and 40.0-40.5 GHz for Government Operations*, IB Docket No. 97-95, Second Report and Order, 18 FCC Rcd 25428, 25440 (2003).

when, and to what extent, PFD levels may exceed the specified "clear-air" levels in the 37.5-40.0 GHz band.[87]

The calculated maximum PFD for the angles of arrival between 5-7.5° will slightly exceed the FCC "clear-air" limit but will fall well below the corresponding ITU limit. This deviation is necessary to compensate for the effects of rain fade and would not result in harmful interference to any incumbent fixed or terrestrial mobile services in this band, given that Audacy will employ narrow antenna beams to use the 37.5-40.0 GHz band for downlink transmissions from its three NGSO Relays to its single Gateway in the United States. A detailed discussion on the mechanisms the Network will employ to eliminate harmful interference into terrestrial systems (including 5G) is described in Part VI of this application. As such, good cause exists to grant Audacy's requested waiver.

J. Request of Authority to Operate on Secondary Basis in 29.5-30.0 GHz Band

Audacy's Network will use the 29.50-30.0 GHz band for uplink operations between its Gateways and Relays on a secondary, no interference basis. The U.S. Table of Frequency Allocations designates the 29.5-30.0 GHz band as co-primary for non-Federal Fixed, Fixed Satellite, and Mobile Services.[88] Under Part 25 of the Commission's rules, the 29.5-30.0 GHz band is allocated on a primary basis for non-Federal GSO FSS operations and on a secondary basis for NGSO FSS operations.[89] There is no Federal allocation indicated in the band.[90] The band segmentation decisions in the broader 27.5-30.0 GHz band were adopted with the objective

87 *See Allocation and Designation of Spectrum for Fixed-Satellite Services in the 37.5-38.5 GHz, 40.5-41.5 GHz and 48.2-50.2 GHz Frequency Bands; Allocation of Spectrum to Upgrade Fixed and Mobile Allocations in the 40.5-42.5 GHz Frequency Band; Allocation of Spectrum in the 46.9-47.0 GHz Frequency Band for Wireless Services; and Allocation of Spectrum in the 37.0-38.0 GHz and 40.0-40.5 GHz for Government Operations*, IB Docket No. 97-95, Third Further Notice of Proposed Rulemaking, 25 FCC Rcd 15663 (2010).

88 47 C.F.R. § 2.106.

89 47 C.F.R. § 25.202(a) n. 4.

90 47 C.F.R. § 2.106.

of "[p]roviding for coordination of new systems with existing services in mind" while "[p]roviding maximum flexibility for system implementation, inter-system sharing, and future system growth."[91]

Audacy will coordinate its operations with GSO systems[92] and will operate its uplink operations on a secondary, no interference basis with respect to GSO operations in the 29.5-30.0 GHz band and will not claim interference protection from GSO FSS stations in this band, as required by the Commission's rules.[93] The Network's uplink operations in the 29.5-30 GHz band will further comply with the EPFD limits Table 22-2 of the ITU-RR.[94] As described above, the Network will only uplink in these bands during off-nominal situations, and due to the narrow beamwidth of the uplink antennas, Audacy anticipates in-line interference events with other operators to be rare. A detailed discussion of the Network's provisions for protecting other space systems can be found in Part VI of this narrative.

K. Request for Authority to Operate on Secondary Basis in 32.3-33.0 GHz Band

The Network will use the 32.3-33.0 GHz band to relay Advanced User forward/return data to/from the Advanced Users to Audacy's Relays. The Table of Frequency Allocations designates the 32.3-33.0 GHz band on a co-primary basis for Federal and non-Federal Inter-Satellite and Radionavigation services.[95] Footnote US278 provides that NGSO inter-satellite links operate on a secondary basis to GSO inter-satellite links in this band.[96]

The Federal Spectrum Use Summary provides that the NSF uses this band for "radio

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[91] *K_a Band Order*, 11 FCC Rcd at 19023; 47 C.F.R. § 25.202(a)(1) n. 2.

[92] 47 C.F.R. § 25.278.

[93] 47 C.F.R. §§ 2.105(c)(2)(i), (ii).

[94] ITU-RR, Table 22-2.

[95] 47 C.F.R. §§ 2.106.

[96] 47 C.F.R. §§ 2.106, n. US278.

astronomy research of various spectral lines, including continuum observations."[97] Audacy commits to coordinating with Federal users in the band, including the NSF, to avoid instances of harmful interference that cannot be remedied. A detailed discussion on the mechanisms the Network will employ to eliminate harmful inter-satellite interference with Federal space operations is described in Part VI of this narrative.

With respect to commercial operations, while an allocation exists for Radionavigation,[98] service rules have not been promulgated and publicly accessible records reflect no active U.S. licenses in this band.[99] Audacy will coordinate its operations with GSO systems[100] and will operate its uplink operations on a secondary, no interference basis with respect to GSO operations in the 32.3-33.0 GHz band and will not claim interference protection from GSO FSS stations in this band, as required by the Commission's rules.[101]

VI. SPECTRUM-SHARING CAPABILITIES

The Network's spectrum-sharing capabilities are similar to those of a GSO constellation, with respect to the low number of space stations and earth stations (three of each), and tight feeder beams between them.

The Network has been carefully designed to eliminate harmful interference to other users of the frequency bands used during both nominal and off-nominal situations. Audacy has also selected higher frequency bands than the vast majority of those currently in use, leading to fewer existing and planned users both during initial coordination and throughout the lifetime of the

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[97] *Federal Spectrum Use Summary 2010* at 73.

[98] *See* 47 C.F.R. §§ 87.173, 87.187.

[99] Based on a search conducted in the FCC's Universal Licensing System, http://wireless2.fcc.gov/UlsApp/UlsSearch/searchLicense.jsp (last visited Nov. 12, 2016).

[100] *See* 47 C.F.R. § 25.278.

[101] *See* 47 C.F.R. §§ 2.105(c)(2)(i), (ii).

Network. The inclination of the Relay orbits at 25° from the equatorial plane will minimize conjunctions with GSO operators and minimize the chance of harmful interference events.

The Relay ↔ Gateway links are few (only three locations across the entire globe), and very localized (<0.5° uplink and downlink beamwidths), meaning that operation and coordination of the Relays will be similar to that of regular GSO communications satellites. There are currently no existing users and only a handful of planned users of the primary V-band uplink and downlink frequencies, but as explained in Audacy's response to 25.114(d)(1) of the Commission's rules, the Network was designed not only to eliminate interference with existing users (none), but also with future users of these bands.

The Relay ↔ User links cover large service areas, but the flexibility of the Network design, particularly that of the Relay RF payload, means that frequencies and polarizations can be dynamically modified on an as-needed basis to accommodate existing and planned users of the spectrum. The Network uses advanced RF technologies in both the space and ground segments to ensure that the Network can rapidly adapt not only in response to User demand and capacity requirements, but also to eliminate interference with other users of the ISS bands.

This section describes the techniques used by the Network to mitigate interference with existing and planned spectrum users, as well as the interference analysis showing that the Network can successfully share spectrum with other co-primary services during nominal operations.

The table below lists the frequency bands the Network proposes to use, as well as co-primary service allocations and the number of operational space users:

Frequency Band (GHz)	(Co-)Primary Service Allocations	# Operational Space Incumbents[102]	
		GSO	NGSO
Downlink			
19.70-20.20	MSS	134	2
37.50-38.60	Fixed, Mobile	0	0
38.60-39.50	Fixed, Mobile	0	0
39.50-40.00	Fixed, Mobile	0	0
40.00-42.00	Broadcasting, BSS, Fixed, Mobile. MSS	1	0
Uplink			
29.50-30.00	MSS, GSO FSS*	107	4
47.20-48.20	Fixed, Mobile	1	0
48.20-50.20	Fixed, Mobile	1	1
50.40-51.40	Fixed, Mobile, MSS	0	1
ISS			
22.55-23.55	Fixed, Mobile, Space Research	23	7
24.45-24.75	Fixed, Radionavigation	0	1
32.30-33.00	Fixed, Radionavigation	0	1
54.25-56.90	Fixed, EESS, Space Research	0	4
57.00-58.20	Fixed, EESS, Mobile, Space Research	0	4
65.00-71.00	Mobile, MSS, Radionavigation	0	0

Table 4: Proposed Network frequency bands and numbers of operational incumbents.

*In the 29.50-30.00 GHz band, the NGSO FSS allocation is secondary to the GSO FSS allocation.

[102] Number of satellites at ‘Notification’ stage according to the ITU’s Space Network List (“SNL”). Accurate as of November 2016.

A. FSS Downlink Spectrum Sharing Capabilities

The Network's downlink emissions are well below all ITU and FCC PFD limits, with a 2 dB exception in the 37.5-40 GHz band at low angles of arrival for which Audacy is requesting a waiver in Part V of this application. The low emissions level is due to the highly directional Gateway receive antennas, which reduce the need for powerful Relay transmitters.

As described above, the tight (<0.5°) downlink beam footprints at only three Gateways worldwide (1 in the United States) mean that potentially affected operators are limited to those in close geographic proximity to the Gateways. Audacy has not yet finalized exact Gateway locations, but it is likely that the number of co-primary terrestrial operators in the Network's downlink frequencies will be small and coordination can occur on a case-by-case basis.

Even within the downlink footprints nearby the Gateways, downlink beams will be incident at predominantly high arrival angles, reducing the likelihood of harmful interference events with usually near-horizontal terrestrial services. The Relays will not downlink at arrival angles below 5°.

The K-band FSS frequencies will be used only by low-gain, omnidirectional onboard antennas to recover the spacecraft should it enter a failsafe mode or require de-tumbling. The Network will use these bands only in off-nominal situations to restore Relay operations through telemetry and command links. All uses of the FSS K-bands will be brief and well below ITU and FCC PFD limits for all angles of arrival.

The plots below show the compliance of the Network's downlink beams with both the Commission's and the ITU's PFD limits. Figure VI-1 shows the 37.5-40 GHz band, including the infraction at low arrival angles for which Audacy is seeking a waiver from the Commission in Part V of this narrative.

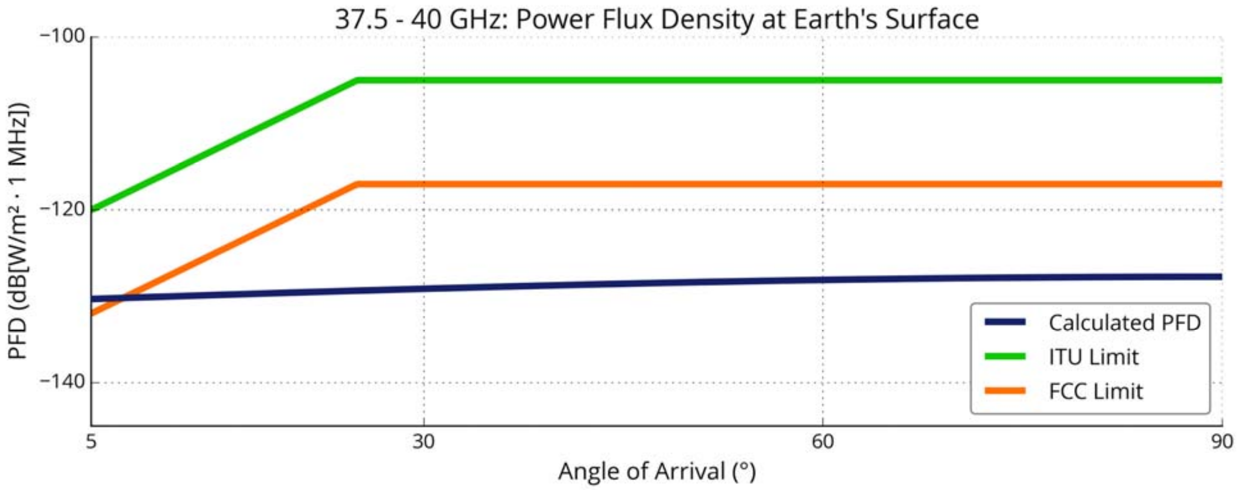

Figure VI-1: 37.5 – 40 GHz downlink PFD.

Figure VI-2 shows the 40-42 GHz band, illustrating that the Network downlink beams are well below both ITU and FCC limits (≥12 dB) for all angles of arrival.

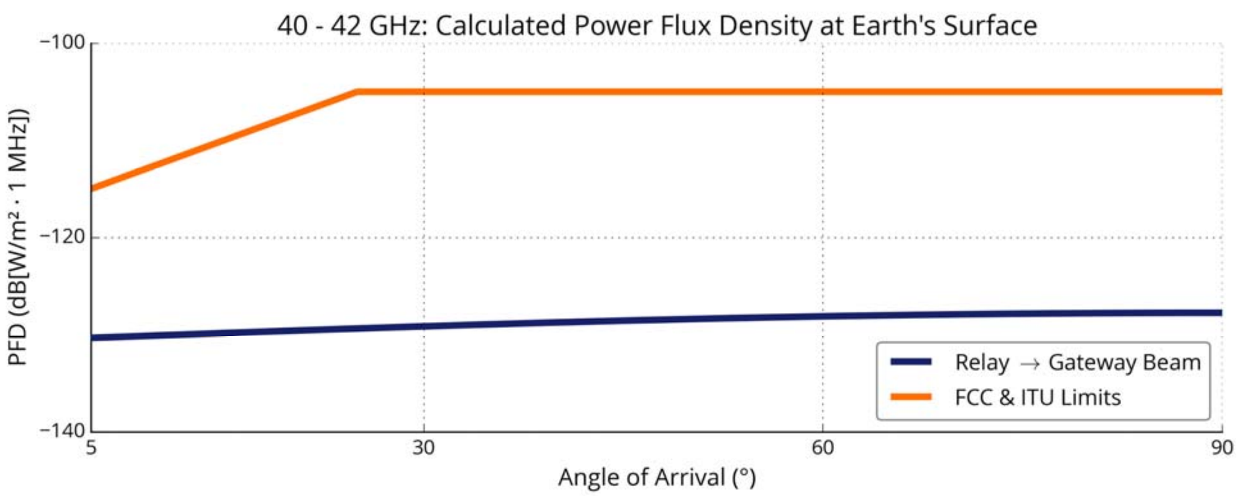

Figure VI-2: 40 – 42 GHz downlink PFD.

Audacy's mechanisms for coordinating with specific co-primary services in the downlink bands are outlined below:

1. Radio Astronomy and Space Research Services

The 37-38 GHz band may be used by the NSF for radio astronomy research and by NASA for solar system exploration, sensor, and navigation research, including for downlink into the Very Long Baseline Interferometer.[103] The 41-45 GHz band is also used for downlink into the Very Large Baseline Array.[104]

Audacy will work with the National Telecommunications and Information Administration ("NTIA") and NASA to locate and characterize any space research and radio astronomy facilities within the footprint of Audacy's U.S. downlink beam. Audacy will complete coordination with individual locations on a case-by-case basis to eliminate the possibility of harmful interference into these facilities, following the coordination process outlined in ITU-R Resolution 743-2 in the case of radio astronomy facilities.

2. Federal and Military Fixed Services

The 37-38 GHz band is used at military test ranges for fixed point-to-point communications, and has previously been used by the military for mobile applications. [105]

Federal and military systems are designed to accept interference up to the level of the ITU PFD limits (≥12 dB),[106] and as the Network downlink operates well below ITU limits at all angles of arrival there is little chance of Network downlink emissions causing harmful interference into these systems.

Audacy will work with the NTIA to locate and characterize any military facilities within the footprint of Audacy's U.S. downlink beam. Audacy will then complete coordination with these facilities on a case-by-case basis to eliminate the possibility of harmful interference.

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103 *See Federal Spectrum Use Summary 2010* at 75.

104 *See Federal Spectrum Use Summary 2010* at 76-77.

105 *See Federal Spectrum Use Summary 2010* at 75.

106 *See* Manual of Regulations and Procedures for Federal Radio Frequency Management, U.S. Department of Commerce, National Telecommunications and Information Administration, Section 8.2.36 (September 2015 Revision of the May 2013 Edition), *available at* https://www.ntia.doc.gov/page/2011/manual-regulations-and-procedures-federal-radio-frequency-management-redbook.

3. Upper Microwave Flexible Use ("UMFU") Systems

As described above, the Network's downlink beams will operate well below (≥12 dB) ITU PFD limits, and well below the Commission's PFD limits the vast majority of the time. Audacy is keen to eliminate harmful interference and coordinate with other co-primary users of the spectrum in the immediate vicinity of Audacy's Gateways. The most important planned systems in the Network's primary downlink band (37.5-40 GHz) are the fifth-generation ("5G") networks providing data services to nearby terrestrial users' handheld devices.

The interference analysis below shows that even in the worst case, the Network will not cause harmful interference to UMFU systems in the vicinity of Network Gateways within the narrow downlink footprint. Audacy will coordinate with individual operators on a case-by-case basis, mitigating potential interference using the location and RF characteristics of individual terrestrial base stations.

The following interference analysis is conducted in two scenarios. In the worst-case scenario, the Relay is at its closest approach to the Gateway and transmitting 5° from the boresight of a 5G base station receiver, resulting in an interference degradation of 0.07 dB. In a more typical scenario, the 5G base station antenna has 16 dB of isolation against satellite emissions, and the Relay is downlinking at a more typical arrival angle closer to 90°, resulting in 0.01 dB interference degradation.

Parameter	Units	Worst-Case	Typical
5G Station Rx Noise Figure	dB	5.0 (Estimated)	
5G Station Rx Noise Density	dBW/MHz	-139.0 (T_0 = 290 K)	
5G Station Rx Gain	dBi	27.0 (Estimated)	
5G Station Rx Isolation	dB	5.0	16.0
Relay PFD at G_i	dBW/m^2/MHz	-124.8	
Power Received at G_i	dBW/MHz	-156.8	-167.8
Interference : Noise	dB (%)	-17.8 (0.02)	-28.8 (0.00)
Interference Degradation	**dB**	**0.07**	**0.01**

Table 5: Network → UMFU system interference analysis.

It is clear from this analysis that even in the worst case, the Network will not result in harmful interference to UMFU networks. Moreover, in the typical case the Network's signals will be virtually undetectable by 5G antennas.

It is unlikely that terrestrial UMFU systems could cause harmful interference into Network Gateway receivers: the high arrival angles of the Network's downlink signals will provide protection from the near-horizontal UMFU signals. The Gateway receivers will also be highly directional with low side lobes, and thus well protected from nearby UMFU transmitters. Audacy will again coordinate with UMFU individual operators on a case-by-case basis to ensure that the Network and UMFU systems can share spectrum without causing harmful interference to each other.

4. High-Density Fixed Systems ("HD FS")

The protection mechanisms the Network affords to HD FS are similar to those described in the UMFU section above. Like UMFU systems, HD FS networks are terrestrial, near-horizontal point-to-point systems, but usually with more directional antennas that provide even greater isolation from off-axis satellite downlink emissions.

The interference analysis below shows two scenarios. In the worst case, the HD FS antenna is pointing directly at a Network Relay at its point of closest approach (0 dB isolation). This would virtually never happen in reality, as the Relays will not transmit at angles of arrival below 5°. In the typical scenario, the near-horizontal HD FS receiver is isolated by a more realistic 30 dB from the incoming downlink signal.

Parameter	Units	Worst-Case	Typical
HD FS Rx Noise Figure	dB	5.0 (Estimated)	
HD FS Rx Noise Density	dBW/MHz	-139.0 (T_0 = 290 K)	
HD FS Rx Gain	dBi	35.0 (Estimated)	
HD FS Rx Isolation	dB	0.0	30.0
Relay PFD at G_i	dBW/m^2/MHz	-124.8	
Power Received at G_i	dBW/MHz	-159.8	-189.8
Interference : Noise	dB (%)	-20.8 (0.01)	-50.8 (0.00)
Interference Degradation	**dB**	**0.04**	**0.00**

Table 6: Relay → HD FS interference analysis.

It should be noted that in both cases, the Network introduces negligible interference in the HD FS system. This is in part due to the highly directional Network receivers, which both reduce the necessary energy of the downlink beams, but make interference into the Network by HD FS emissions unlikely. Audacy will coordinate with individual HD FS operators in the close vicinity of its Gateways on a case-by-case basis to ensure that the two services can share spectrum efficiently without one causing harmful interference to the other.

5. GSO, NGSO, and Federal/Military Space Systems

The 37-38 GHz band may be used by Federal FSS and MSS space systems,[107] while the 39.5-40 GHz band is allocated for Federal military satellite systems. The SNL lists a single GSO operator in the Network's primary downlink bands, and no incumbent NGSO operators.

Audacy will work with the NTIA to determine the specific bands currently used by Federal and military space Systems, as well the locations and characteristics of associated earth stations within the footprint of Audacy's downlink beams. Audacy will coordinate on a case-by-case basis to ensure that its Network does not cause harmful interference to any Federal System

The ITU-R is currently developing regulatory guidelines for NGSO FSS operations in V-band frequencies, to ensure protection of EESS and facilitate spectrum sharing between NGSO and GSO systems.[108] Audacy looks forward to the implementation of this study process by WRC-19, and will incorporate the published guidelines and any included EPFD limits into the coordination process.

As explained in the introduction to this Part VI, the Network's GSO-like characteristics such as the small number of Relays and Gateways, narrowness of downlink beams, and real-time adaptive power control, lead to straightforward coordination and spectrum sharing between the Network and other space systems.

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[107] *See Federal Spectrum Use Summary 2010* at 75.

[108] *See* Resolution 162, Studies relating to spectrum needs and possible allocation of the frequency band 51.4-52.4 GHz to the fixed-satellite service (Earth-to-space) (WRC-15), *available at* http://www.itu.int/dms_pub/itu-r/oth/0c/0a/R0C0A00000C0025PDFE.pdf (last visited Nov. 13, 2016).

Audacy will coordinate with incumbent and future FSS operators on a case-by-case basis to ensure an equitable sharing of spectrum.

B. FSS Uplink Spectrum Sharing Capabilities

With only three worldwide Gateways (one in the United States), and highly directional beams with low side lobes transmitting at least 5° above each Gateway's local horizon, it is unlikely that a terrestrial operator could cause harmful interference to Audacy's Network and vice versa. In any case, the zone of even potential interference is limited to the geographic area in close proximity to the Network Gateways, and Audacy will identify and coordinate with at-risk operators on a case-by-case basis. As a last resort, the Network's Gateways will be capable of adaptive power control, so that their transmit power can be immediately reduced in the case of unexpected harmful interference events.

The 50.2-50.4 GHz band is allocated to passive EESS operations including by NASA and the National Oceanic and Atmospheric Administration ("NOAA"),[109] and is adjacent to two FSS bands used by the Network. Audacy will comply with US156 to protect EESS sensing in this band, and will complete coordination with individual facilities on a case-by-case basis. As described above, Audacy's Gateways are few with highly directional uplink beams and low out-of-band emissions. Line-of-sight conjunctions with EESS satellites can be managed individually by the Network to mitigate the likelihood of harmful interference.

NASA and the military have reported using the 50-55 GHz band for radar research.[110]

The K-band uplink frequency band will, like the K-band downlink band, be used only to recover the Relays in off nominal and tumbling situations. These low-energy telemetry and

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109 *See* 47 C.F.R. § 1.06 n. US156; *Federal Spectrum Use Summary 2010* at 78.

110 *See id.* at 78-79.

command links will be to low-gain, omnidirectional receivers onboard the spacecraft, and will be well below ITU and Commission PFD limits.

1. GSO, NGSO, and Federal/Military Space Systems

Audacy has designed the Network from the ground up to minimize the possibility of harmful interference with existing and planned spectrum users and ensure effective spectrum sharing and compatibility. The Relays' inclined orbits mean that conjunctions with the geostationary orbit occur only twice per orbit, and Audacy has ensured that these occur during Gateway handover periods when neither Gateway nor Relay are transmitting. This minimizes possible interference with GSO operators, as a Relay will usually appear from the Gateways to be well-separated from the geostationary orbit during periods of uplink.

SNL lists zero current users of the V-band uplink frequency bands that the Network proposes to use. Audacy plans to coordinate with future NGSO users of these bands, and is confident that the GSO-like RF characteristics of the Network described above, including the paucity and narrowness of the uplink beams, will enable efficient sharing between the Network and future spectrum users.

The V-band coordination guidelines and EPFD limits currently being developed by the ITU-R will be useful in coordination efforts between the Network and planned NGSO and GSO operators. Audacy will comply with the ITU's recommendations should Network coordination be ongoing at the time of the guidelines' release at WRC-19.

The analysis below shows two interference scenarios between a Network Gateway and an unsuspecting GSO space station. In the worst case, the Gateway, Relay and GSO satellite (G_1) in conjunction, and G_1 has a high-gain antenna steered precisely at the Network Gateway, tuned to the exact frequency of Network uplink emissions, which in turn have not employed any adaptive power methods to reduce interference. In a more typical scenario, G_1's high-gain antenna has 30 dB isolation from the Network's uplink beam. Figure VI-3 below shows the in-line interference event:

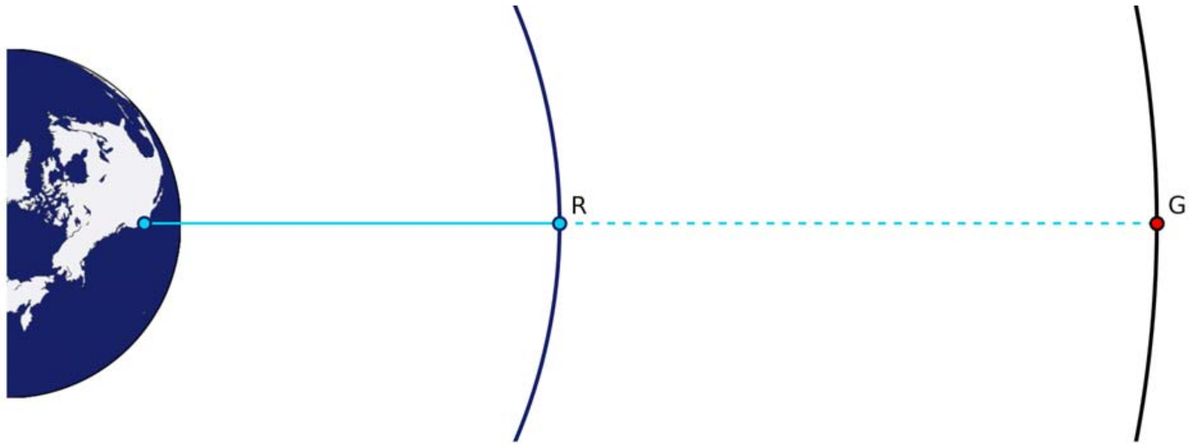

Figure VI-3: Uplink interference diagram.

Parameter	Units	Worst-Case	Typical
G_1 Rx Noise Figure	dB	4.0 (Estimated)	
G_1 Rx Noise Density	dBW/MHz	-140.0 (T_0 = 290 K)	
G_1 Rx Gain	dBi	50.0 (Estimated)	
G_1 Rx Isolation	dB	0.0	30.0
Relay PFD at G_1	dBW/m^2/MHz	-107.2	
Power Received at G_1	dBW/MHz	-157.2	-187.2
Interference : Noise	dB (%)	-17.2 (0.02)	-47.2 (0.00)
Interference Degradation	**dB**	**0.08**	**0.00**

Table 7: Uplink → GSO interference analysis.

The analysis shows that even in the worst case, which would be an extremely unusual occurrence in reality, the Network introduces negligible interference into GSO systems.

C. ISS Spectrum Sharing Capabilities

The Network is compliant with both ITU and Commission PFD limits throughout the ISS service areas (*see* Part III of this narrative and Schedule S). The characteristics of the Network described earlier in this section that are designed to streamline coordination apply equally to the ISS bands used by the Network. The few GSO conjunctions, adaptive power control over every transmit beam, and precise pointing all help eliminate harmful interference events with prior and future co-primary spectrum users.

1. GSO Systems

As described earlier in this narrative, the Network will employ three narrow Relay ↔ Relay inter-satellite links in the internationally allocated ISS V-band. Audacy is requesting a waiver of the GSO-only restriction in the 54.25-56.9 and 57-58.2 GHz bands (see Part V of this narrative) due to the Network's GSO-like characteristics including the high MEO orbit, narrow beams, and few space stations and Gateways. The plot below shows the Network's compliance with the PFD limit in CFR 47(1)(2)(105), footnote 5.556A, for all angles of arrival onto a 1000 km-altitude sphere.

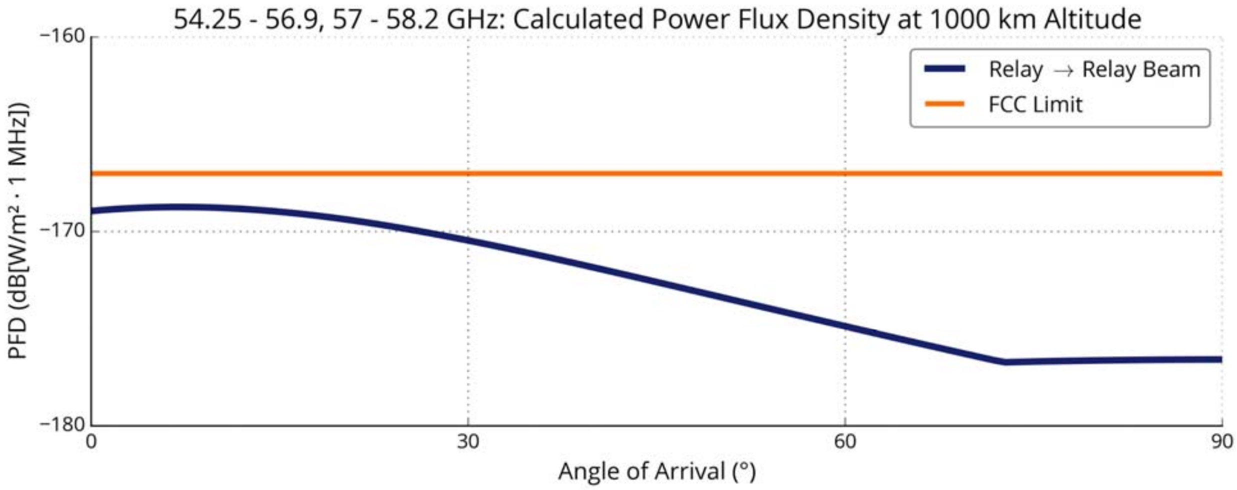

Figure VI-4: Crosslink PFD.

The SNL does not list any current space users of the V-band ISS spectrum, and the Network allows straightforward spectrum sharing and coordination with future users of these bands. The 25° inclination of the Relay orbits means that V-band ISS emissions in the geostationary plane are rare and of short duration, occurring a maximum of three times a day. The narrow beamwidth of these inter-satellite beams (~0.25°) ensures that in-plane emissions and GSO conjunctions are brief and that off-axis events pose a low threat of harmful interference.

Given that there are currently no incumbent space users of these bands, and that Network emissions are all directed away from Earth and predominantly away from the geostationary plane, Audacy is confident that there is no possibility of terrestrial interference and that coordination can be completed with future space operators on a case-by-case basis using the procedure outlined in ITU-R S.1591.

Example interference analyses for both the Advanced and Base services are presented below. The diagram below depicts a worst case scenario in which the Relay is transmitting in the geostationary plane to Base and Advanced users at the limit of their respective service areas (thus resulting in the shortest Relay ↔ GSO distance), as well as crosslinking to the next Relay. There are three GSO operators ($G_{1,2,3}$) directly behind the intended targets of the Relay's emissions, with high-gain antennas precisely pointed at the Relay.

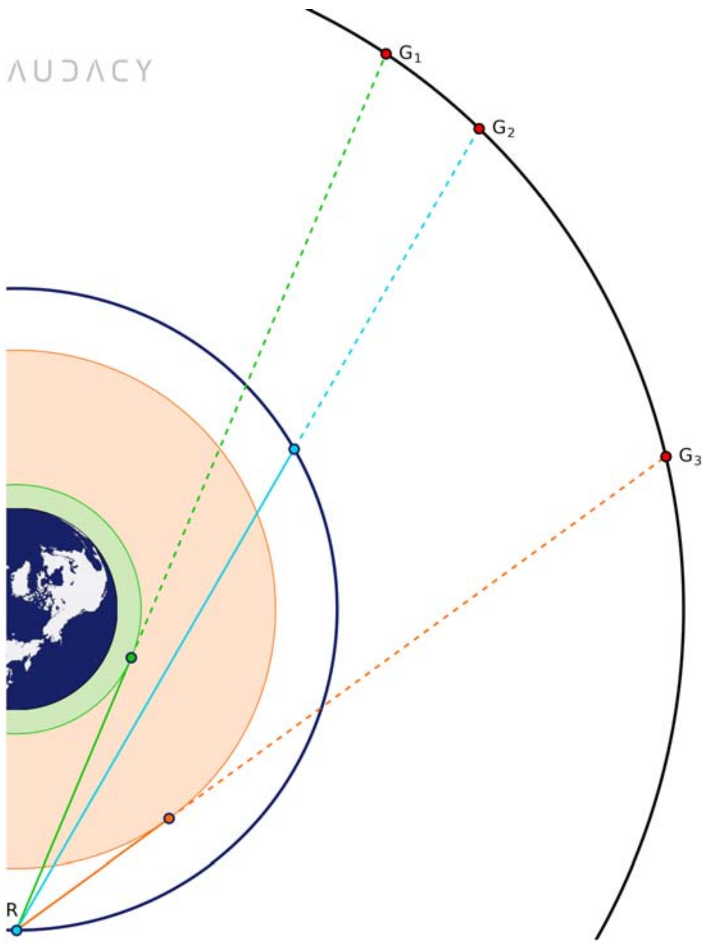

Figure VI-5: Relay → GSO interference diagram.

The resulting interference analysis is shown in the table below:

Parameter	Units	Worst-Case Value		
		Base (G_1)	Crosslink (G_2)	Advanced (G_3)
G_i Noise Figure	dB	7.0 (Estimated)		
G_i Rx Noise Density	dBW/MHz	-143.8 (T_0 = 60 K)		
G_i On-Axis Rx Gain	dBi	50.0 (Estimated)		
Relay PFD at G_i	dBW/m^2/MHz	-143.2	-132.8	-132.8
Power Received at G_i	dBW/MHz	-193.2	-182.8	-182.8
Interference : Noise	dB (%)	-49.3 (0.00)	-39.0 (0.00)	-39.0 (0.00)
Interference Degradation	**dB**	**0.00**	**0.00**	**0.00**

Table 8: Relay → GSO interference analysis.

From this analysis, it is clear that Network operations introduce negligible harmful interference into GSO operations.

Following similar arguments as outlined above, the likelihood of a GSO ISS signal interfering with Network operation is small. Given the lack of current users and small number of planned users combined with the significant GSO ↔ Relay spatial separation highly directional receivers, Audacy again anticipates coordinating with future operators on a case-by-case basis.

2. NGSO Systems

The plots below show that Base and Advanced services are compliant with both the power flux density rules of both the Commission and the ITU at all angles of arrival (*see* the earlier description of the Advanced and Base service areas) and in all frequency bands in which they emit (*see* Schedule S for a complete list of the Network's beams and their emission frequencies).

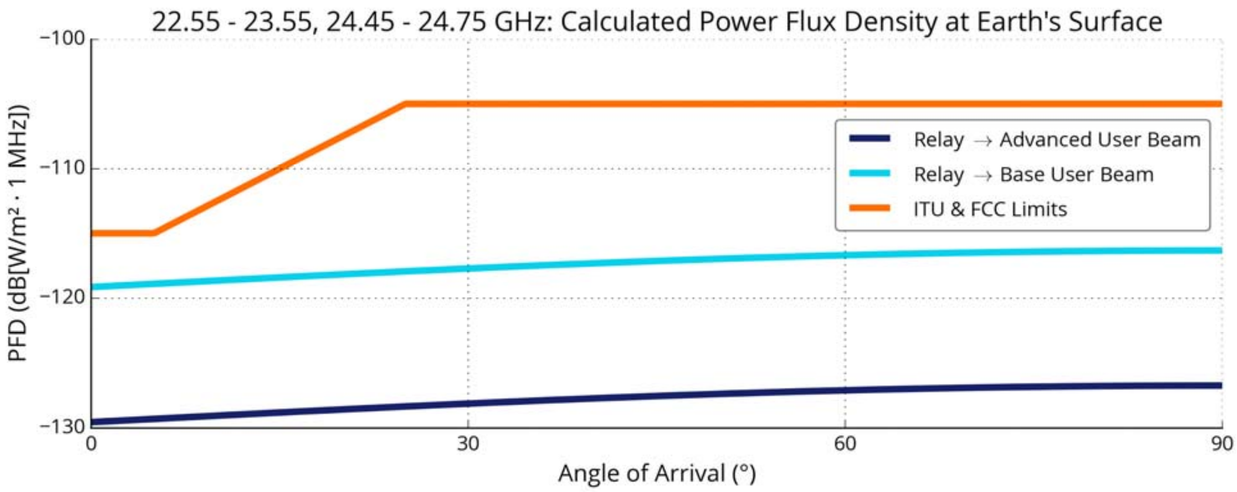

Figure VI-6: User forward PFD.

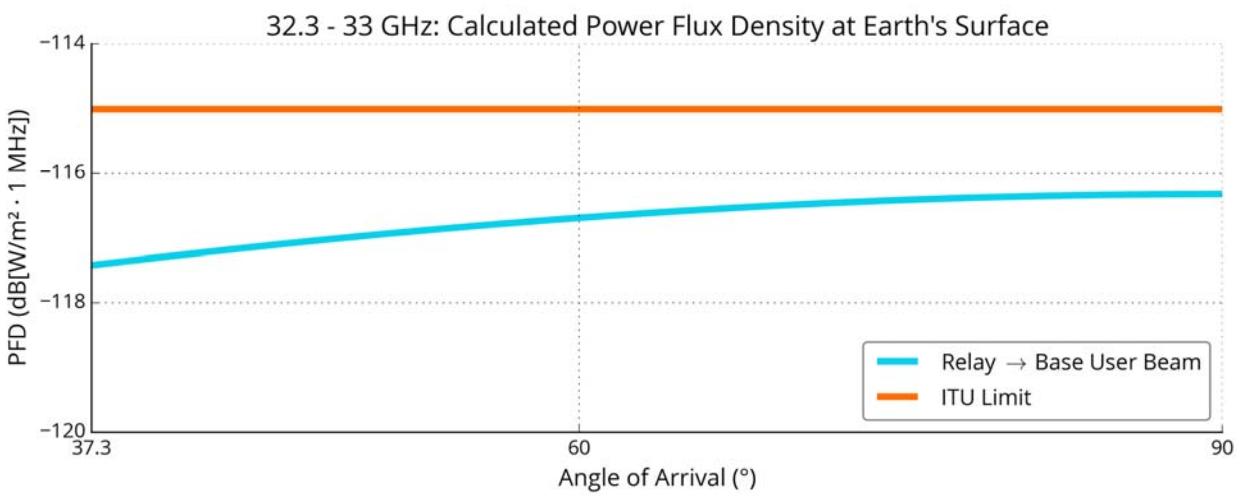

Figure VI-7: User forward PFD.

As a last resort, Audacy has the capability to adapt the power levels or each and every transmit beam to instantly mitigate harmful interference events.

The diagram below shows the scenario of one of the Relay's base user beams interfering with a spacecraft (G_0) in an NGSO constellation in a polar 1,500 km orbit. In the worst case, the affected satellite's high-gain antenna is steered precisely towards the Network Relay, and is tuned to the appropriate ISS frequency. In the typical scenario, the NGSO satellite's antenna is steered towards other LEO satellites along a near-horizontal plane, and is well isolated from the zenith-originating Network emissions.

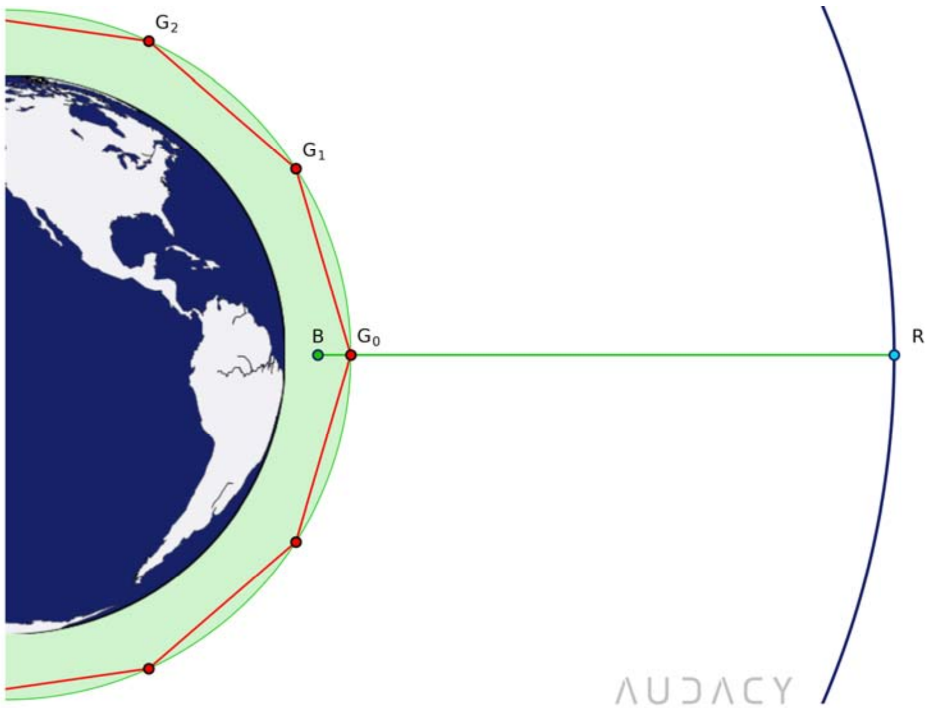

Figure VI-8: Relay → NGSO interference diagram.

Interference analysis for the two scenarios is described below:

Parameter	Units	Worst-Case	Typical
G_0 Rx Noise Figure	dB	4.0 (Estimated)	
G_0 Rx Noise Density	dBW/MHz	-146.8 (T_0 = 60 K)	
G_0 Rx Gain	dBi	35.0 (Estimated)	
G_0 Rx Isolation	dB	0.0	30.0
Relay PFD at G_0	dBW/m^2/MHz	-129.4	
Power Received at G_0	dBW/MHz	-164.4	-194.4
Interference : Noise	dB (%)	-17.6 (0.02)	-47.6 (0.00)
Interference Degradation	**dB**	**0.07**	**0.00**

Table 9: Relay → NGSO interference analysis.

As these analyses show, even in the worst case the Network introduces negligible interference into even the nearest NGSO constellations.

Although there are few current users of the ISS spectrum, Audacy will coordinate with incumbent and planned operators on a case-by-case basis to ensure spectrum sharing and compatibility. The likelihood of interference between the Network and other systems is small, as the vast majority of current and future users operate in LEO with over 10,000 km of spatial separation and up to 90° of angular separation between these systems and the Network.

In all cases of potential harmful interference, the Relay payload can adapt the power level, frequency characteristics, and shape of any beam across the Relay's coverage footprint. This infinite flexibility leads to straightforward coordination with individual operators on a case-by-case basis.

The Advanced service transmit beams are extremely narrow (~1°) and widely steerable, so interference events can be eliminated through spatial separation and adaptive power control.

3. Crosslinks

There are currently no space users of the 65-71 GHz ISS band, and the small number (3) of Audacy's links and narrow beamwidth (<0.5°) mean that coordination with future space operators can occur on a case-by-case basis using the procedures and guidelines outlined in ITU-R S.1591 and ITU-R S.1327.

VII. ENGINEERING CERTIFICATION

The undersigned hereby certifies to the Federal Communications Commission as follows:

I. I am the technically qualified person responsible for the engineering information contained in the foregoing Application for Authority to Launch and Operate a Non-Geostationary Medium Earth Orbit Satellite System in the Fixed- and Inter-Satellite Services;

II. I am familiar with Part 25 of the Commission's Rules; and

III. I have prepared and reviewed the engineering information contained in the foregoing Application for Authority to Launch and Operate a Non-Geostationary Medium Earth Orbit Satellite System in the Fixed- and Inter-Satellite Services, and it is complete and accurate to the best of my knowledge and belief.

Signed: *_/s/ James Spicer_*

James Spicer
Head of Engineering
Audacy Corporation

Dated: November 15, 2016