Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
	)	
THE BOEING COMPANY	)	
	)	
Application for Modification of	)	
Authority to Launch and Operate a	)	File No.
Non-Geostationary Satellite Orbit	)	
System in the Fixed-Satellite Service	)	

MODIFICATION APPLICATION

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November 4, 2021

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MODIFICATION APPLICATION

The Boeing Company ("Boeing"), by its attorneys and pursuant to Section 25.117 of the Commission's rules, hereby requests authority to modify its recently granted license to launch and operate a non-geostationary satellite orbit ("NGSO") fixed-satellite service ("FSS") system operating in the 37.5-42.0 GHz (space-to-Earth) and the 47.2-50.2 and 50.4-51.4 GHz (Earth-to-space) bands (the "V-band"), with inter-satellite links in the 65-71 GHz band.[1] As detailed in the Commission's authorization order, Boeing's Licensed Satellites include 132 low earth orbit ("LEO") satellites operating together with 15 inclined NGSO satellites at an altitude near geostationary orbit ("GSO") to provide high speed broadband communications that are intended to primarily serve direct-to-end user markets.[2]

[1] *See The Boeing Company, Application for Authority to Launch and Operate a Non-Geostationary Satellite Orbit System in the Fixed-Satellite Service*, Order and Authorization, FCC 21-115 (November 3, 2021) ("*Authorization Order*").

[2] *See id.*, ¶¶ 1-3

This modification does not seek to make any changes to Boeing's Licensed Satellites. Instead, Boeing seeks authority to operate two additional groups of satellites operating in the V-band consisting of 119 medium earth orbit ("MEO") satellites operating in 11 planes at an altitude of range of 9,000 to 10,000 kilometers and 5,670 additional LEO satellites operating in 180 planes in three clusters with nominal altitudes of 670, 680, 690, 1040, 1070, and 1085 kilometers (the "Additional Satellites"). Boeing's Additional Satellites will provide substantially greater direct-to-end user capabilities to facilitate the provision of services to major enterprise and governmental user segments.

Although Boeing is seeking authority for its Additional Satellites as a modification to its existing *Authorization Order*, Boeing requests that the Commission distinguish its Licensed Satellites from its Additional Satellites for purposes of their regulatory treatment under Section 25.157(c) of the Commission's rules. Specifically, Boeing's Licensed Satellites were authorized pursuant to the processing round for V-band NGSO FSS systems that was subject to a filing deadline of March 1, 2017 ("2017 Processing Round").[3] In contrast, Boeing's Additional Satellites are being requested pursuant to the processing round for V-band NGSO FSS systems that is subject to a filing deadline of November 4, 2021 ("2021 Processing Round").[4] Boeing requests that the Commission continue to treat Boeing's Licensed Satellites as authorized pursuant to the 2017 Processing Round, while

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[3] *See* Public Notice, *Satellite Policy Branch, Boeing Application Accepted for Filing in Part, 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*, 31 FCC Rcd 11957 (Nov. 1, 2016).

[4] *See* Public Notice, *Satellite Policy Branch Information, Cut-Off Established for Additional NGSO-Like Satellite Systems in the 37.5-40.0 GHz, 40.0-42.0 GHz, 47.2-50.2 GHz and 50.4-51.4 GHz Bands*, DA 21-941 (Aug. 4, 2021).

considering the grant of authority for Boeing's Additional Satellites pursuant to the 2021 Processing Round. The regulatory basis for this dual path approach is addressed below.

Importantly, Boeing seeks the Commission's grant of this modification application only if the Commission consents to this dual path approach. In the unlikely event that the Commission determines that it cannot grant this modification application without concurrently removing Boeing's Licensed Satellites from the 2017 Processing Round, then Boeing may seek to withdraw this modification application in order to retain the status of Boeing's Licensed Satellites in the 2017 Processing Round. As discussed in a subsequent section of this application, however, any such decision would disserve the public interest because it would prevent Boeing from providing additional broadband communications services that are greatly needed by end users in a number of critically important market segments.

I. THE COMMISSION SHOULD CONSIDER BOEING'S ADDITIONAL SATELLITES IN THE 2021 PROCESSING ROUND, WHILE RETAINING BOEING'S LICENSED SATELLITES IN THE 2017 PROCESSING ROUND

The Commission's rules and policies permit the Commission to authorize Boeing to launch and operate its Additional Satellites as a part of the 2021 Processing Round, while leaving undisturbed the authorization that was granted to Boeing in November 03, 2021 to operate its Licensed Satellites as a part of the 2017 Processing Round. There is substantial support within the satellite industry for treating modifications to increase the number of authorized satellites using this dual path approach.

Modifications to NGSO FSS authorizations are governed by Section 25.117(d) of the Commission's rules, which instructs that "[a]pplications for modifications of space station authorizations will be granted" except under two circumstances that are applicable to NGSO FSS systems.[5] First, a modification application will not be granted if the modification would make the applicant unqualified to operate a space station under the Commission's rules.[6] This exception is clearly inapplicable to Boeing's application. Second, a modification application will not be granted if it "would not serve the public interest, convenience, and necessity."[7] As discussed in the next section of this application, the grant of Boeing's modification application would clearly benefit the public interest, convenience and necessity and therefore its approval is warranted.

In considering whether the grant of a modification application for an NGSO FSS authorization would serve the public interest, convenience, and necessity, the International Bureau developed a criteria in its 1999 Teledesic decision[8] that was reaffirmed by the International Bureau in it 2019 decision involving Space Exploration Technologies ("SpaceX").[9] The International Bureau explained in its Teledesic decision that "[i]f the proposed modification does not present any significant interference problems and is

[5] 47 C.F.R. § 25.117(d)(2). Section 25.117(d)(2)(iv) appears to continue to make reference to a third exception involving NGSO FSS systems that was associated with the implementation of Section 25.157(e) of the rules, but Section 25.157(e) was eliminated by the Commission and therefore it would appear appropriate to remove this cross reference.

[6] 47 C.F.R. § 25.117(d)(2)(i).

[7] 47 C.F.R. § 25.117(d)(2)(ii).

[8] *See Teledesic LLC for Minor Modification of License to Construct, Launch and Operate a Non-Geostationary Fixed Satellite Service System*, Order and Authorization, 14 FCC Rcd 2261 (Int. Bur. 1999) ("*Teledesic Order*").

[9] *See Space Exploration Holdings, LLC, Request for Modification of the Authorization for the SpaceX NGSO Satellite System*, Order and Authorization, 34 FCC Red 2526(Int. Bur. 2019) ("*SpaceX Order*").

otherwise consistent with Commission policies, it is generally granted."[10] The International Bureau further explained in its SpaceX decision that

> This focus on the public interest in avoiding radiofrequency interference is consistent with the purpose of the Commission's processing round procedure, which is designed to establish the interference environment in which participants in the processing round could operate their systems. If a modification would worsen the interference environment, that would be a strong indication that grant of the modification would not be in the public interest.[11]

Although the Commission has devoted considerable attention to the question of what types of modifications would worsen the interference environment, the Commission has generally indicated that an increase in the number of satellites will usually have this effect.[12] As the Commission explained, "the number of spatial configurations that have the potential for generating interference" between NGSO systems is considered to be "a fundamental element in assessing whether there would be significant interference problems as a result of granting the proposed modification."[13] In less abstract terms, the Commission has observed that "NGSO licensees can more easily coordinate with an NGSO constellation that has 30 satellites instead of 288."[14]

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[10] *Teledesic Order* at 2264, ¶ 5 (*citing Geostar Positioning Corporation*, 6 FCC Rcd 2276 (Com. Car. Bur. 1991)).

[11] *SpaceX Order*, ¶ 9.

[12] *Contra O3b Limited,* IBFS File Nos. SAT-LOI-20141029-00118 and SAT-AMD-20150115-00004 (Call Sign S2935), Grant Stamp at 3, ¶ 12 (Jan. 22, 2015) (permitting O3b to add four satellites to its constellation because O3b "will employ satellite diversity at low to medium latitudes, which will enable it to share spectrum with other NGSO FSS systems").

[13] *SpaceX Order,* ¶ 11.

[14] *Establishment of Policies and Service Rules for the Non-Geostationary Satellite Orbit, Fixed Satellite Service in the Ka-Band*, Report and Order, 18 FCC Rcd 14708, ¶ 26 (2003).

Unfortunately, this treatment of proposals to add additional satellites to existing NGSO FSS authorizations has created problems for the satellite industry. As the Commission is aware, the design, manufacture and launch of NGSO FSS satellite systems takes considerable time to complete and during the course of that development process, market conditions and end user requirements may change, necessitating modifications in the system design. This is particularly true with respect to broadband Internet services, the minimum speed and capacity expectations for which keep increasing.

For NGSO FSS system operators, the primary means to increase system capacity is to increase the size of the constellation. Therefore, NGSO FSS system operators require a regulatory path to add additional satellites without jeopardizing the regulatory processing round status of their previously authorized satellites. Various participants in the satellite industry have proposed different solutions to this problem. ViaSat proposed a dynamic approach in which it would increase the size of its constellation from 20 to 288 satellites, but would operate the larger system in such a manner that it "does not exceed the interference profile of its pre-modified system with respect to other same-round NGSO FSS systems." [15] ViaSat's proposal is intriguing, but would involve significant complexities in its implementation, such as transparently modeling the interference profile

[15] *See Consolidated Opposition to Petitions and Response to Comments of Viasat, Inc.*, File No. SAT-MPL-20200526-00056 (call sign S2985) at 27 (Sept. 15, 2020).

of its previously authorized 20 satellite system and imposing that model on the actual operations of ViaSat's proposed 288 satellite system.[16]

Three other NGSO FSS system operators, Worldvu,[17] Telesat[18] and O3b,[19] proposed (expressly or implicitly) a much simpler approach, which is to consider proposals for new satellites in a new processing round, while retaining the regulatory status of their previously authorized satellites in a prior processing round. Thus, different satellites covered under the same Commission license would be subject to two different processing rounds depending on the date of their authorization.

The Commission has not acted on any of these proposals. Boeing's however, strongly endorses the consensus proposal of Worldvu, Telesat and O3b to permit new

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[16] *See generally Reply Comments of The Boeing Company*, File No. SAT-MPL-20200526-00056 (call sign S2985) (Sept. 25, 2020) (detailing the complexities in ViaSat's proposed approach).

[17] See *WorldVu Satellites Limited, Modification to OneWeb U.S. Market Access Grant for the OneWeb Ku- and Ka-Band System, Application for Modification*, IBFS File No. SAT-MPL-20200526-00062 (Call Sign S2963) (May 26, 2020) (proposing to reduce its Phase 1 satellites from 720 to 716 spacecraft while retaining their status in the first Ku-/Ka-band NGSO FSS processing round and adding 47,128 Phase 2 satellites that it proposed to be considered in the second Ku-/Ka-band NGSO FSS processing round).

[18] *See Telesat Canada, Application to Modify Petition for Declaratory Ruling to Grant Access to the U.S. Market for Telesat's NGSO Constellation, Application for Modification of Market Access Authorization*, IBFS File No. SAT-MPL-20200526-00053 (Call Sign 2976) (May 26, 2020) (proposing to increase its Phase 1 constellation from 298 satellites to 1671 satellites while retaining its regulatory status in the first processing round for Ku-/Ka-band NGSO FSS systems and adding 1373 more satellites as a part of the second Ku-/Ka-band NGSO FSS processing round).

[19] *See O3b Limited, Application to Modify U.S. Market Access Grant for the O3b Ka-band Satellite Systems*, IBFS File No. SAT-MOD-2020526-00058 (Call Sign S2935) (May 26, 2020) (proposing to add an additional 70 satellites to its NGSO FSS constellation as a part of the second Ku-/Ka-band processing round apparently without disturbing the first round status of its previously authorized satellite system).

satellites to be added as a part of a subsequent processing round without disturbing the regulatory status of satellites authorized pursuant to a previous processing round. This approach would provide an objective and easily managed solution to a problem that must be resolved to permit the satellite industry to continue to respond to market demands for continually escalating broadband capacity that is available to end users in all locations of the world, regardless how remote. Further, it would uphold the underlying purpose of the Commission's processing round rules, which is to ensure that the participants in each processing round are provided with a reasonable expectation of the interference environment that will exist for the satellite systems that they design, launch and operate.

Boeing therefore requests that its proposed Additional Satellites be considered as a part of the 2021 Processing Round for V-band NGSO FSS systems without disturbing the regulatory status of its Licensed Satellites as a part of the 2017 Processing Round. As discussed in the next section of this Application, such an approach would greatly serve the public interest. In the event the Commission concludes that it cannot employ this dual path approach, Boeing may seek to withdraw this modification application so as not to alter the regulatory status of its Licensed Satellites.

II. SUBSTANTIAL PUBLIC INTEREST BENEFITS WOULD RESULT FROM THE GRANT OF BOEING'S REQUEST TO ADD ADDITIONAL SATELLITES TO ITS V-BAND NGSO FSS AUTHORIZATION

The Commission has recognized that large constellations of NGSO FSS satellites can be used to help bridge the digital divide by making high data-rate broadband services available to end users regardless of where they are located. As the Commission has explained, "[t]he Commission values the public interest benefits that could flow from NGSOs offering an affordable solution for delivering high-speed Internet services to communities that might be more expensive to serve through other technologies."[20] Unlike terrestrial technologies, which require the construction of infrastructure in each location that they serve, "the long reach of satellite technology, with the particular advantages of lower-latency associated with NGSO FSS systems, provide inherent incentives for future NGSO FSS systems to likewise provide coverage across the United States, especially the underserved areas.[21] Further, broadband satellite systems provide the only effective solution to deliver high speed internet access to end users in mobile locations, such as on ships and aircraft, and to monitor and control the operations of autonomous vehicles, such as long range drones and unmanned maritime systems.

Multiple NGSO FSS systems are already being launched to address these important market needs. Their ability to adequately serve the broadband requirements of end users, however, is subject to two severe constraints, spectrum availability and constellation size. With respect to the first issue, spectrum is an exceedingly scarce resource and its availability for broadband satellite systems is threatened by adopted and proposed reallocations of frequency bands that are already intensively used by the satellite industry.

On the second issue, NGSO FSS systems operators have continued to propose the launch of increasingly large satellite constellations, with recent proposals involving nearly

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[20] *Expanding Flexible Use of the 12.2-12.7 GHz Band*, Notice of Proposed Rulemaking, 36 FCC Rcd 606, 629, ¶ 58 (2021).

[21] *Update to Parts 2 and 25 Concerning Non-Geostationary, Fixed-Satellite Service Systems and Related Matters*, Second Report and Order, 35 FCC Rcd 10168, 10170, ¶ 7 (2020) (*footnote omitted*).

30,000[22] and nearly 50,000 satellites.[23] The Commission has recognized that the significant benefits of NGSO FSS systems with respect to the ubiquitous services that they can provide must be balanced against the risks to the orbital environment, explaining that although the Commission "seek[s] to facilitate the development of this new landscape through our role in satellite authorization, the Commission also has a responsibility to ensure that the operations it authorizes are conducted safely and consistent with the public interest."[24]

One potential solution to both of these problems is the use of higher frequency bands, such as the V-band, for the provision of broadband satellite communications services. The existing V-band allocation in the United States that is available for NGSO FSS satellite systems includes two gigahertz of paired spectrum identified for end user links and additional spectrum that is available on a restricted basis for gateway earth station links. Each megahertz of V-band spectrum can transmit more data at faster speeds than lower frequency bands. Therefore, the use of V-band spectrum for future broadband satellite systems will greatly serve the public interest by enabling the use of larger frequency segments and potentially fewer satellites to provide very high data rate capabilities to end users.

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[22] *See Space Exploration Holdings, LLC, Amendment to Pending Application for the SpaceX Gen2 NGSO Satellite System, Amendment*, IBFS File No. SAT-AMD-20210818-00105 (Call Sign S3069) (Aug. 18, 2021).

[23] See *WorldVu Satellites Limited, Modification to OneWeb U.S. Market Access Grant for the OneWeb Ku- and Ka-Band System, Application for Modification*, IBFS File No. SAT-MPL-20200526-00062 (Call Sign S2963) (May 26, 2020) (proposing a total constellation size of 47,844 satellites).

[24] *Mitigation of Orbital Debris in the New Space Age*, Notice of Proposed Rulemaking and Order on Reconsideration, FCC Rcd 11352, ¶ 2 (2018).

Boeing's request for authority to launch its Additional Satellites will optimize the inherent advantages of V-band frequencies to make high speed broadband services available to a range of important market segments, including supporting the needs of business, industry, health care and education in remote locations; the communications, navigation and situational awareness needs of the aviation and maritime market segments; and the requirements of federal users with remote deployment obligations, particularly in support of science, research and our national defense. The Commission should recognize the tremendous public interest benefits that can be achieved through the launch and operation of Boeing's Additional Satellites using the V-band and promptly grant Boeing's Application.

III. NARRATIVE INFORMATION REQUIRED BY PART 25

The following narrative information is required by Part 25 of the Commission's rules for applications to modify authorizations for NGSO FSS satellite systems that are not addressed either by Form 312 or Schedule S.

§ 25.111 ITU Publication Information

Boeing will submit to the Commission the materials necessary for filing with the International Telecommunication Union ("ITU") to support the Additional Satellites pursuant to Section 25.111(b). In relation to this submission, Boeing has included with this Application an executed declaration that it unconditionally accepts all consequential ITU cost-recovery responsibility for the ITU filings as required by Section 25.111(d).

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

A. System Facilities, Operations, and Services

The Additional Satellites are primarily comprised of an NGSO space segment, ground segment, and a user equipment segment. This Application is seeking authorization for launch and operation of Boeing's Additional Satellites, which constitutes the NGSO space segment.

The Additional Satellites in the NGSO space segment will consist of 5,670 LEO satellites and 119 MEO satellites, not including spares. The satellites will operate at eight distinct altitudes and inclinations providing global coverage with a primary satellite coverage area defined by a 35° elevation footprint. The LEO satellites will be technically identical to each other. Similarly, the MEO satellites will be technically identical to each other. Both types of satellites will have advanced beamforming antennas to provide shapeable and steerable V-band beams for user and gateway feeder communications links.

The LEO constellation will be made up of six complementary orbital shells. The shells will be grouped in two altitude ranges with three shells in the range of 670 km-690 km and three shells in the range of 1,040 km-1,085 km altitude. The lower altitude shells will be comprised of 3,564 satellites at three different inclination values. The higher altitude shells will be comprised of 2,106 satellites at three different inclination values. A summary of the LEO satellite constellation is shown in Table 1 below.

Table 1 LEO Satellite Constellation Values

Shell	Altitude	Inclination	Satellites	Planes	Satellites per Plane
1	670 km	82.9°	600	20	30
2	680 km	54.9°	1400	40	35
3	690 km	37.9°	1564	46	34
4	1,040 km	37.2°	840	28	30
5	1,070 km	48.8°	980	35	28
6	1,085 km	79.6°	286	11	26

Wider area coverage will be provided by 119 satellites operating in the range of MEO altitude in two distinct constellations. One constellation will be comprised of 39 satellites in an equatorial orbit. Another constellation will consist of 80 satellites operating at an inclination of 41.2°. A summary of the MEO satellite constellation is shown in Table 2 below.

Table 2 MEO Satellite Constellation Values

Shell	Altitude	Inclination	Satellites	Planes	Satellites per Plane
7	9000 km	0°	39	1	39
8	10,000 km	41.2°	80	10	8

For more than two decades, Boeing (including the former Hughes Space and Communications Company) has developed and implemented proprietary and patented constellations incorporating NGSO orbits. By design, Boeing's Additional Satellites will enable efficient spectrum reuse and avoid interference to GSO satellites. A detailed description of the satellite constellation parameters is included in the "Non-geostationary Satellite Orbital Information" section of the Schedule S for this Application.

Each NGSO satellite will employ advanced antennas to generate and dynamically shape and steer the beams over the coverage area to connect users and the gateways. Figure 1 and Figure 2 show the 1,040 km LEO satellite coverage at 35° elevation angle and a beam laydown example, respectively. Figure 3 and Figure 4 show the 10,000 km MEO satellite coverage at 35° elevation angle and a beam laydown example, respectively. The spot beams can be configured as either user or gateway beams on-orbit. Because the V-band gateway and user beams on both types of NGSO satellites are steerable and shapeable, coverage can be provided out to a 5° elevation angle footprint. The Command and Telemetry coverage area extends to the visible earth edge for both LEO and MEO spacecraft. Global coverage can be provided. The complete set of antenna patterns is included in Schedule S.

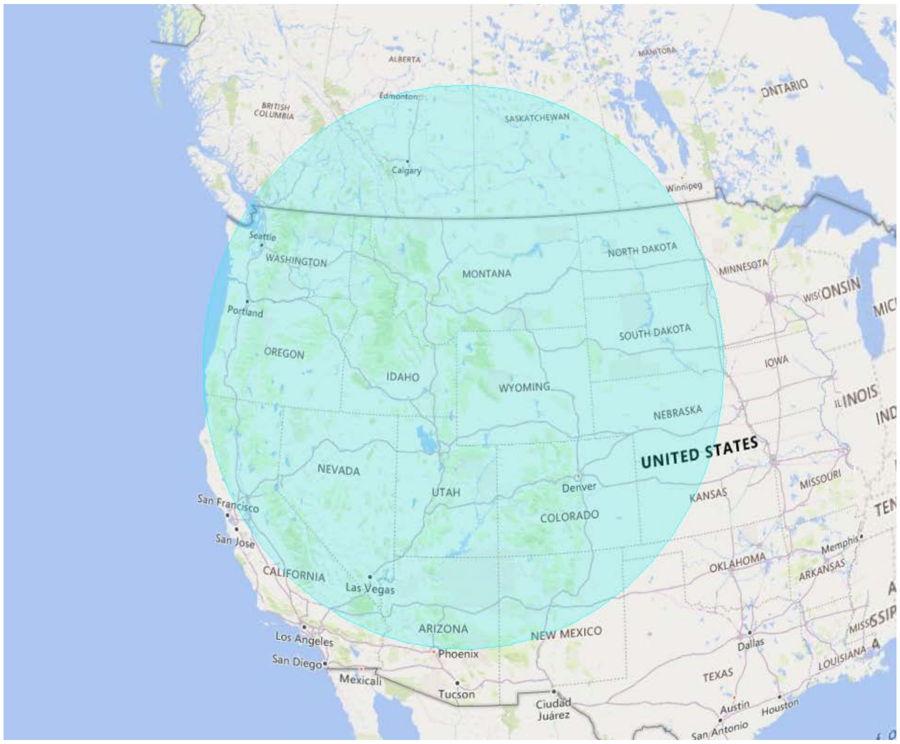

Figure 1 Example 1040 km LEO FOV

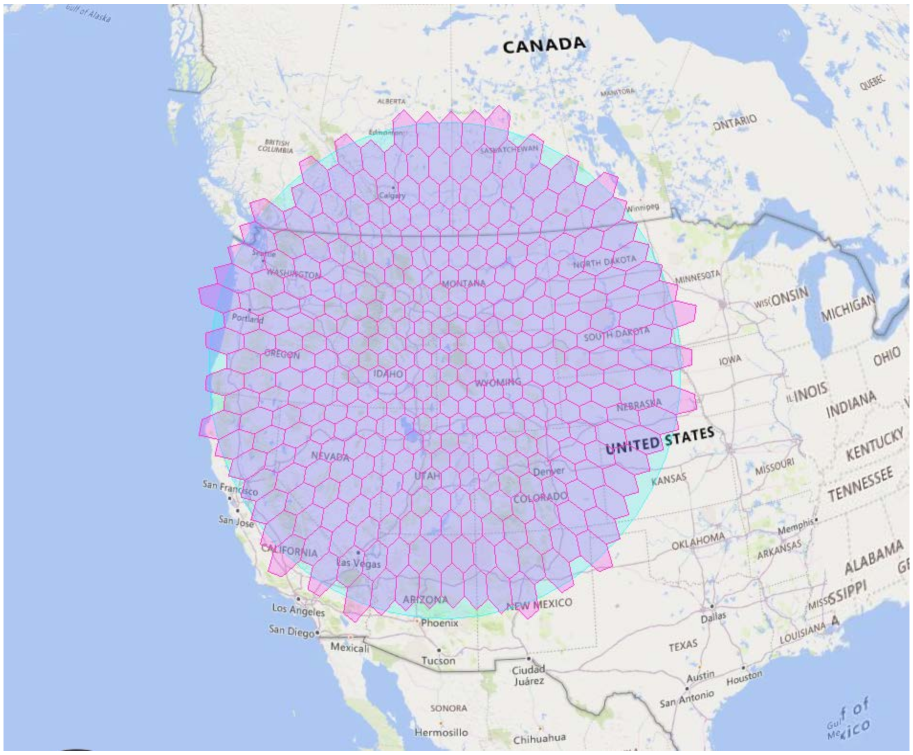

Figure 2 Example 1040 km LEO Beams

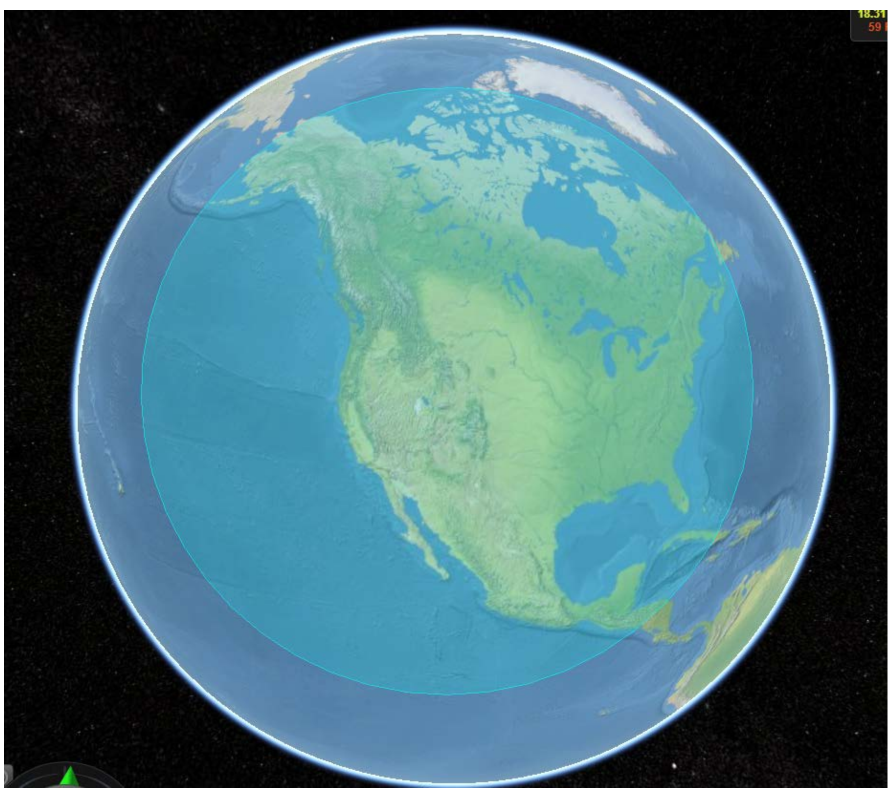

Figure 3 Example 10,000 km Altitude MEO FOV

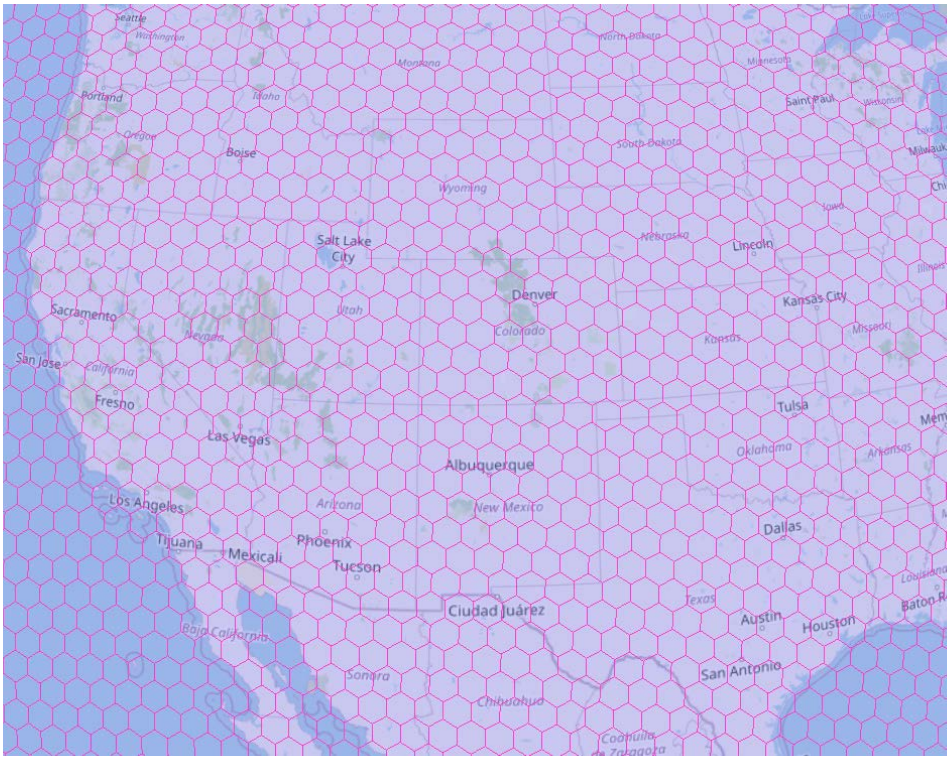

Figure 4 Example 10,000 km Altitude MEO Beams

The ground segment portion for the Additional Satellites is comprised of the TT&C earth stations, Satellite Operations Centers ("SOC"), and gateways. The TT&C earth stations provide V-band command uplinks to control and telemetry downlinks to monitor the satellites. The SOC controls the Additional Satellites, configures the satellites, manages collision avoidance and manages interference mitigation. The SOC coordinates and dynamically provides the resource management of the satellites, earth stations, SOC, and gateways. The gateways provide bidirectional V-band feeder link communications to the satellites within their field of view.

The user equipment will provide a range of capability for different types of users. The V-band bidirectional user equipment will support high speed data links to and from the Additional Satellites. These terminals will have the capability to track the satellites and accommodate handovers within the coverage area.

B. System Frequency Usage and Frequency Plan

The uplink and downlink frequency plans for the Additional Satellites are shown in the figures below, and in the "Operating Frequency Bands" section of Schedule S. The user and gateway channels, and the T&C links will use dual circular polarization. The channels are flexible and subchannel bandwidths can be adjusted on-orbit.

1. Uplink Frequency Plan—Communication Channels

User uplink data communication channels will use the frequency band from 48.2-50.2 GHz. Gateway uplink data communications channels will range from 47.2-50.2 and 50.4-51.4 GHz, as depicted in the figure below.

Figure 5. Uplink Communications Frequency Plan

2. Uplink Command Channels

The uplink spacecraft command channels will be located within the 51.15–51.4 GHz segment, as shown in Figure 6. The spectrum sharing between command and communications in this band will be managed by the SOC.

Figure 6. Uplink Command Frequency Plan

3. Downlink Frequency Plan—Communication Channels

The gateway downlink data communication channels will use the frequency band from 37.5-42.0 GHz in the United States, as depicted in the figure below. The user links will operate on a downlink basis using the 40.0-42.0 GHz band in the United States.

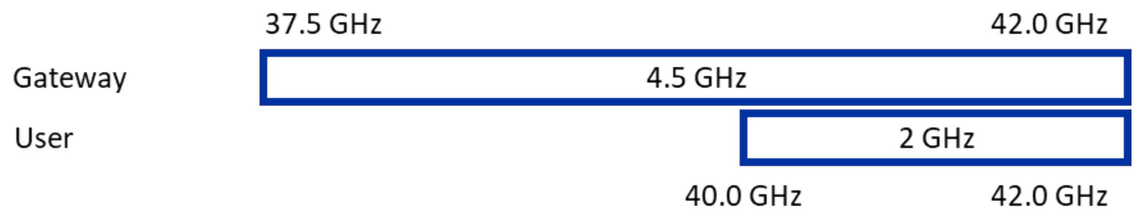

Figure 7. Downlink Communications Frequency Plan

4. Downlink Telemetry Channel

The downlink spacecraft telemetry channels will be located within the 41.75-42.0 GHz segment, as depicted in Figure 8. The spectrum management between telemetry and communications in this band will be performed by the SOC.

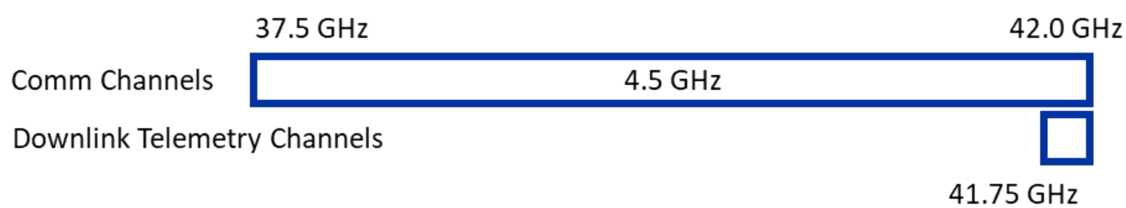

Figure 8. Downlink Telemetry Frequency Plan

5. Uplink to Downlink Communication Channels and Frequency Band Connectivity

Each satellite will have uplink and downlink beams that will be capable of operating over the entire communications frequency band as defined above. The uplink beam signals will be channelized and the designated subchannels will be combined and routed to the appropriate downlink beam. In general, each communications channel can be routed to and from any communications beam. The satellite payloads will use advanced beamforming antennas and digital technology. This flexibility allows the system capacity to be optimized as the satellites move over different coverage areas and adjusted over the mission life.

6. Inter-Satellite Links

In addition to communications between the satellites and the Earth, the LEO satellites will be capable of ISL communications between Boeing's authorized satellites. The satellites will operate bi-directional ISLs in the 65-71 GHz band, which is allocated on a primary basis for NGSO ISL transmissions. This capability will increase the efficiency and functionality of the system while providing much greater flexibility in the geographic location of gateway earth stations used to support the constellation. Boeing's ISL capability will enable high-speed connectivity for satellites in the constellation that may not be in view of a system gateway. Thus, the ISL capabilities expand the ability of the constellation to provide data directly to user processing centers from remote points across the globe. The operating characteristics of the ISL beams are included in Schedule S.

Boeing's ISL operations will be able to share the 65-71 GHz band with other satellite systems using these frequencies for ISL transmissions. Therefore, Boeing's request to use the 65-71 GHz band for ISL operations involving its Additional Satellites does not require the initiation of an NGSO-like application processing round for this spectrum.[25]

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[25] *See Authorization Order*, ¶ 21 (reaching this same conclusion for Boeing's Licensed Satellites).

§ 25.114(d)(6) Public Interest Considerations

Public interest considerations supporting the grant of this Application are set forth in Part II of this Application.

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

Boeing will ensure safe operations and mitigate orbital debris via a combination of constellation design, satellite design techniques, on-orbit monitoring, and on-orbit active control. Boeing has assessed and limited the probability that its satellites will become a source of debris by collision with small debris or meteoroids that would cause loss of control and prevent post-mission disposal. The standard satellite designs are consistent with the United States Government ("USG") Orbital Debris Mitigation Standard Practices ("ODMSP"), initially established in 2001, and most recently updated in November 2019. The Additional Satellites will employ the following design and operational strategies to mitigate orbital debris.

§ 25.114(d)(14)(i) Minimizing Debris Generated by Collisions with Small Objects

Boeing's standard design practices limit the probability that its satellites could become a source of debris by collision with micrometeoroids or small debris (objects smaller than 1 cm) that would cause loss of control and prevent post-mission disposal. Boeing's analysis indicates that the probability that any individual satellite will become a source of debris by collision with small debris or meteoroids that would cause loss of control and prevent disposal will be less than 0.01 (1 in 100).

During on-station operations, Boeing will have no activities or events (such as deployments or use of release devices) that would generate debris larger than 5 mm in any dimension. Boeing uses non-explosive release mechanisms where possible and ensures that any explosive release devices are fully captured, and that no hardware is jettisoned. All exterior surfaces are designed to avoid production of debris due to space exposure.

Boeing's designs also limit the probability of the satellite itself becoming a source of debris by collisions with micrometeoroids and small debris (objects smaller than 1 cm) that could cause loss of control and prevent post-mission disposal. The spacecraft designs use exterior panels which prevent intrusion into the interior cavity of any objects large enough to cause damage to spacecraft electronics or propulsion system hardware.

Additionally, Boeing's contracts with providers of launch vehicles include clauses requiring them to take similar actions to limit the probability of debris, by minimizing any hardware (such as spacing rings or jettison springs) that may by jettisoned.

§ 25.114(d)(14)(ii) Minimizing Debris Generated by Accidental Explosions

Boeing's standard design practice and analysis limit the probability of accidental explosion to less than 0.001 (1 in 1,000) during deployment and full mission operations. Boeing pays special attention to energy sources on board the spacecraft which could potentially fragment and create debris that fragments the spacecraft. These onboard energy sources are as follows: pressurized fuel tank(s), fuel lines, reaction wheels, batteries, constant conductance heat pipes. The pressurized tanks are designed and operated with industry standard safety margins to avoid accidental explosions. The fuel line thruster valves will be left in a closed position (they are power-driven and therefore cannot be left open once the power is depleted). The post-mission disposal maneuver is intended to deplete all fuel remaining in the vehicle fuel tanks and leave the fuel lines unpressurized. The reaction wheels (spin rate) and batteries (state of charge) are operated well within their safe operating limits, again using industry standard safety margins. The heat pipe system uses low pressure ammonia, with very limited energy, and are similar in design to those with more than twenty years of flight heritage with no incidents of explosion.

§ 25.114(d)(14)(iii) Minimizing Debris From Collisions with Large Objects

Along with the standard design practices discussed in 25.114(d)(14)(i), Boeing uses a combination of constellation design, analysis, and on-orbit control to limit the probability that our satellites could become a source of debris by collision with micrometeroids or large objects (10 cm and larger). Boeing's analysis indicates that the probability that any individual satellite will become a source of debris by collision with large objects will be less than 0.001 (1 in 1000).

The Additional Satellites include satellites in both LEO and MEO orbits, as detailed in Tables 1 and 2. The LEO portion is split into a lower and higher altitude range.

Boeing's collision avoidance strategy identified and assessed planned or operational satellite systems located in the vicinity of, the proposed orbital location of Boeing's Additional Satellites and whether they present an operational risk. This led to a single fundamental collision avoidance design approach, with small differences for each orbit regime.

The launch vehicle providers will plan their trajectories in a manner that avoids all existing satellites or systems already in orbit. This will be done using readily available data on in-orbit spacecraft, as well as data from USSPACECOM's Combined Space Operations Center ("CSpOC").

For the lower LEO orbit, the satellites will separate from the launch vehicle at a nominal orbit altitude of 680 km. With standard launch vehicle injection accuracy of ±10 km, this ensures Boeing's satellites will stay in the range of 670-690 km specified for this portion of its constellation. After separation, Boeing will perform the necessary maneuvers to position the satellites at the correct altitude, inclination, and right ascension specified for each plane. The final orbital configuration provides large in-track spacing between vehicles, with over 1000 km nominal separation at closest approach.

For both the higher LEO and MEO orbits, Boeing will target separation at the nominal orbit altitude specified. In these less crowded orbit regions, Boeing can ensure that the satellites stay away from the closest large constellations. Boeing will use CSpOC data to ensure that we are able to avoid avoids all existing satellites or systems already in orbit.

Upon final placement into operational orbit, the effects of Earth oblateness, residual orbit eccentricity, and other orbital effects will cause both short-term and long-term variations in altitude, inclination, and right ascension. Variations in altitude will require ongoing active control.

The lower LEO shells have 10 km nominal spacing between them, and 15 km to the nearest nearby large constellation. The maximum allowable variation from nominal over any orbit is thus ±5 km under worst-cased conditions. Boeing's active control systems will target control to less than that value, to maintain lower LEO altitude within ±5 km of the nominal specified values. Boeing's designs have redundant autonomous systems on-board for orbit determination and thruster control, making the overall system highly reliable.

The higher LEO shells have 15 km nominal spacing between them, and 25 km to the nearest nearby large constellation. The maximum allowable variation from nominal over any orbit is thus $\pm$7.5 km under worst-cased conditions. In this case, Boeing's active control systems will again target control to less than that value, to maintain lower LEO altitude within $\pm$7.5 km of the nominal specified values.

The MEO shells do not have nearby large constellation. In this case, Boeing's active control systems will target control to within $\pm$20 km of nominal specified values.

Natural variations in inclination and right ascension are small for all planes ($\pm$0.5°), and so do not need ongoing active control. However, should control be necessary, it can be performed autonomously in conjunction with the altitude control maneuvers.

Boeing has an existing agreement with the CSpOC that provides orbital alerts for any satellites that Boeing is controlling and flying. Boeing will extend this agreement to Boeing's Additional Satellites. With this agreement, CSpOC provides notifications of any potential upcoming collisions or close passes, either with our own satellites, or with satellites owned/operated by others. Boeing will then take the necessary actions as required to maneuver satellites to avoid collisions.

This same approach, using CSpOC notification, will be used to avoid collisions with large non-satellite objects.

Boeing hereby certifies that, upon receipt of such a space situational awareness conjunction warning, Boeing will review and take all possible steps to assess the collision risk, and will mitigate the collision risk if necessary, including, as appropriate, contacting the operator of any active spacecraft involved in such a warning; sharing ephemeris data and other appropriate operational information with any such operator; and/or modifying space station attitude and/or operations.

§ 25.114(d)(14)(iv) Post-Mission Disposal of Space Structures

Boeing will actively decommission and maneuver satellites to a final disposal orbit within one year of the end of the active mission lifetime.

The LEO planes' systems will lower each satellite to a 300 km circular orbit. This is well below the planned operational orbit of any other constellation, with the nearest system being the SpaceX satellites at a nominal altitude of 340 km. During the maneuver and orbit change, Boeing will coordinate with CSpOC to ensure safe passage. After the final orbit is achieved, de-energization of on-board systems will be performed, including depletion of all remaining propellant onboard each satellite. From this final orbit, the satellite will undergo passive reentry from atmospheric drag. Boeing's satellites are designed to employ demisable materials that limit the survivability of these materials upon reentry thereby minimizing the risk of human casualties to below 0.0001 (1 in 10,000). With conservative projections for solar flare activity, Boeing's analysis indicates that reentry and demise will occur within one year, well within the 25-year duration specified in the ODMSP.

For the MEO satellites, each satellite will be maneuvered to an orbit 100 km below or 100 km above the operational orbit. The same de-energization process will be followed as described above. With the sparse density of space systems near this orbit range, Boeing's analysis indicates the final orbit will be stable for over 100 years, as specified by the ODMSP.

§ 25.117(d)(2) Modification of Station License

As discussed in Section II of this Application, declining to grant the proposed modification request would disserve the public interest, convenience, and necessity.

§ 25.124 Unified Space Station and Earth Station Authorization

For the absence of doubt, Boeing is not requesting at this time the grant of a unified authorization for both its Additional Satellites and the associated blanket-licensed earth stations. If Boeing subsequently seeks authority for a unified authorization, Boeing will file an amendment to this modification application to address that request.

§ 25.157(h) Bandwidth Specific Service Rules

Boeing recognizes that the Commission has yet to adopt service rules for NGSO FSS systems operating in the V-band. Boeing therefore herein affirms the compliance of its Additional Satellites with the Commission's default service rules indicated in § 25.217.

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

Section 25.202(j) of the Commission's rules indicates that out-of-band emissions into the 50.2-50.4 GHz band under the clear-sky conditions shall not exceed -20 dBW/200 MHz (measured at the input of the antenna), except that the maximum unwanted emission power may be increased to -10 dBW/200 MHz for earth stations having an antenna gain greater than or equal to 57 dBi. This requirement is also reflected in footnote US156 of Section 2.106 of the Commission's rules.

The 2019 World Radiocommunication Conference (WRC-19) tightened certain of the limits on unwanted emission power into the 50.2-50.4 GHz band to provide additional protection to the earth exploration-satellite service (passive). The new limits are reflected in Resolution 750 (Rev. WRC-19) and Boeing agrees to comply with these limits subject to future rulemaking action by the Commission with respect whether these new limits will be incorporated into the Commission's rules for NGSO FSS satellite systems.

§ 25.204(e) Uplink Adaptive Power Control

In compliance with Section 25.204(e), earth station transmissions under conditions of uplink fading will use power control methods to not exceed 1 dB above the actual uplink excess attenuation over clear-sky conditions in order to meet the desired link performance while minimizing interference between networks.

§ 25.208 Power Flux-Density Limits

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 and energy dispersal bandwidths, if any, needed for compliance with Section 25.208. The Additional Satellites when considered in the aggregate with the Licensed Satellites will comply with the PFD limits specified in Sections 25.208(r), 25.208(s), and 25.208(t) of the Commission's rules for NGSO FSS satellite systems operating in the 37.5-40.0, 40.0-40.5 and the 40.5-42.0 GHz bands, respectively.

Pursuant to the Note to Paragraph (r) of Section 25.208(r),[26] a possibility exists that NGSO satellites may be permitted to exceed the PFD limits for normal free space propagation identified in Section 25.208(r)(1) to compensate for the effects of rain fading based on future technical studies and further Commission rulemaking proceedings

[26] 47 C.F.R. Section 25.208(r), Note to Paragraph (r).

addressing the results of these studies. The Commission concluded in its *Spectrum Frontiers* proceeding, however, that the technical studies completed by Boeing and other satellite industry participants to date "have not yet met the burden of proving that they can strengthen their satellite signals during rain storms without interfering with terrestrial systems in the 37.5-40 GHz band" and therefore "the record does not establish conditions under which FSS could operate at a higher PFD consistent with terrestrial use of the band."[27] Given these conclusions, Boeing's Additional Satellites will comply with the PFD limits specified in Sections 25.208(r), 25.208(s), and 25.208(t) of the rules without any adjustment for rain fade unless further action by the Commission permits such adjustments by satellite operators to facilitate spectrum sharing in the 37.5-40.0 GHz band.

Although Boeing's V-band NGSO FSS system will comply with the PFD limits indicated in Sections 25.208(r), 25.208(s), and 25.208(t), the information that is included in the "Transmitting Beams" section of the Schedule S for this Application reflects the PFD levels specified in Sections 25.208(s) and 25.208(t) that are applicable to NGSO FSS systems operating in the 40.0-42.0 GHz band and not the tighter limit that is specified in Section 25.208(r) for the 37.5-40.0 GHz band. Despite this, Boeing will operate its NGSO FSS systems in full compliance with the PFD limits indicated in Section 25.208(r) within the 37.5-42.0 GHz frequency range.

[27] Use of Spectrum Bands Above 24 GHz for Mobile Radio Services et. al., Second Report and Order, Second Further Notice of Proposed Rulemaking, *Order on Reconsideration, and Memorandum Opinion and Order*, 32 FCC Rcd 10988, 11058-11060 (2017).

§ 25.289 Protection of GSO Networks by NGSO Systems

Boeing's Additional Satellites, when considered in the aggregate with its Licensed Satellites, will operate in compliance with Article 22, Sections 22.5L and 22.5M of the ITU Radio Regulations with respect to the protection of GSO networks operating in the V-band. As the Commission has concluded, these limits adequately address the protection of GSO systems by NGSO FSS satellites operating in the V-band.

IV. REQUESTED WAIVER

Pursuant to Section 25.112(b)(1) of the Commission's rules, Boeing requests a partial waiver of Section 25.114(c), which requires submission of certain technical information using Schedule S. The Commission's rules permit the FCC to grant waivers of its rules on a showing of "good cause."[28] The Commission's authority to grant waivers is firmly rooted. The U.S. Supreme Court has indicated that the FCC not only has the legal right, but also the obligation to consider and grant waivers of its rules.[29] The Court has indicated that the Commission's responsibility to consider waivers stems from its statutory obligation to serve the "public interest, convenience, or necessity."[30] Pursuant to this obligation, the Commission maintains Section 1.3 of its rules, which indicates that the FCC will waive its rules "if good cause therefor is shown."

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[28] 47 C.F.R. § 1.3 (1999).

[29] National Broadcasting Co. v. U.S., 319 U.S. 190 (1943) (upholding the Commission's "chain broadcasting regulations," which prohibit exclusive arrangements between networks and radio stations, in part because the Commission may still grant waivers of the rules); *see also* United States v. Storer Broadcasting Co., 351 U.S. 192, 205 (1956) (concluding that the Commission must grant a hearing to consider a justified request for waiver of its multiple ownership rules).

[30] *National Broadcasting Co.*, 319 U.S. at 225.

In this case, good cause exists for the grant of a limited waiver of Section 25.114(c) with respect to the submission of certain technical information using Schedule S. First, it is impracticable to submit complete orbital parameter data for Boeing's Additional Satellites using the Schedule S web-based entry form due to the complex architecture of the full constellation. Accordingly, Boeing provides a representative set of data at each orbital altitude in the electronic version of Schedule S and is submitting to the Commission the complete orbital information in a separate file, including orbital parameters, for inclusion in the record of this application.

Second, Schedule S web-based entry form requests for in-orbit spares to be identified in a separate orbital plane. However, because Boeing's in-orbit spares are in the same orbital plane as its active satellites, it is not possible to represent the actual deployment of Boeing's full constellation. Moreover, Schedule S field S4(o) does not permit "Other or Spare" to be notated in this instance. The "Other" in Tables A.2-1 and A.2-2 is to provide an explanation of the status of the in orbit spares as indicated in Schedule S and Tables A.2-1 and A.2-2. To the extent that a waiver of Schedule S S.4(o) is necessary to show in-orbit spare information in the manner Boeing has provided it, a waiver is hereby requested.

Third, Section 25.114(c)(4)(v) requires both the minimum and maximum saturation flux density ("SFD") values for each space station receive antenna that is connected to transponders. The concept of SFD only applies to "bent pipe" satellite systems, and thus is not relevant to the Boeing's Additional Satellites. However, the Schedule S software does not allow an entry of "not applicable." Instead, it requires a numerical entry for SFD, which must be different for the maximum and minimum values.

In order to accommodate this requirement, Boeing has entered values of "0" and "-0.1" in Schedule S with respect to these parameters.

Fourth, in the "Transmitting Beams" section of the Schedule S for this Application, Boeing found it necessary to reflect one PFD level for each of the transmitting beams across the entire 37.5-42.0 GHz band. The PFD level that was reflected was the PFD limit indicated in Sections 25.208(s) and 25.208(t) that are applicable to NGSO FSS systems operating in the 40.0-42.0 GHz band and not the tighter limit that is specified in Section 25.208(r) for the 37.5-40.0 GHz band. Despite this, Boeing will operate its NGSO FSS systems in full compliance with the PFD limits indicated in Section 25.208(r) within the 37.5-42.0 GHz frequency range. Therefore, no harm would result from Boeing's use of the PFD mask for the 40.0-42.0 GHz band in the Schedule S that was submitted with this Application and good cause exists to grant a waiver allowing the use of this approach.

In the event that the Commission refrains from granting the above discussed waiver of Section 25.114(c), Boeing herein requests that the Commission permit Boeing to supplement the Schedule S for this modification application in order to further address these issues.