Before the

FEDERAL COMMUNICATIONS COMMISSION

Washington, D.C. 20554

In the Matter of	)	
	)	
O3b LIMITED	)	
	)	
Petition for a Declaratory Ruling	)	File No.
Granting Access to	)	
the U.S. Market for the	)	
O3b MEO Satellite System	)	
	)	

PETITION FOR DECLARATORY RULING

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October 29, 2014

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PETITION FOR DECLARATORY RULING AND REQUEST FOR CONSOLIDATION OF SPACE STATION AUTHORITY

O3b Limited ("O3b") hereby files this Petition for Declaratory Ruling ("PDR") seeking access to the U.S. market for O3b's four new medium earth orbit ("MEO") satellites.[1] For administrative convenience, O3b also requests consolidation of the U.S. market access authority for its eight operating MEO satellites with the U.S. market access authority for its four new MEO satellites.

I. INTRODUCTION AND SUMMARY

O3b operates a U.K.-authorized, non-geostationary orbit ("NGSO") Fixed-Satellite Service ("FSS") system in the Ka-band. O3b has eight satellites in orbit: O3b's first four satellites were launched in June 2013, and an additional four satellites were launched on July 10, 2014 (collectively, the "Eight Operating Satellites"). O3b has satisfied all FCC milestones associated with the Eight Operating Satellites.[2] O3b plans to launch four more satellites (the "Four New Satellites") in the fourth quarter of 2014 using the same orbital plane, altitude, frequencies, and satellite design as the Eight Operating Satellites previously authorized by the Commission.

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[1] It is O3b's understanding that its market access request should be styled as a PDR. Because there is no PDR entry for responding to item 17b on FCC Form 312 (other than for PDRs involving the Permitted List), however, O3b has checked the "Letter of Intent" box in response to item 17b.

[2] *See* Public Notice, Report No. SES-01681, p. 12 (Sept. 10, 2014).

The Commission has authorized the Eight Operating Satellites to serve the United States by granting various earth station applications that specify O3b's satellite system as a point of communication.[3] The Commission also has granted O3b special temporary authority, and O3b has sought regular authority, for up to two of the Eight Operating Satellites to serve as spares, with the remaining satellites evenly distributed in O3b's authorized orbital plane.[4]

This filing has two components. First, pursuant to Section 25.137 of the Commission's rules,[5] O3b hereby files a PDR requesting access to the U.S. market for the Four New Satellites.[6] O3b seeks authority to serve the U.S. portions of the service area identified in Schedule S.[7] In connection with its PDR, O3b asks for waivers of certain FCC rules.[8]

Second, for administrative convenience, O3b asks that the Commission consolidate under a single authorization all of O3b's authority to use its space stations to serve the U.S. market. More specifically, O3b asks that the authority for the Eight Operating Satellites to serve the U.S. market, which until now has been associated with licenses for earth stations that communicate with O3b's system, instead be associated with the authority for the Four New Satellites that O3b is requesting in its PDR.

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[3] For example: In September 2012, the Commission granted O3b a license to operate a gateway earth station in Haleiwa, Hawaii, to communicate with its NGSO FSS system. *See* FCC File No. SES-LIC-20100723-00952 (granted September 25, 2012) (the "Hawaii License"). In June 2013, the Commission granted O3b a license to operate a second gateway in the United States, located in Vernon, Texas (the "Texas License"). *See* FCC File No. SES-LIC-20130124-00089 (granted June 20, 2013). In May 2014, the Commission granted O3b a blanket license to operate maritime earth stations (the "Blanket Maritime License"). S*ee* FCC File No. SES-LIC-20130528-00455 (granted May 13, 2014).

[4] *See* FCC File Nos. SES-STA-20140814-00656, SES-STA-20140814-00657, SES-STA-20140814-00658, SES-MOD-20140814-00652, SES-MOD-20140814-00654, SES-MOD-20140814-00655, and SES-AMD-20140814-00653.

[5] 47 C.F.R. § 25.137.

[6] O3b anticipates that Space Activity Licenses covering the Four New Satellites' launch and space operations will have been authorized under the UK's Outer Space Act by the time the Commission acts on O3b's PDR. O3b will file the Space Activity Licenses with the Commission once they have been issued.

[7] The area includes the contiguous United States, Hawaii, Puerto Rico, the U.S. Virgin Islands, Guam, American Samoa, and a discrete number of small U.S. territories.

[8] *See* Section II.D.2, below.

Once both of O3b's requests in this filing have been granted, O3b will have a single authorization granting U.S. market access for twelve O3b space stations. O3b asks that it be permitted to operate up to three of these twelve space stations as spares,[9] with the remaining space stations evenly distributed in O3b's authorized orbital plane.

II. THE PUBLIC INTEREST WILL BE SERVED BY AUTHORIZING THE FOUR NEW SATELLITES TO SERVE THE U.S. MARKET.

O3b hereby requests a Declaratory Ruling authorizing its Four New Satellites to serve the U.S. market.

The Commission has an established framework for considering requests for non-U.S. licensed space stations to access the U.S. market. In evaluating requests for such authority, the Commission considers the effect on competition in the United States, spectrum availability, eligibility and operational requirements, and concerns related to national security, law enforcement, foreign policy, and trade.[10] Operators seeking U.S. market access for non-U.S. licensed space stations need to provide the same information concerning legal and technical qualifications as must be provided by applicants for space station licenses issued by the FCC.[11]

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[9] It is possible that O3b may decide to operate the O3b constellation in a different configuration from "9+3" in the future, such as, for example, "10+2". As explained in the attached Technical Statement (see particularly, Section A.12), the increase in the number of active operational satellites, such as from nine to ten, would not impact other users of the spectrum. In the event that O3b decides to locate the spare satellites in a configuration that differs from that given in the associated Schedule S, O3b will notify the Commission accordingly, consistent with §25.118(f) of the rules.

[10] *See* Amendment of the Commission's Regulatory Policies to Allow Non-U.S. Licensed Space Stations to Provide Domestic and International Satellite Service in the United States, 12 FCC Rcd 24094, ¶ 29 (1997) ("*DISCO II Order*"), *on reconsideration,* 15 FCC Rcd 7207, ¶ 5 (1999).

[11] *See In the Matter of Amendment of the Commission's Space Station Licensing Rules and Policies; Mitigation of Orbital Debris,* First Report and Further Notice of Proposed Rulemaking in IB Docket No. 02-34, and First Report and Order in IB Docket No. 02-54, 18 FCC Rcd 10760, ¶ 288 (2003) *("Space Station Licensing Reform Order").* Some of the Commission's application policies for authorizing non-U.S. licensed space stations are codified in Section 25.137 of the Commission's rules, 47 C.F.R. § 25.137.

O3b demonstrates below that its request to access the U.S. market via the Four New Satellites is supported by the considerations identified above. O3b also shows that it is legally and technically qualified to use the Four New Satellites to serve the United States and shows that it is in the public interest to provide this service. In addition to making these showings, O3b is requesting confirmation that no modifications to earth station licenses or amendments to earth station applications involving authority to communicate with O3b's space stations should be needed in connection with O3b's PDR.

A. Effect on Competition in the United States

When authority is sought for a satellite licensed by a World Trade Organization ("WTO") member country other than the United States to provide satellite services that are covered by the WTO Basic Telecommunications Agreement (the "WTO Agreement"), the Commission presumes that foreign entry will promote competition in the United States.[12] O3b's satellites are licensed by the United Kingdom, and the United Kingdom is a member of the WTO.[13] O3b, moreover, only seeks authority to provide satellite services that are covered by the WTO Agreement.[14] O3b, therefore, is entitled to a presumption that market entry will promote competition in the United States, and it need not make an effective competitive opportunities showing.[15]

B. Spectrum Availability

The Commission also considers spectrum availability as a factor in determining whether to allow a foreign-licensed satellite to serve the U.S. market.[16] In doing so, the Commission evaluates whether grant of access would create the potential for harmful interference with U.S.-licensed satellite and terrestrial systems.

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[12] *DISCO II Order* at ¶ 29.

[13] O3b is headquartered in St. John, Jersey, Channel Islands, which is a British Crown Dependency. The Commission treats British Crown Dependencies like Jersey and Guernsey as members of the WTO. *See, e.g., Intelsat Holdings, Ltd., Transferor, and Serafina Holdings Limited, Transferee, Consolidated Application for Consent to Transfer Control of Holders of Title II and Title III Authorizations*, 22 FCC Rcd 22151, ¶ 25, n. 57 (2007).

[14] O3b does not seek authority to provide direct-to-home, Digital Audio Radio Service, or Direct Broadcast Satellite Service in the United States.

[15] *See* 47 C.F.R. § 25.137(a)(2).

[16] *See DISCO II Order*, at ¶¶ 149-50.

O3b proposes to operate on the following Ka-band frequencies:

Downlink Frequency	Ka-Band Plan	O3B Proposed Use
17.8-18.3 GHz	FS	Service Links and Gateway Links
18.3-18.6 GHz	GSO FSS down	Service Links and Gateway Links
18.8-19.3 GHz	NGSO FSS down	Service Links, Gateway Links and TT&C[17]
Uplink Frequency	**Ka-Band Plan**	**O3B Proposed Use**
27.6-28.35 GHz	LMDS fss (secondary)	Service Links and Gateway Links
28.35-28.4 GHz	GSO FSS up ngso fss up (secondary)	Service Links and Gateway Links
28.6-29.1 GHz	NGSO FSS up gso fss up (secondary)	Service Links, Gateway Links and TT&C[18]

A more precise description of the channel plan for the O3b system is included in the Schedule S and the Technical Statement accompanying this application. O3b recognizes that not all of the frequencies that it proposes to use are allocated in the United States for NGSO FSS systems on a primary basis under the U.S. Table of Allocations[19] and the Commission's Ka-Band Plan.[20] Figure 1 below shows O3b's proposed frequency plan in comparison to the Commission's Ka-Band Plan:

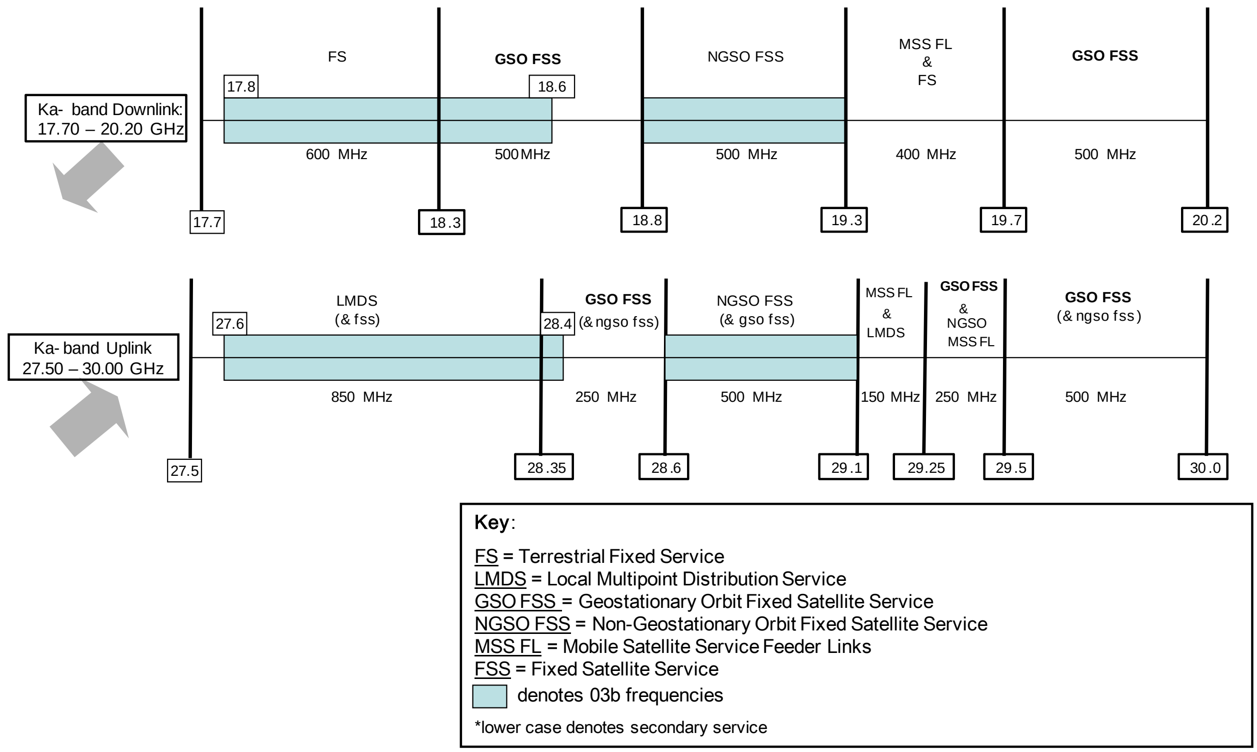
[17] O3b will conduct TT&C operations in the band edges just below 19.3 GHz (downlink) and 29.1 GHz (uplink). *See* 47 C.F.R. § 25.202(g).

[18] *Id.*

[19] *See* 47 C.F.R. § 2.106.

[20] The Ka-Band Plan is a combination of the 18 GHz band plan established in IB Docket No. 98-172 , including *In the Matter of 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 Broadcast Satellite-Service Use*, 15 FCC Rcd 13430, ¶ 28 (2000) and related decisions, and the 28 GHz band plan established in CC Docket No. 92-297, including *In the Matter of 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 29.5-30.0 GHz Frequency Band, to Establish Rules and Policies for Local Multipoint Distribution Service and for Fixed Satellite Services*, 11 FCC Rcd 19005, ¶ 42 (1996) and related decisions. The 18 GHz band plan and the 28 GHz band plan are collectively referred to herein as the Ka-Band Plan.

Figure 1: O3b Frequency Plan Compared to the U.S. Ka-Band Plan



O3b demonstrates below that adding the Four New Satellites to O3b's system would not create the potential for harmful interference to U.S.-licensed satellite and terrestrial systems. Granting U.S. market access for the Four New Satellites, therefore, would be consistent with the Commission's spectrum availability policies for non-U.S. licensed satellites.

The 18.8-19.3 GHz (Downlink) and 28.6-29.1 GHz (Uplink) NGSO FSS Bands.

Other NGSO FSS systems. These frequency bands are allocated on a primary basis to NGSO FSS. Use of the frequencies by O3b will not cause harmful interference to any U.S.-licensed commercial NGSO FSS Ka-band systems operating in the bands because – at present – there are no such systems. Moreover, as noted in Section II.D.2 below, in connection with O3b's request for a waiver of the processing round rules set forth in Sections 25.137(c) and 25.157 of the Commission's rules, O3b's system is capable of sharing these frequency bands with future co-frequency NGSO FSS systems.

Terrestrial stations. In the uplink band (28.6-29.1 GHz), there is no allocation in the Commission's Ka-Band Plan for terrestrial services.[21] In the downlink band (18.8-19.3 GHz), Fixed Service stations in the United States are no longer co-primary with FSS users.[22] Although according to Sections 101.85-101.97 of the Commission's rules there are some legacy Fixed Service stations in this band, these stations are required to protect, and may not claim protection from, FSS systems such as O3b's.

The 18.3-18.6 GHz (Downlink) GSO FSS Band.

This frequency band is allocated in the U.S. on a primary basis to GSO FSS. Because the 18.3-18.6 GHz downlink band is not allocated to NGSO FSS even on a secondary basis, O3b proposes to use this band on a non-conforming basis – *i.e.*, on a non-harmful interference, non-protected basis relative to any service allocated in that band – and, per Section II.D.2 below, respectfully requests a waiver of the Ka-Band Plan and Section 2.106 (footnote NG 164) of the Commission's rules to permit such use.

The Commission has allowed similar non-conforming use of FSS frequencies in the Ka-band downlink allocated to GSO on a primary basis where applicants are prepared to accept interference from primary operations and can demonstrate that their proposed operations are not likely to cause harmful interference to primary operations.[23] O3b's waiver request is consistent with these precedents.

O3b acknowledges that it has no protection against interference from U.S.-licensed GSO FSS networks in the 18.3-18.6 GHz band, and as shown in the attached Technical Statement,[24] O3b will keep its downlink transmissions in the band within the downlink equivalent power flux density ("$EPFD_{down}$") and EPFD(is) limits[25] developed by the ITU to protect GSO FSS networks.[26]

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[21] *See In the Matter of Verizon Washington D.C., Application for Renewal of License for Common Carrier Fixed Point to Point Microwave Station KGC79*, 26 FCC Rcd 13511, 13516 (WTB 2011).

[22] *See* 47 C.F.R. § 101.85(b)(2).

[23] *See Northrop Grumman* at ¶¶ 74-75 and *In the Matter of contactMEO Communications, LLC*, 21 FCC Rcd 4035, at ¶¶ 25-26, (Int'l Bur., 2006) ("*contactMEO*").

[24] *See* Technical Statement, Section A.8.1 and Annex 2.

[25] The EPFD(is) limits protect the "inter-satellite interference paths" that exist in certain bands where bidirectional allocations exist.

[26] *See* ITU Radio Regulations, Article 22.

The 28.35-28.4 GHz (Uplink) GSO FSS Band.

This frequency band is allocated to the GSO FSS on a primary basis and to the NGSO FSS on a secondary basis. O3b proposes to use these frequencies consistent with the secondary allocation for the NGSO FSS in this band, *i.e.*, on a non-harmful interference, non-protected basis relative to U.S.- licensed GSO FSS networks operating in the same frequencies. Given the secondary NGSO FSS allocation, no waiver of the Ka-Band Plan is required for O3b's proposed uplink operation in the 28.35-28.4 GHz band.

The Commission has allowed similar secondary use of frequencies in the Ka-band uplink allocated to GSO FSS on a primary basis where applicants are prepared to accept interference from and can demonstrate that their proposed operations are not likely to cause harmful interference to primary operations.[27] O3b's proposed operations are consistent with these precedents.

As a secondary user of the 28.35-28.4 GHz band in the United States, O3b makes no claim of protection from interference from U.S.-licensed GSO FSS networks in this band segment. And O3b will protect against harmful interference to GSO FSS networks. In the 28.35-28.4 GHz band, the ITU has developed uplink equivalent power flux density ("$EPFD_{up}$") limits to protect co-frequency GSO FSS operations from unacceptable interference from NGSO FSS systems operating in the same frequencies.[28] Specifically, in accordance with Article 22 of the ITU Radio Regulations, if the applicable $EPFD_{up}$ limits are met, the NGSO FSS satellite system is considered to have met its obligations to protect GSO FSS networks from unacceptable interference.

In this case, as demonstrated in the attached Technical Statement, the O3b system will meet the applicable ITU $EPFD_{up}$ limits in all frequency ranges where these limits apply and which overlap those used by the O3b system (*i.e.*, 27.6-28.4 GHz).[29] As a result, co-coverage GSO FSS networks will not experience unacceptable interference in the 28.35-28.4 GHz band. In any event, O3b confirms that its operations will be on a secondary basis relative to U.S.-licensed GSO FSS networks in the same band.

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[27] *Northrop Grumman* at ¶¶ 72-73; *contactMEO* at ¶¶ 23-24.
[28] *See* ITU Radio Regulations, Article 22.
[29] *See* Technical Statement, Section A.8.1.

The 17.8-18.3 GHz (Downlink) FS Band.

This frequency band is allocated on a primary basis to the FS, and there is no secondary allocation for NGSO FSS in the band. Accordingly, and per Section II.D.2 below, O3b requests a waiver of the Ka-Band Plan and Section 2.106 of the Commission's rules to permit O3b to operate its NGSO FSS system in the 17.8-18.3 GHz band for downlink operations on a non-conforming, non-interference basis.

As stated above, in analyzing requests for non-conforming spectrum uses, the Commission has indicated it will generally grant such waivers when harmful interference is not expected into any service authorized under the Table of Frequency Allocations and the non-conforming operator accepts any interference from allocated services. O3b's proposed use of the 17.8-18.3 GHz band satisfies this standard.

O3b's downlink operations in the band will protect FS stations in the band from harmful interference. This is because, as demonstrated in the attached Technical Statement,[30] O3b will meet the power flux density ("PFD") limits at the earth's surface prescribed by the ITU for the protection of terrestrial services in this band.[31] In addition, as a non-conforming user, O3b will accept interference from FS operations in the band.[32]

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[30] *See* Technical Statement, Section A.7.

[31] *See* ITU Radio Regulations tbl. 21-4. *See also* Recommendation ITU-R SF.1483, at 4 ("Extensive studies have provided ample technical justification that the pfd limits of *recommends* 1 are certainly adequate to protect the FS systems from aggregate interference from the satellites of multiple, co- frequency non-GSO FSS systems operating in the 17.7-19.3 GHz band. Therefore, the pfd limits of *recommends* 1 are acceptable in that they protect the FS systems without unduly constraining the development of non-GSO FSS networks.").

[32] O3b also has identified at least three steps that, if needed, could be undertaken to eliminate or mitigate potential interference. First, O3b can add bandpass filtering to its low noise amplifier assemblies. Second, O3b can modify the timing of satellite handover events such that they occur at higher elevation angles. Third, O3b could work constructively with the FS licensee to explore alternate FS link configurations. *See* Application to Operate a Gateway Earth Station with a Non-U.S. Licensed, Non-Geostationary Orbit Ka-band Space Station System, FCC File No. SES-LIC-20100723-00952 (June 23, 2010) ("Hawaii Application"), Technical Attachment at Appendix B, Section 6 for more details concerning these mitigation techniques.

The 27.6-28.35 GHz (Uplink) Band.

This frequency band is allocated to the local multipoint distribution service ("LMDS") on a primary basis. NGSO FSS operations are allocated on a secondary basis in the same band and, therefore, no waiver of the Ka-Band Plan is required for O3b to operate in those frequencies.[33]

As stated above, however, a secondary NGSO user in the Ka-band must not cause harmful interference to primary operations, nor can it claim protection from interference caused by primary operations. O3b's proposed use of the 27.6-28.35 GHz band satisfies this standard.

As a secondary NGSO user in the 27.6-28.35 GHz frequency band, O3b makes no claim for protection from interference caused by LMDS operations. Moreover, earth station applications that propose to transmit to O3b's system in the 27.6-28.35 GHz band routinely include a showing addressing the need to protect LMDS stations.[34] These showings have included reports from Comsearch stating that the LMDS licensees that potentially could be affected had been notified and had not objected to O3b's operations. In addition, O3b has identified four mitigation techniques that could be used if necessary to avoid interference to LMDS stations.[35]

C. National Security, Law Enforcement, Foreign Policy, and Trade Issues

The Commission has stated that issues of national security, law enforcement, foreign policy, and trade, which it considers in evaluating requests for market access for non-U.S. licensed satellites, are likely to arise only in rare circumstances.[36] The Commission further stated that it will accord deference to the expertise of the Executive Branch in identifying and interpreting issues of this nature.[37]

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[33] *See 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 29.5-30.0 GHz Frequency Band, to Establish Rules and Policies for Local Multipoint Distribution Service and for Fixed Satellite Services*, 12 FCC Rcd 22310, ¶ 42 (1997) ("GSO and NGSO FSS systems have equal status as secondary users in this band segment").
[34] *See, e.g.*, Hawaii Application, Technical Attachment at A.10.4.
[35] *See* Technical Statement, Section A.8.4.
[36] *DISCO II Order* at ¶ 180.
[37] *DISCO II Order* at ¶ 180.

O3b's PDR for the Four New Satellites raises no such issues on its face. Moreover, neither the Commission nor the Executive Branch identified any concerns with national security, law enforcement, foreign policy, and trade in connection with O3b's prior request to serve the U.S. market via the Eight Operating Satellites, or any of its or its customers' earth station authorization requests. And for this purpose, the considerations associated with the Eight Operating Satellites are identical to the considerations associated with the Four New Satellites. Thus, this element of the Commission's *DISCO II Order* market access analysis is satisfied.

D. Eligibility and Operational Requirements

Pursuant to Section 25.137 of the Commission's rules, the filer of a PDR for U.S. market access must provide the legal and technical information for its non-U.S. licensed space station(s) that is required by Part 25 of the Commission's rules, including Section 25.114.[38]

1. Legal and Technical Qualifications

The information set forth in this legal narrative, the attached Technical Statement, Schedule S, and the accompanying FCC Form 312 demonstrates compliance with the requirements of Section 25.137 and the other applicable Sections of Part 25 of the Commission's rules. O3b highlights here certain Part 25 rules that warrant special attention:

Section 25.145(e) – Prohibition Against Exclusive Arrangements

Section 25.145(e) of the Commission's rules[39] precludes the Commission from granting a Ka-band FSS space station license to any applicant if it (or its affiliates) has or acquires an exclusive right to construct or operate space segment or earth stations, or to interchange traffic, for the purpose of handling traffic to or from the United States, its territories, or possessions. O3b hereby confirms that it has no such exclusive right, and that it will not acquire such an exclusive right in the future.

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[38] *See* 47 C.F.R. § 25.137(b). *See also DISCO II Order* at ¶ 189.
[39] 47 C.F.R. § 25.145(e).

Sections 25.137(d)(1) & 25.164(b) – Satellite Construction Milestones

Section 25.137(d)(1) of the Commission's rules[40] requires parties filing PDRs to demonstrate compliance with satellite construction milestones. The milestones for NGSO systems like O3b's are set forth in Section 25.164(b) of the Commission's rules.[41] They are as follows:

> (1) *One year*: Enter into a binding non-contingent contract to construct the licensed satellite system.
>
> (2) *Two years*: Complete the critical design review of the licensed satellite system.
>
> (3) *Two years, six months*: Begin the construction of the first satellite in the licensed satellite system.
>
> (4) *Three years, six months*: Launch and operate the first satellite in the licensed satellite system.
>
> (5) *Six years*: Bring all the satellites in the licensed satellite system into operation.

The first four of these milestones already have been satisfied. O3b previously entered into binding, non-contingent contracts for both the Eight Operating Satellites and the Four New Satellites. Critical Design Review has been completed for both the Eight Operating Satellites and the Four New Satellites. And the International Bureau has accepted O3b's showing that it began construction of the first satellite in its system and has launched and is operating the first satellite.[42] In fact, O3b has brought all of the Eight Operating Satellites into operation.[43] O3b will notify the Commission when it has completed the final milestone by bringing the Four New Satellites into operation.

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[40] 47 C.F.R. § 25.137(d)(1).

[41] 47 C.F.R. § 25.164(b).

[42] *See* Public Notice, Report No. SES-01681, p. 12 (Sept. 10, 2014).

[43] *See id*.

Sections 25.137(d)(4) & 25.165 – Posting of Bond

Section 25.137(d)(4) of the Commission's rules requires a bond to be posted in connection with filings involving non-U.S. licensed satellites that are not in orbit and operating.[44] The bond required for a new NGSO system is in the amount of $5 million,[45] which typically must be posted within 30 days of FCC action providing access to the U.S. market. The party posting the bond may reduce the amount of the bond by $1 million each time a milestone has been satisfied.[46]

Assuming the Commission determines that a bond is required in connection with O3b's PDR, the amount of the bond should be reduced to take into account the fact that, as discussed above, O3b has satisfied four of the five milestones for NGSO systems. Accordingly, at most O3b should be required to post a bond in the amount of $1 million.

Section 25.114(d)(14) – End-of-Life Disposal

Section 25.114(d)(14) states that applicants for space station authorizations should provide a "description of the design and operational strategies that will be used to mitigate orbital debris," including various items of information that the rule enumerates.[47] O3b provided this information when, in the Hawaii License application, it sought U.S. market access for the Eight Operating Satellites.[48] In connection with its showing in the application, O3b requested a partial waiver of Section 25.283(c) of the rules because a small amount of pressurant could not be vented at end-of life.[49]

Two subsequent developments collectively have altered the orbital debris mitigation showing O3b needs to make in connection with the Four New Satellites. First, the Commission has amended its rules so that "[f]or non-U.S.-licensed space stations, the requirement to describe the design and operational strategies to minimize orbital debris risk can be satisfied by demonstrating that

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[44] 47 C.F.R. § 25.137(d)(4).
[45] *Id. See also Space Station Licensing Reform Order*, ¶ 309 (2003).
[46] 47 C.F.R. § 25.137(d)(4). *See also* 47 C.F.R. § 25.165(d).
[47] 47 C.F.R. § 25.114(d)(14).
[48] *See* Hawaii Application, Technical Attachment at A.13.1.
[49] *See* Hawaii Application, Technical Attachment at A.13.2.

debris mitigation plans for the space station(s) for which U.S. market access is requested are subject to direct and effective regulatory oversight by the national licensing authority."[50] Second, when the Commission granted the Hawaii License application, it found that O3b's system "is and will be subject to direct and effective regulation by the United Kingdom concerning orbital debris mitigation."[51]

The net effect of these subsequent developments is to make it unnecessary for O3b to make a Section 25.114(d)(14) orbital debris mitigation showing, or to request a waiver of Section 25.283(c) of the rules, in connection with O3b's request for U.S. market access for the Four New Satellites. Space stations that are subject to direct and effective regulatory oversight by the national licensing authority are no longer subject to these requirements. And the Four New Satellites are subject to the same UK regulatory oversight that the Commission has determined, in connection with the Hawaii License application, is "direct and effective" for orbital debris mitigation purposes. Given these circumstances, O3b is not including an orbital debris mitigation showing or requesting a waiver of Section 25.283(c) of the rules in connection with its PDR.

2. Waiver Requests

Table of Frequency Allocations and Ka-band Frequency Plan

O3b respectfully requests waivers of the U.S. Table of Allocations and the Ka-Band Plan to allow O3b to use non-NGSO FSS Ka-band frequencies on a non-conforming basis relative to the allocated services in the applicable bands. As shown in Section II.B, above, O3b's operations on a non-conforming basis would not create the potential for harmful interference to U.S.-licensed satellite and terrestrial systems. There is good cause, therefore, for a waiver.

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[50] 25. C.F.R. § 25.114(d)(14)(v).
[51] Hawaii License, Condition 90045.

Section 25.145(c) - Geographic Coverage

Section 25.145(c) of the Commission's rules requires Ka-band NGSO systems to provide service coverage (i) to all locations as far north as 70 degrees latitude and as far south as 55 degrees 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.[52] The Commission has previously waived this rule so that O3b may use its NGSO system to serve O3b's Hawaii and Texas gateway earth stations and O3b's maritime earth stations.[53]

Adding the Four New Satellites to O3b's system has no impact on O3b's geographic coverage of the United States or on the factors that led the Commission to grant O3b the above-mentioned waivers of Section 25.145(c). O3b's Four New Satellites will provide the same coverage as its Eight Operating Satellites, and O3b will serve the same earth stations with the Four New Satellites as it already has been authorized to serve with the Eight Operating Satellites. The Commission, therefore, should waive Section 25.145(c) when it grants O3b's PDR, on the same terms and conditions as the waivers of Section 25.145(c) it already has granted O3b.

In addition, the architecture of O3b's system furnishes good cause for waiving this provision. Because of where O3b's target customers are located, O3b chose an equatorial orbit for its constellation of satellites. Due to look-angle constraints, this orbit carries with it a limitation on the northernmost and southernmost latitudes that can be served by O3b's system. A waiver is needed to take this unique system architecture into account.

A waiver, moreover, would not undercut the underlying purpose of Section 25.145(c); it would promote it. The rule is intended to foster a seamless global communications network.[54] O3b's system, which has ten steerable spot

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[52] 47 C.F.R. § 25.145(c).

[53] *See* Hawaii License, Condition 90044; Texas License, Condition 90044; Blanket Maritime License, Condition 6597. O3b also has requested a waiver of the geographic coverage requirements in connection with its application for a blanket license to operate up to one thousand 1.2m, one thousand 2.2m, one thousand 1.8m, and one thousand 2.4m fixed earth stations. *See* FCC File No. SES-LIC-20141001-00781.

[54] *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 29.5-30.0 GHz Frequency Band, to Establish Rules and Policies for Local Multipoint Distribution Service and for Fixed Satellite Services,* 12 FCC Rcd 22310, ¶ 34 (1997).

beams per satellite, is designed to focus bandwidth efficiently to areas where it is needed by the customer, rather than waste satellite power purporting to serve areas already adequately served or where there is no demand. In doing so, it helps extend the seamless global communications network of very high-speed Internet service.

Accordingly, there is good cause for waiving Section 25.145(c).

Section 25.210(i)(1) – Cross-polarization Isolation

Section 25.210(i)(1) of the Commission's rules requires FSS space station antennas to provide a cross-polarization isolation such that the ratio of the on-axis co-polar gain to the cross-polar gain of the antenna in the assigned frequency band is at least 30 dB within its primary coverage area.[55] As shown in the attached Technical Statement, the minimum cross-polar isolation of the O3b satellite transmit and receive antennas is 18.5 dB, which is less than the minimum 30 dB requirement.[56] This shortfall is a worst case value[57] and occurs only in limited geographic areas and only for certain limited pointing directions.

The Commission's cross-polarization requirements are designed to avoid interference into other networks and systems. As noted in the Technical Statement, however, it is the co-polar transmissions, rather than the level of cross-polar radiation in the O3b system, that dictate the interference levels to and from other networks and systems.[58] O3b, therefore, provides adequate protection for other networks and systems.

The cross-polarization levels can have an impact on O3b's own links. But as explained in the Technical Statement, O3b already has taken its system's cross-polarization performance into account, so the impact on O3b's service quality is negligible.[59]

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[55] 47 C.F.R. § 25.210(i)(1).
[56] *See* Technical Statement, Section A.11.
[57] *Id.*
[58] *Id.*
[59] *Id.*

For all of the above-stated reasons, the Commission waived Section 25.210(i)(1) when it granted U.S. market access for the Eight Operating Satellites.[60] The cross-pol performance of the Four New Satellites that are the subject of O3b's PDR is the same as the cross-pol performance of the Eight Operating Satellites for which a waiver already has been granted. Accordingly, when the Commission authorizes the Four New Satellites to access the U.S. market, it should extend the previously-granted waiver of Section 25.210(i)(1) to those satellites.

Sections 25.137(c) and 25.157– Processing Rounds

Under Sections 25.137(c) and 25.157 of the Commission's rules, applications for authority to communicate with a non-U.S.-licensed NGSO-like system (including requests for U.S. market access) are ordinarily processed under a "modified processing round" framework, which would use a band-splitting sharing mechanism to divide spectrum among competing applicants. The Commission, however, has waived the processing round requirement and allowed NGSO systems access to the entire frequency band when doing so "will not preclude additional entry."[61]

O3b presented good cause in its Hawaii License application for waiving the processing round and band segmentation requirements in connection with its proposed system.[62] O3b demonstrated that its system will not preclude additional NGSO entry; the system can share with other NGSO systems by relying on angular separation between orbital arcs, satellite diversity, and (as a last resort) band segmentation.[63] Based on this showing, the Commission granted O3b's application without requiring a processing round.[64]

In the attached Technical Statement, O3b demonstrates that adding the Four New Satellites to its system will enhance O3b's sharing capabilities. As

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60 *See* Hawaii License, Condition 90041.

61 *Northrop Grumman Space & Missions Systems Corporation*, 24 FCC Rcd 2330, at ¶¶ 29, 34 (Int'l Bur. 2009) ("*Northrop Grumman*"). *See also Space Imaging, LLC*, 20 FCC Rcd 11964, ¶ ¶ 10, 11(Int'l Bur., 2005) ("*Space Imaging*"); *Lockheed Martin Corporation*, 20 FCC Rcd 11023, ¶ 15 (Int'l Bur., 2005); and *Digital Globe, Inc.*, 20 FCC Rcd 15696, ¶ 8 (Int'l Bur., 2005).

62 *See* Hawaii Application, Narrative, Section IV.

63 *Id*.

64 *See* Hawaii License, Condition 90043.

more O3b satellites are launched, the ability to employ satellite diversity improves because more O3b satellites are visible simultaneously.[65]

The case for a waiver of the processing round and band segmentation requirements, therefore, is even stronger with the Four New Satellites in place than it was when the Commission granted a waiver based on the Eight Operating Satellites alone. Accordingly, the Commission should again waive the processing round and band segmentation requirements when it grants O3b's PDR.

E. Request for Clarification

O3b believes no modifications to earth station licenses or amendments to earth station applications involving authority to communicate with O3b's space stations should be needed in connection with O3b's PDR so long as

- The licensed and proposed earth stations will continue to operate in accordance with the parameters specified in the earth station applications and licenses; and
- The Four New Satellites will operate at the same altitude, and in the same orbital plane, as the Eight Operating Satellites.

O3b respectfully requests that the Commission confirm O3b's understanding is correct.

F. Grant of O3b's PDR Would Be in the Public Interest.

Adding the Four New Satellites to O3b's NGSO constellation will enhance O3b's capabilities to serve the public. The launch of four additional satellites will allow O3b to keep up with customer demand for its offerings, as indicated by strong customer take-up to date. Grant of O3b's request for U.S. market access for the Four New Satellites, therefore, would be in the public interest.

The capabilities of O3b's system already are substantial; O3b's service represents a major advance in the state of the art. Using fully steerable beams, O3b's Medium Earth Orbit satellites can provide high-quality, broadband

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[65] *See* Technical Statement, Sections A.8.2 and A.12.

Internet access that is comparable to fiber-based broadband services. O3b's system offers scalable bandwidth options, with speeds from 100 Mbps up to 800 Mbps in each direction. In addition, because the O3b satellites are at the MEO altitude of 8062 km, users on O3b's system experience round trip latency of less than 150 milliseconds, which is one quarter the latency of geostationary orbit satellites.

O3b's unique architecture makes it ideal for government and business applications that require high data throughput and low latency. For example, it is expected that O3b's system will be used in the United States for 3G and 4G backhaul services; for data trunking in industries with high data requirements (like the energy sector); for local networks on business campuses; for specialized communications requirements of government agencies, the military, and first responders; and for network monitoring. O3b's system supports numerous real-time broadband applications, including cloud-based services, very large file transfers, interactive video and voice conferencing, interactive web content, video streaming, and real-time multiplayer video games.

III. THE PUBLIC INTEREST WILL BE SERVED BY CONSOLIDATING O3B'S SPACE STATION AUTHORITY UNDER A SINGLE MARKET ACCESS AUTHORIZATION.

The Commission has adopted two alternative procedures for authorizing non-U.S. licensed space stations to serve the United States. Under one procedure, a full showing as to the space stations is made in an earth station application.[66] Under the other procedure, a full showing as to the space stations is made in a PDR or letter of intent filing.[67]

O3b previously followed the first procedure by making a full showing as to its UK-licensed NGSO FSS system, which at the time was to consist of eight space stations, in its application for the Hawaii License. Out of an abundance of caution, the space station showing has been incorporated by reference/replicated in subsequent earth station applications.[68] By granting O3b's Hawaii License application and subsequent earth station applications that specified O3b's system

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[66] *See* 47 C.F.R. § 25.137(b), (d). *See also* Space Station Licensing Reform Order, ¶¶286-288.
[67] *See* 47 C.F.R. § 25.137(c)-(d). *See also* Space Station Licensing Reform Order, ¶¶286-288.
[68] *See, e.g.,* Application for Texas License, FCC File No. SES-LIC-20130124-00089, Exhibit 1, Legal Narrative at 2.

as a point of communication, the Commission has determined that O3b's space station operations satisfy the FCC's technical and legal requirements for non-U.S. licensed space stations that are authorized to serve the United States.

In the initial portion of this filing, O3b is seeking a Declaratory Ruling that will provide access to the U.S. market for O3b's Four New Satellites.[69] At present, however, U.S. market access for O3b's Eight Operating Satellites is not in the form of a Declaratory Ruling but rather, as stated above, is associated with licenses for earth stations that communicate with O3b's system. For administrative convenience, O3b asks that the Commission associate the pre-existing authority for O3b's Eight Operating Satellites with the Declaratory Ruling it will grant for O3b's Four New Satellites.

Associating the authority for the Eight Operating Satellites with the Declaratory Ruling for the Four New Satellites is administratively efficient, and therefore is in the public interest, because:

- There will be consolidation of the authority for all of O3b's space stations;
- A single call sign can be assigned that can be used to upload filings relating to all of O3b's space stations;
- The call sign will provide a central repository in IBFS for information concerning O3b's space stations, absent which one might have to review multiple earth station files to be certain one has all relevant information; and
- There will be a clear dividing line between the authority for O3b's space stations and the authority for earth stations authorized to communicate with the O3b satellite system.

[69] *See* Section II, above.

Conclusion

For the reasons stated herein, the Commission should: (1) issue a Declaratory Ruling that provides U.S. market access for the Four New Satellites; and (2) consolidate the authority for the Eight Operating Satellites and the authority for the Four New Satellites under a single market access authorization.

Respectfully submitted,

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O3B NON-GEOSTATONARY SATELLITE SYSTEM

ATTACHMENT A

Technical Information to Supplement Schedule S

A.1 Scope and Purpose

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

A.2 Overall Description of System Facilities, Operations and Services and Explanation of How Uplink Frequency Bands are Connected to Downlink Frequency Bands (§25.114(d)(1))

The O3b non-geostationary orbit ("NGSO") satellite system consists of a constellation of evenly spaced operational satellites, plus in-orbit spares, in an equatorial circular Medium Earth Orbit ("MEO") orbit of altitude 8,062 km, as well as associated ground control facilities, gateway earth stations and end customer earth stations. Using fully steerable satellite beams and tracking earth station antennas, O3b can provide high-quality, broadband Internet access that is comparable to fiber-based broadband services with typical data rates ranging from 100 Mbps to to 800 Mbps in each direction. In addition, because the O3b satellites are at a much lower altitude than that of a GSO satellite, users on O3b's system experience round trip latency of less than 150 milliseconds, which is one quarter the latency of GSO satellites.

There are currently eight deployed O3b satellites. O3b plans to launch a further four satellites in the fourth quarter of 2014. Full commercial service is currently offered using these in-orbit satellites. The number of satellites in the constellation is expected to further increase over time to add necessary capacity and improve performance and operational flexibility.

With there being the expectation of 12 O3b satellites in orbit following the next launch, the Schedule S accompanying this application defines a constellation of 12 satellites operating in a "9+3" configuration. This involves nine active operational satellites evenly spaced around the orbit with three in-orbit spare satellites located close to three of the nine operational satellites. The accompanying Schedule S has the three spare satellites located 2.5° away from the closest active operational satellite, and with the three spares evenly spaced around the 360° orbit.[1] [2] [3]

The O3b system provides wideband communications channels between customer earth stations and gateway earth stations located on the global fiber network. There are nine fiber connected O3b gateway earth stations already installed and operational around the world, at geographic locations that ensure full-time connectivity to the O3b constellation. The list of these gateway earth stations is given in Table A.2-1 below. Four of these nine gateways act also as primary TT&C earth stations. Two of these gateway earth stations are located in the USA: one is in Sunset Beach, Hawaii and the other is in Vernon, Texas.[4] The Hawaii gateway earth station also

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[1] The spacing of 2.5° between each spare satellite and the neighboring active operational satellite provides for a longitudinal freedom of ±1° for both operational and spare satellites while preventing any overlap in longitude of the two satellites. O3b may increase or reduce this 2.5 degree nominal spacing between a spare satellite and the nearest operational satellite provided that, in the event that it reduces it, it also reduces the longitudinal freedom of both satellites accordingly to ensure that the station-keeping volumes of the two satellites do not overlap.

[2] In the event that O3b decides to locate the spare satellites in a configuration that differs from that given in the associated Schedule S, O3b will notify the Commission accordingly, consistent with §25.118(f). An exception to the ten day notice period may occur only in the event of an unplanned reconfiguration of the O3b constellation, as might be necessary in the event of a satellite anomaly.

[3] It is possible that O3b may decide to operate the O3b constellation in a different configuration from "9+3" in the future, such as, for example, "10+2". As explained in this document (see particularly, Section A.12), the increase in the number of active operational satellites, such as from nine to ten, would not impact other users of the spectrum. In the event that O3b does decide to change the operational configuration of the constellation, it will notify the Commission accordingly.

[4] In September 2012, the Commission granted O3b a license to operate a gateway earth station in Haleiwa, Hawaii, to communicate with its NGSO FSS system. *See* FCC File No. SES-LIC-20100723-00952 (granted September 25, 2012) (the "Hawaii License"). In June 2013, the Commission granted O3b a license to operate a second gateway in the United States, located in Vernon, Texas (the "Texas License"). *See* FCC File No. SES-LIC-20130124-00089 (granted June 20, 2013).

acts as one of the four global primary TT&C earth stations while the Vernon, Texas gateway has been authorized to provide back-up TT&C.

Table A.2-1: O3b Gateway Earth Stations

Station
Sunset Beach, Hawaii, USA
Vernon, Texas, USA
Lima, Peru
Hortolandia, Brazil
Lisbon, Portugal
Nemea, Greece
Karachi, Pakistan
Perth, Australia
Dubbo, Australia

All of the first 12 O3b satellites are technically and operationally identical. Each O3b satellite contains 20 wideband channels with usable bandwidths ranging from 250 to 300 MHz bandwidth.[5] There are 12 nominally identical and independently steerable antennas on each O3b satellite, each creating a single spot beam. In the normal mode of operation, ten of the channels are used for links from two gateway beams to ten user beams ("forward links") and ten different channels for links from the same ten user beams back to the same two gateways ("return links").

[5] Note that the usable channel bandwidths, as defined in the accompanying Schedule S, are somewhat different from those filed with the original Schedule S that accompanied the Hawaii earth station application. Based on practical measurements on the O3b satellites, O3b has been able to increase the effective bandwidth of the transponders by using some of the frequency ranges originally set aside in between transponders. This provides more effective transmission bandwidth in the O3b system and hence more capacity to be achieved. The use of the spectrum between O3b channels in this way has no negative impact on O3b's internal channel operations or on other users of the spectrum because these small portions of spectrum could not have been exploited in practice by others because (a) inter-channel spectrum was not wide enough to provide viable satellite system capacity on their own, and (b) there would have been residual energy falling in this spectrum anyway from the adjacent wideband O3b transmissions due to the filter characteristics of the O3b satellites and earth stations. This approach also fully complies with the Commission's out-of-band emission requirements. Finally, this adjustment does not extend the frequency range of any of O3b's transmissions outside of the various band segments of the FCC and ITU band plans.

However, each O3b satellite may be reconfigured differently from this normal mode, as explained in Annex 1.[6]

Each forward channel downlinking in a user beam typically operates with one channel per active traveling wave tube amplifier ("TWTA"). Each group of five return channels that downlinks to the same gateway beam is combined and transmitted in a single active TWTA per gateway making a total of two active TWTAs used for all of the return channels. In total there are 12 active TWTAs per O3b satellite.

In the normal mode of operation each wideband channel, for uplinks from and downlinks to user beams, is connected to one of the ten independently steerable user spot beam antennas on the satellite. These ten steerable spot beams are pointed towards the target geographic locations where the customer earth stations are located. Each of the two groups of five channels is connected to the remaining two independently steerable gateway spot beam antennas which can be pointed towards two geographically separate gateway earth stations or towards the same gateway location. All steerable spot beams are pointed to constant positions on the Earth as the O3b satellite traverses its active arc above those Earth positions. At the beginning and end of the active arc that serves each ground position the steerable spot beams are repointed to provide the necessary connectivity for the next active arc. Handover of traffic between satellites is handled seamlessly as there are always two satellites visible to each earth station at the times that satellite handover is required.

The O3b system uses the 27.6-28.4 GHz and 28.6-29.1 GHz uplink bands and the 17.8-18.6 GHz and 18.8-19.3 GHz downlink bands. TT&C operations are performed at all phases of the mission in the band edges just below 29.1 GHz (uplink) and 19.3 GHz (downlink). Four-fold frequency re-use is achieved by a combination of dual orthogonal polarization and spatial beam isolation

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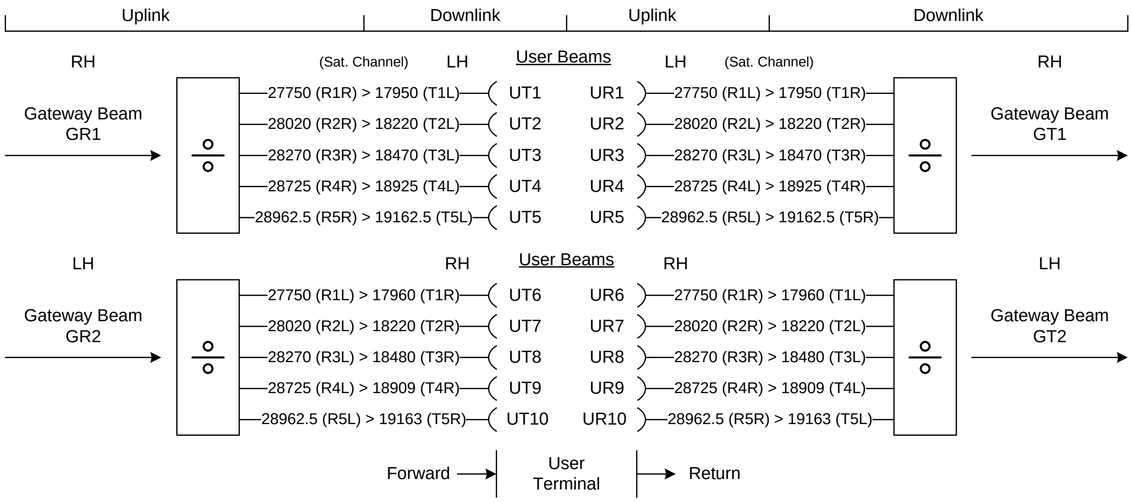
6 As the normal mode of operation is the only one that is planned to be used for O3b satellites accessing the United States, the associated Schedule S reflects only this normal mode configuration of channels and their connectivity to beams.

(between gateway and customer beams). A schematic of the use of the frequency spectrum between gateway and user beams, for the normal configuration, is given in Figure A.2-1 below. The terminology used in Figure A.2-1 is consistent with that used in the associated Schedule S. The forward uplinks from each of the two gateway beams (GR1 and GR2) are separated in the satellite into five channels (numbered R1R/T1L to R5R/T5L for GR1 and R1L/T1R to R5L/T5R for GR2) and retransmitted on the downlink toward five separate downlink user beams (User Beams UT1 to UT5 for GR1 and User Beams UT6 to UT10 for GR2). Similarly, the return uplinks from the ten user beams (UR1 to UR10) in the ten channels are multiplexed in the satellite into two groups of five channels and downlinked to the originating gateway beams (channels R1L/T1R to R5L/T5R towards GT1 and channels R1R/T1L to R5R/T5L towards GT2).[7]

[7] In the associated Schedule S the beam names described above have the suffix "N" or "G" depending on the frequency range in which they operate. Details of these frequency ranges are contained in the Schedule S.

Figure A.2-1: Schematic showing the use of spectrum between beams (normal configuration)



The transponder frequencies and bandwidths as well as the connectivity between the uplink and downlink beams in each O3b satellite for the normal mode of operation are defined in tabs S9 and S10 of the associated Schedule S.

Each wideband channel on an O3b satellite typically supports a single wideband carrier, or a small number of medium bandwidth channels, supporting a variable information data rate, depending on the instantaneous modulation and coding scheme employed. Adaptive coding and modulation ("ACM") is used to ensure the optimum data throughput as a function of the link margin available at the time, which varies as a function of rain fade as well as the time varying geometry of the link due to the moving O3b satellite. Other transmission plans may also be operated in the O3b transponders, involving more than one carrier per wideband channel, and this mode of operation also involves the use of ACM.

The transmission capability of each wideband channel is dedicated to the particular spot beam, but may be shared by multiple earth stations within the service area of the spot beam.

There are three broad categories of earth stations in the O3b system – the combined TT&C/gateway stations, the gateway-only stations and the customer terminals. The primary gateway and TT&C earth stations are typically 7.3 meters in antenna diameter and consist of two active tracking antennas plus a backup antenna and associated electronics so that continuity of service can be provided in accessing the O3b satellites. The customer earth stations are typically in the range 1.2 to 7.3 meters in antenna diameter. Each station consists of at least two tracking antennas and associated electronics so that continuity of service can be provided in accessing the O3b satellites.

The primary satellite control center for the O3b satellite constellation is in Betzdorf, Luxembourg, with a backup facility in Manassas, VA. Network operations are primarily controlled from the facility in Manassas, VA with back-up from Betzdorf, Luxembourg. Connectivity between these control centers and the TT&C earth stations is implemented using terrestrial leased circuits and secure Internet virtual private networks (VPN).

The O3b satellite constellation operates under a UK registration at the ITU (network name "O3B-A"). Further details of this are provided in Section A.9 below.

A.3 Predicted Space Station Antenna Gain Contours (§25.114(c)(4)(vi)(B))

The antenna gain contours for the O3b satellite receive and transmit beams, as required by §25.114(c)(4)(vi)(B), are embedded in the associated Schedule S submission. All of the 12 spot beams on each O3b satellite are independently steerable over the full field of view of the Earth. The format used to define the O3b satellite beam contours is that used by O3b in its response to a request from the Commission.[8]

[8] See Question 11 in the FCC letter to O3b Limited dated September 25, 2013 regarding IBFS File No. SES-LIC-20130528-00455, and O3b's response to the FCC dated October 25, 2013.

A.4 Geographic Coverage
(§25.145(c))

The O3b next-generation global satellite system is designed primarily to establish infrastructure for providing very high speed, low latency Internet and mobile connectivity to the "other three billion" people who currently have little or no Internet access at an affordable price. The majority of these people live at low-to-medium latitudes relatively near the equator. This directly determines the orbit used for the O3b constellation, which is equatorial and relatively low in altitude compared to the geostationary orbit. In turn, this means that satellites in the O3b orbit cannot see locations at the higher latitudes seen by geostationary satellites, as demonstrated by Figure A.4-1 below which compares the elevation contours for the O3b orbit to those for the geostationary orbit for the same satellite longitude, which is arbitrarily assumed to be 115°W.

Figure A.4-1(a): Elevation angle contours for geostationary satellite orbit

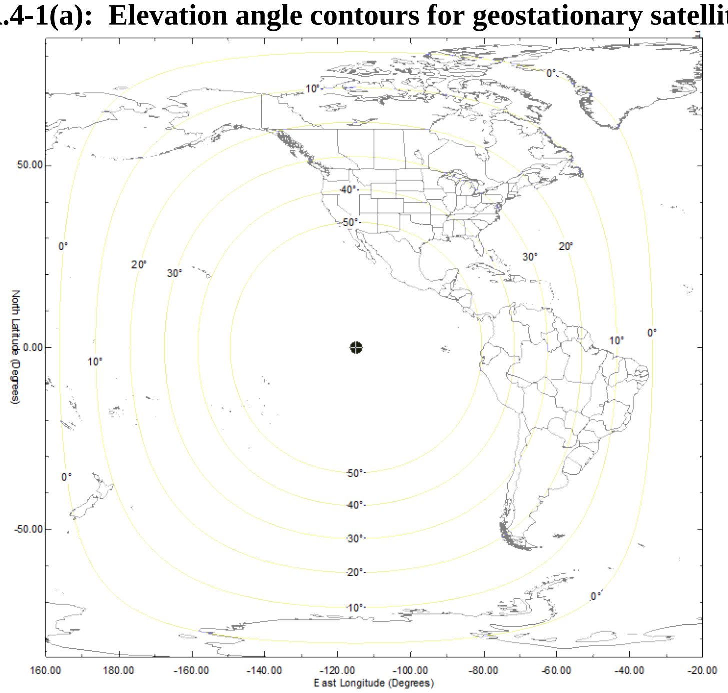
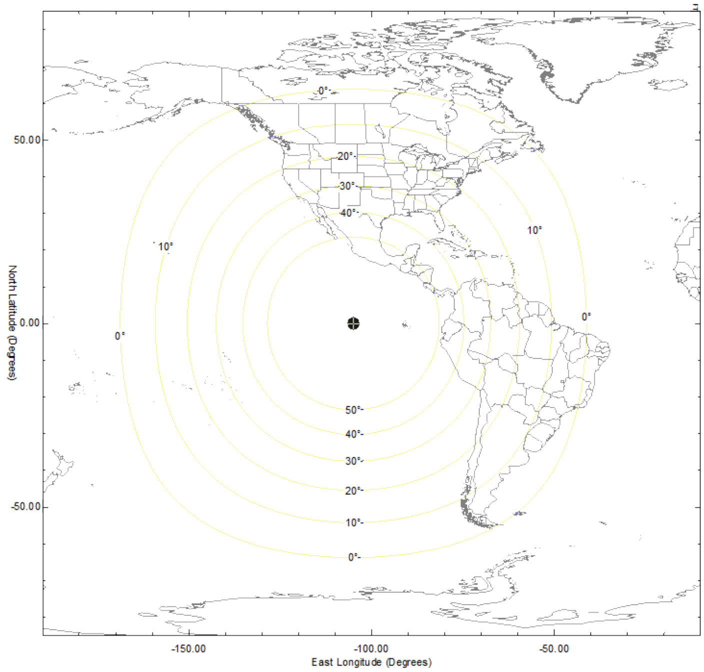


Figure A.4-1(b): Elevation angle contours for O3b satellite orbit



50.00
0.00
-50.00
North Latitude (Degrees)
-150.00
-100.00
-50.00
East Longitude (Degrees)
0°
10°
20°
30°
40°
50°

In addition, the O3b system is designed to make efficient use of spectrum and satellite power by deploying bandwidth only to where it is needed – *i.e.* to where customers are located. Rather than covering the entire visible earth, the steerable spot beams on the O3b satellites are focused on customer locations and O3b gateways only, thus maximizing the throughput between those locations and ensuring a high-performance link into the global Internet or into the public switched telephone network. This system design means that the O3b system cannot meet §25.145(c) of the Commission's rules for geographic coverage by NGSO FSS systems in the Ka-band. That rule requires coverage between 55°S and 70°N for at least 75% of every 24-hours and continuous coverage of the 50 states, Puerto Rico and the U.S. Virgin Islands. From the above elevation diagrams, it can be seen that at approximately 64° latitude the elevation from the O3b satellite orbit is zero, so service to 70°N is impossible from the O3b orbit. At 55° latitude the elevation is less than 10°, even for the sub-satellite longitude, and so service performance, although possible, would be reduced significantly in terms of achievable data rates and link availability due to blockage and particularly rain attenuation problems caused by the low elevation angle and high operating frequency. From the O3b orbit, service to the northern parts of CONUS would be just feasible, albeit with undesirably low elevation angles, and service to anything more than the very southern part of Alaska would not be possible as it is not visible to the O3b orbit. Service to Hawaii, Puerto Rico and the US Virgin Islands is possible for 100% of the time at high elevation angles.

Because the O3b network promotes a seamless global communications network, O3b respectfully requests a waiver of the Commission's geographic service requirements for the reasons set out in the legal narrative of this Application.

A.5 TT&C Characteristics (§25.202(g))

The information provided in this section complements that provided in the associated Schedule S submission.

The O3b TT&C sub-system provides for communications during pre-launch, transfer orbit and on-station operations, as well as during spacecraft emergencies. The TT&C sub-system operates at the edges of the communications uplink and downlink frequency ranges, and within the portion of Ka-band allocated to NGSO satellite systems, during all phases of the mission. This ensures consistency with §25.202(g).

During all phases of the mission, including transfer orbit, spacecraft emergencies and normal operations, the TT&C uplink signals are received by the satellite using a combination of antennas on the satellite that create a near omni-directional gain pattern. The TT&C downlink signals are also transmitted by the satellite using a combination of antennas on the satellite that create a near omni-directional gain pattern. However, for normal operations, where the spacecraft is directed towards the Earth, the minimum operational antenna gain of the TT&C downlink antenna is higher than for safe-mode operations (i.e., during transfer orbit and spacecraft emergencies).

A summary of the TT&C subsystem characteristics is given in Table A.5-1.

Table A.5-1: TT&C Performance Characteristics

Command Modulation	PCM/PSK
Command/Ranging Frequencies	29,088.5 MHz
Uplink Flux Density (Minimum)	>-80 dBW/m^2 (Command)
Polarization of Satellite Rx/Tx Antennas	Rx: LHC Tx: LHC and RHC
Telemetry/Ranging Frequencies <u>Notes:</u> 1. Each satellite is equipped with one of these frequencies. 2. Frequencies can be re-used when more than 16 O3b satellites are in operation.	19296.6 MHz 19296.8 MHz 19297.0 MHz 19297.2 MHz 19297.4 MHz 19297.6 MHz 19297.8 MHz 19298.0 MHz 19298.2 MHz 19298.4 MHz 19298.6 MHz 19298.8 MHz 19299.0 MHz 19299.2 MHz 19299.4 MHz 19299.6 MHz
Maximum Downlink EIRP	+20.5 dBW (Transfer orbit and emergency modes) +5.2 dBW (Normal mode)

A.6 Cessation of Emissions (§25.207)

Each active satellite transmission chain (channel amplifiers and associated TWTA) can be individually turned on and off by ground telecommand, thereby causing cessation of emissions from the satellite, as required by §25.207 of the Commission's rules.

A.7 Compliance with PFD Limits (§25.208(c) and §25.208(e))

The O3b system complies with all applicable FCC and ITU Power Flux Density ("PFD") limits, which are designed to protect the terrestrial Fixed Service ("FS") from downlink interference from the satellite transmissions.

The FCC's PFD limits in §25.208(c) and §25.208(e) apply in different parts of the downlink frequency bands used by O3b. §25.208(c) applies in the 18.3-18.6 GHz band and §25.208(e) applies in the 18.8-19.3 GHz band, and these PFD limits, as well as those of the ITU, are essentially the same for NGSO systems with less than 50 satellites.[9] There are no FCC PFD limits in the 17.8-18.3 GHz band that is used by O3b, although there are ITU PFD limits in Article 21 (Table 21-4) of the Radio Regulations that apply in this band and those are the same as the FCC PFD limits in §25.208(c).

Therefore, the PFD limits that can be considered to apply to all of the downlink transmissions of the O3b system are as follows:

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

Compliance with the PFD limits referenced above is demonstrated below using a simple worst-case methodology. The maximum (saturated TWTA) downlink EIRP per channel (stated in the accompanying Schedule S) for the O3b satellites is 49.7 dBW. Normally, this EIRP is spread

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9 See the formulae in §25.208(e) which contain the variable "X" which is related to the number of satellites in the NGSO constellation. In these formulae, X equals zero for an NGSO constellation of 50 satellites or less.

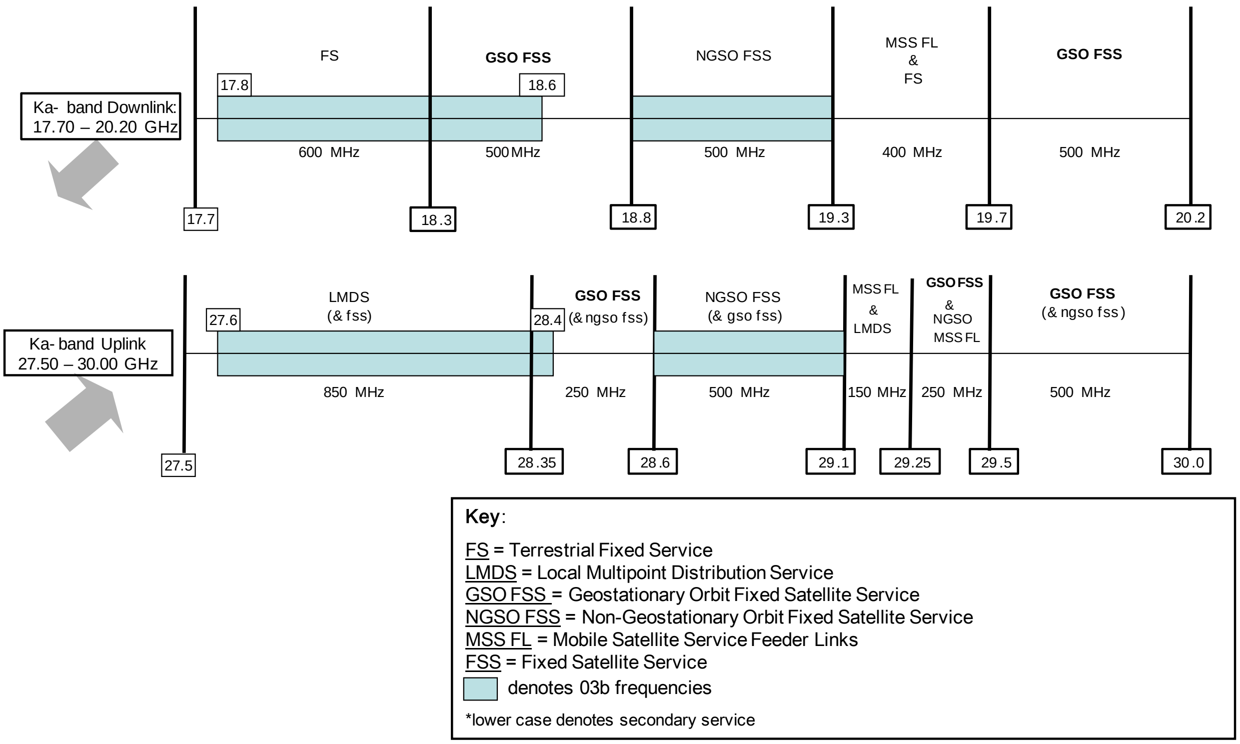
across the full channel bandwidth. However, in some situations the spread bandwidth of this signal may be reduced to 40 MHz, which would result in the maximum EIRP density being 33.7 dBW/MHz (i.e., 49.7-10*log(40)). Using this worst case value, and taking the shortest distance from the O3b satellite to the Earth's surface (8,062 km), the worst case (i.e., smallest) spreading loss is 149.1 dB. Therefore the highest PFD at the Earth's surface, for the nadir situation and for the worst case EIRP density of 33.7 dBW/MHz, is -115.4 dBW/m^2/MHz, which is less than the -115 dBW/m^2/MHz PFD limit value that applies at elevation angles of 5° and below. Therefore, compliance with the PFD limits is assured under the assumption of the maximum downlink EIRP density.

The PFD limits in the FCC rules and in the ITU Radio Regulations are defined in terms of the PFD caused by each space station (satellite). As noted above, the PFD limit values do not vary for NGSO systems with multiple operational satellites until there are more than 50 NGSO satellites in the constellation, after which the PFD limit per satellite is somewhat reduced. Therefore, the O3b system with nine active operational satellites is able to apply the same PFD limits as when there were fewer satellites in the constellation. In practice, however, the O3b satellite downlink transmissions will not exceed a PFD at the Earth's surface of -118 dBW/m^2/MHz, regardless of the angle of arrival, and this ensures significant margin against any of the PFD limits that exist, so the terrestrial Fixed Services are well protected from downlink interference from the O3b satellites.

A.8 Interference Analyses

Figure A.8-1 below shows the frequency plan for O3b together with the FCC's Ka-band frequency allocations. This is being provided to accompany the more detailed explanations of each sharing / interference scenario described in the sub-sections below.

Figure A.8-1: Frequency plan for O3b showing the FCC Ka-band frequency allocations



A.8.1 Interference Protection for GSO Satellite Networks

The O3b NGSO satellite system has been designed to provide the necessary interference protection to GSO satellite networks as required under Article 22 of the ITU Radio Regulations. Specifically, No. 22.5C defines Equivalent Power Flux Density ("EPFD") limits for the downlink transmissions from a NGSO satellite system in certain frequency ranges that must be met in order to not cause unacceptable interference to GSO satellite networks.[10] Similarly, No. 22.5D defines corresponding EPFD limits applicable to the uplinks from a NGSO satellite system.[11] No. 22.5I also defines *operational* EPFD limits applicable to the downlinks from a NGSO satellite system.

[10] These limits are referred to in the Radio Regulations as "epfd↓" limits.

[11] These limits are referred to in the Radio Regulations as "epfd↑" limits.

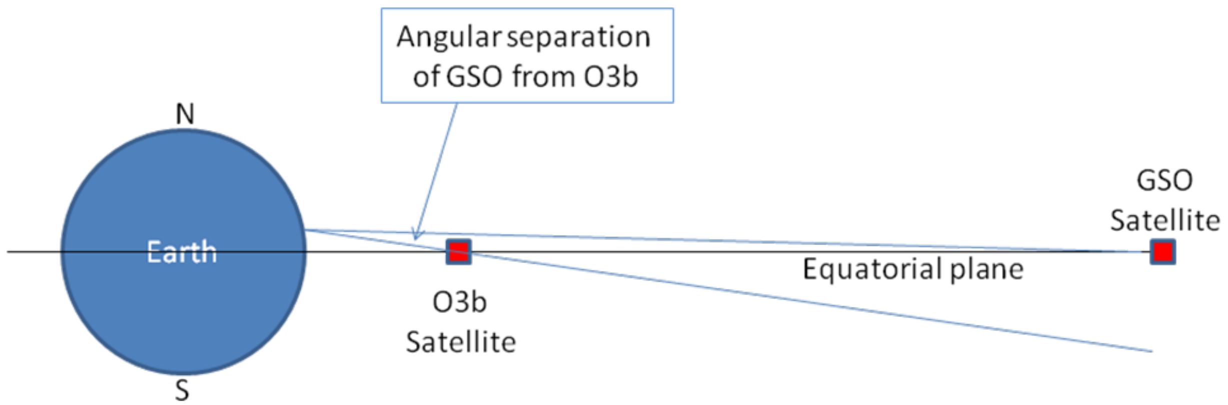
There are also EPFD limits in Article 22.5F of the Radio Regulations designed to protect GSO satellites using any frequency ranges in the opposite transmission direction.[12] O3b meets the EPFD limits that apply within the frequency ranges used by O3b, and all other obligations of the ITU Radio Regulations in this regard, including the operational limits to the downlink EPFD, within the frequency ranges where such limits apply. The frequency ranges used by O3b and in which EPFD limits apply are:

- Uplink: 27.6-28.4 GHz
- Downlink: 17.8-18.6 GHz

O3b meets the EPFD limits by constraining the uplink earth station EIRP density and the downlink PFD at the Earth's surface from the O3b system within these frequency ranges depending on the Earth latitude at which the relevant O3b earth station and satellite beam is operating. This technique effectively limits the interference to GSO satellite networks by exploiting the inherent angular separation of the O3b and the GSO orbits when viewed from the surface of the Earth at latitudes away from the equator. This angular separation also protects the O3b system from interference from GSO satellite networks at latitudes away from the equator. The angular separation geometry is shown in Figure A.8-2 below where the off-axis angle, θ, becomes larger as the latitude of the Earth location increases (either North or South of the equator).

[12] These limits are referred to in the Radio Regulations as "$epfd_{is}$" limits. They relate to the potential interference path from transmitting NGSO satellites to receiving GSO satellites.

Figure A.8-2: Inherent angular separation geometry of the O3b orbit relative to the GSO orbit for earth locations away from the equator



As an example, for a latitude of 20° (north or south) the minimum separation angle varies from 7° to 11° depending on the difference in longitude between the Earth location and the O3b satellite, with the lower value applying to the case where the O3b satellite is at a very low elevation angle (~5°) as viewed from the Earth. Thus O3b is able to operate using higher uplink and downlink power density levels further away in latitude from the equator, which means it can use smaller earth stations at higher latitudes and must use larger earth stations at lower latitudes, within these frequency ranges where EPFD limits apply. While there is no hard cut-off in terms of latitude for O3b services within these frequency ranges in order to comply with the ITU EPFD limits, for latitudes greater than 20° there are no practical constraints on O3b operations, and between 10° and 20° latitude the practical constraints are minimal. Between 5° and 10° latitude, the constraints limit the minimum size of earth station that can be used and for latitudes less than 5° the constraints are very significant and limit certain O3b service in these bands where EPFD limits apply.

Using this latitude-dependent approach, we demonstrate how the EPFD limits are met by O3b in the 17.8-18.6 GHz frequency band for two different latitudes. The first latitude to be considered is at the point closest to the equator within the service area that applies to the frequency ranges where EPFD limits apply, which is 13.0°N latitude, where the uplink and downlink power density levels are reduced below the maximum values given in the Schedule S in order to comply with the EPFD limits. The next latitude to be analyzed below is at 43°N where the maximum values of uplink and downlink power densities can be used and compliance with the EPFD limits is achieved.

For the case of the earth location being at 13°N, the minimum separation angle θ, as viewed from the surface of the Earth, varies from 5.0° to 7.5° depending on the difference in longitude between that Earth location and the O3b satellite or the GSO satellite. The lower value (5.0°) applies to the case where either the O3b satellite or the GSO satellite is at a low elevation angle (10°) as viewed from the Earth location where the EPFD is being assessed.[13] The higher value (7.5°) applies when either the O3b satellite or the GSO satellite is at the highest elevation angle as viewed from the Earth location. The EPFD analyses presented below assume the worst-case minimum separation angle of 5.0°. This separation angle applies to both the off-axis angle for the transmitting O3b earth station towards the GSO orbit as well as the off-axis angle of a GSO receiving earth station towards the O3b orbit.

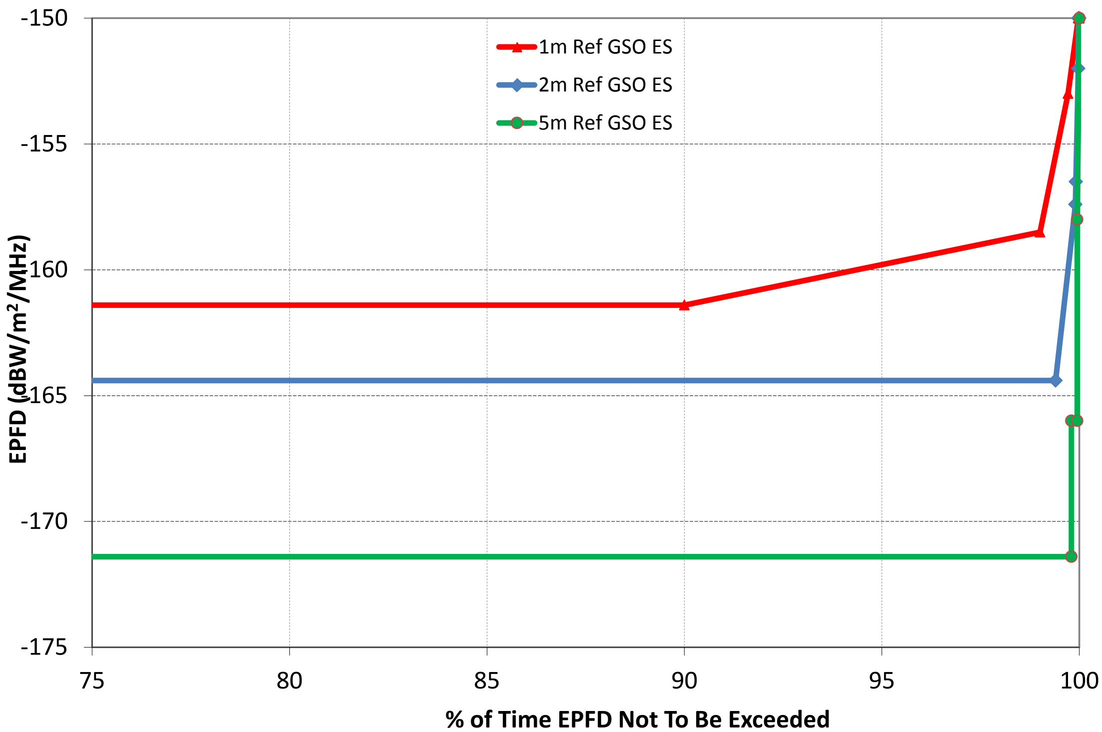
Compliance with EPFD↓ Limits

The downlink EPFD limits ("EPFD↓") are defined in terms of various EPFD levels that must not be exceeded for certain percentages of time – they are in essence statistical limits. These masks permit higher levels of EPFD↓ for shorter periods of time. The EPFD↓ limits that apply to the 17.8-18.6 GHz band are plotted in Figure A.8-3 below.[14] They consist of three different EPFD↓ masks, each of which applies to a particular reference GSO earth station antenna size: 1 meter, 2 meters and 5 meters.

[13] A 10° elevation angle to the GSO from a relatively low latitude of 13.0°N would mean that the GSO satellite is removed in longitude from the earth location being served by 70°, which is an unlikely scenario. In practice, elevation angles to the GSO from such low latitudes are likely to be significantly higher than 10°.

[14] *See* Table 22-1B in Article 22.5C of the ITU Radio Regulations. The EPFD↓ values not to be exceeded for lower percentages of time are the same as the values shown in Figure A.9-3 for 75% of the time.

Figure A.8-3: EPFD↓ limits applicable to the 17.8-18.6 GHz band



In order to fully evaluate the statistics of the resulting EPFD↓ a time domain simulation would be required. However, absolute compliance with these statistical limits can also be demonstrated using a much simpler worst-case analysis approach. This has the advantage that the results can more easily be replicated by others without having to resort to time domain simulation software. This simplified worst-case approach does not involve any approximation and it can be used to demonstrate compliance with the EPFD↓ limits with 100% certainty.

The simplified approach is to calculate the worst case EPFD↓ levels for the three sizes of reference antenna that are required in the definition of the EPFD↓ limits, and compare them to the most stringent long term values from the EPFD↓ masks (i.e., -161.4 dBW/m^2/MHz for the 1 meter reference antenna, -164.4 dBW/m^2/MHz for the 2 meter reference antenna, and -171.4

dBW/m^2/MHz for the 5 meter reference antenna). This ensures that the actual EPFD↓ always falls below all applicable EPFD↓ limits.

This worst-case analysis approach inevitably results in overstating the actual O3b EPFD↓ level relative to the EPFD↓ mask, because we are comparing the actual short-term (i.e., 100% of the time, never to be exceeded) EPFD↓ level from O3b with the mask values that apply for the longer term (i.e., for percentages of time less than 100%). Figure A.8-4 below demonstrates the degree of conservatism that is introduced by this approach. This shows one example of the computed EPFD↓ levels for the O3b system compared to the most constraining EPFD↓ mask (i.e., the one related to the 1 meter reference GSO earth station antenna). The computed EPFD in this example is for an arbitrary latitude of 14° although the shape of the EPFD↓ characteristic for O3b is consistent over a wide range of latitudes from typically 3° latitude and higher. The O3b EPFD↓ levels in Figure A.8-4 have been derived from a time-domain simulation of the O3b system using Visualyze software, consistent with ITU definitions and EPFD software requirements.[15] Figure A.8-4 shows that, when compliance is achieved for all the defined percentages of time, the most constraining EPFD↓ limit value is the one that applies for 90% and lower periods of time. From this example we can conclude the following: (a) The actual EPFD↓ levels produced by O3b are approximately 1 dB lower for 90% and lower percentages of time than the peak EPFD↓ level, and (b) there is considerable margin against the EPFD↓ limit value that applies for 100% of the time, which helps to ensure that O3b will not violate the *operational* EPFD limit values in Article 22 of the Radio Regulations.[16]

[15] See ITU-R Recommendation S.1503 entitled "Functional description to be used in developing software tools for determining conformity of NGSO satellite orbit fixed-satellite system networks with limits contained in Article 22 of the Radio Regulations".

[16] The operational EPFD limits for Ka band (see No. 22.5I and Table 22-4B) provide a single limit to be met for 100% of the time.

Figure A.8-4: Comparison of EPFD↓ levels from O3b with ITU mask values (17.8-18.6 GHz) (Red = ITU Mask; Blue = O3b Levels)(14° latitude)

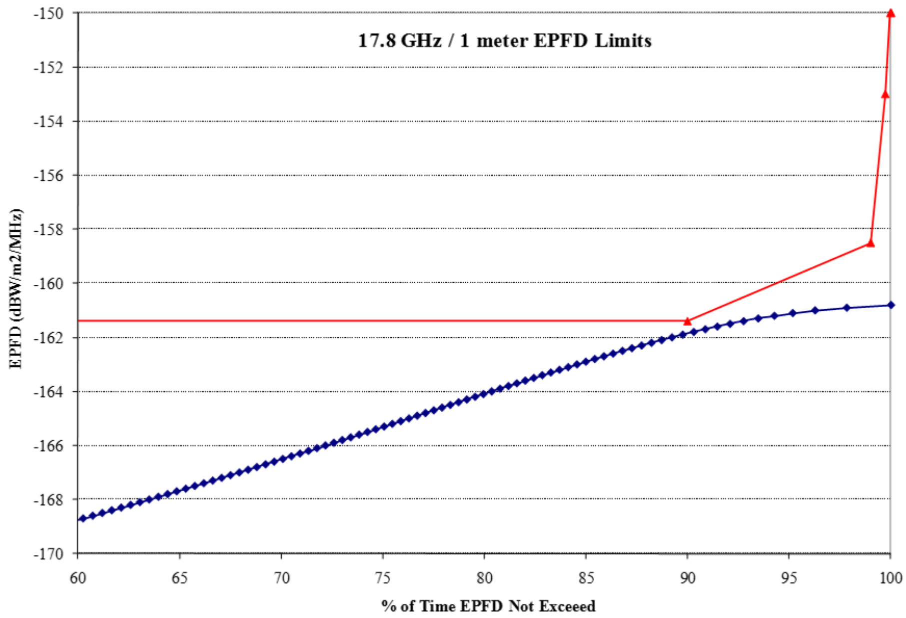


Table A.8-1 below presents the results using this approach for the 13°N case, which is the lowest latitude in the service area applicable to the frequency bands where EPFD limits apply. The maximum O3b satellite downlink EIRP density level that will be used for downlink transmissions towards 13°N is 23.1 dBW/MHz.[17] The path length and hence spreading loss from the O3b satellite to the GSO receiving earth station is based on the 10 degree elevation angle assumed for the GSO receiving earth station. The resulting PFD at the Earth's surface is then converted to EPFD↓ using the off-axis discrimination of the GSO receiving antenna prescribed in ITU-R Recommendation S.1428.1. The resulting worst-case EPFD↓ levels all meet or fall below the most stringent EPFD↓ levels from the three masks. In practice, the EPFD↓ levels from the O3b satellite have margin relative to the EPFD↓ masks, even for the 1 meter reference earth station, because the worst-case EPFD↓ levels will exist for relatively short periods of time (i.e., we are comparing the short-term EPFD↓ level from the O3b satellite with the long-term EPFD↓

[17] This value is below the maximum value given in the Schedule S for the O3b satellite system.

level from the EPFD↓ mask). As explained above, this introduces approximately 1 dB of additional margin to this calculation.

Table A.8-1: Calculation of worst-case EPFD↓ levels for 13°N

GSO Reference Earth Station Antenna Diameter			Units	Comments
1m	2m	5m		
23.1	23.1	23.1	dBW/MHz	Maximum O3b satellite downlink EIRP density
10	10	10	deg	Assumed elevation angle to GSO satellite (lowest elevation angle gives smallest separation angle and so is worst-case)
153	153	153	dB	Spreading loss from O3b satellite to Earth's surface for assumed elevation angle
-129.4	-129.4	-129.4	$dBW/m^2/MHz$	Resulting maximum PFD at Earth's surface
43.5	50.2	58.2	dBi	Peak Gain of GSO Ref ES for EPFD assessment
5.0	5.0	5.0	deg	Minimum off-axis angle between O3b and GSO orbits at 13°N latitude (for 10° minimum elevation)
11.5	11.5	11.5	dBi	Off-axis gain of GSO Ref ES based on ITU Recommendation S.1428-1
32.0	38.7	46.7	dBi	Off-axis discrimination of GSO Ref ES
-161.4	-168.1	-176.1	$dBW/m^2/MHz$	Maximum EPFD↓ due to O3b satellite downlink
-161.4	-164.4	-171.4	$dBW/m^2/MHz$	Most stringent EPFD↓ limit
0.00	3.72	4.68	dB	Margin to most stringent EPFD↓ limit

Table A.8-2 below gives the corresponding EPFD↓ analysis for an Earth latitude of 43°N, and demonstrates that, at this latitude, the maximum downlink EIRP density level of 33.7 dBW/MHz still results in compliance with the EPFD↓ limits.[18] The resulting worst-case EPFD↓ levels all fall below the most stringent EPFD↓ levels from the three masks.

[18] Note that the highest maximum downlink EIRP density level given in tab S13 of the associated Schedule S, which is an EIRP of 47.7 dBW spread over a bandwidth of 40 MHz, corresponds to a maximum EIRP density of 31.7 dBW/MHz which is 2 dB lower than the value used here to calculate the EPFD levels at 43°N latitude. This provides additional margin against the EPFD↓ limits.

Table A.8-2: Calculation of worst-case EPFD↓ levels for 43°N

GSO Reference Earth Station Antenna Diameter			Units	Comments
1m	2m	5m		
33.7	33.7	33.7	dBW/MHz	Maximum O3b satellite downlink EIRP density
10	10	10	deg	Assumed elevation angle to GSO satellite (lowest elevation angle gives smallest separation angle and so is worst-case)
153	153	153	dB	Spreading loss from O3b satellite to Earth's surface for assumed elevation angle
-118.8	-118.8	-118.8	$dBW/m^2/MHz$	Resulting maximum PFD at Earth's surface
43.5	50.2	58.2	dBi	Peak Gain of GSO Ref ES for EPFD assessment
13.5	13.5	13.5	deg	Minimum off-axis angle between O3b and GSO orbits at 43°N latitude (for 10° minimum elevation)
0.7	0.1	0.1	dBi	Off-axis gain of GSO Ref ES based on ITU Recommendation S.1428-1
42.8	50.1	58.1	dBi	Off-axis discrimination of GSO Ref ES
-161.6	-168.9	-176.9	$dBW/m^2/MHz$	Maximum EPFD↓ due to O3b satellite downlink
-161.4	-164.4	-171.4	$dBW/m^2/MHz$	Most stringent EPFD↓ limit
0.16	4.53	5.49	dB	Margin to most stringent EPFD↓ limit

The above calculation of the worst-case EPFD↓ levels produced by the O3b satellites is based on the single entry from one downlink beam on one O3b satellite. We demonstrate below that, for the planned "9+3" satellite O3b constellation that will exist after the next O3b launch, the aggregate worst-case EPFD↓ level is less than 1 dB higher than the worst-case EPFD↓ level resulting from the single-entry calculation above.

Regarding the potential multiple entry from other beams on the same O3b satellite, note the following:

(i) Each O3b satellite only re-uses the same frequency on the same polarization between the gateway and user beams. No spatial frequency reuse takes place between user beams or between gateway beams on the same O3b satellite.

(ii) There has to be considerable geographic separation between co-frequency, co-polar gateway and user beams on the same O3b satellite, otherwise the gateway beam and user beam would interfere with each other. This minimum geographic separation must be sufficient to ensure that the unwanted contribution from the adjacent O3b downlink beam is at least 15 dB below the intended O3b downlink transmission. This ensures that the aggregate of both the user and gateway downlink transmissions from a single O3b satellite cannot be more than approximately 0.13 dB (i.e., the contribution of a -15 dB sidelobe from the other beam) more than the single entry, even if both the user and gateway downlink beams were both causing the same single-entry EPFD↓ level.

(iii) Allowing for the minimum cross-polar isolation of the O3b satellite downlink beam of 18.5 dB (see accompanying Schedule S and Section A.11 below), if the cross-polar channel was being used in a beam that was also pointed towards the victim GSO receiving earth station, then the increase in interference due to the cross-polar component would be 0.06 dB.

(iv) Therefore the combination of the co-polar and cross-polar frequency re-use in a single O3b satellite (items (ii) and (iii) above) would only add, in the worst-case, approximately 0.2 dB to the single-entry EPFD↓ levels calculated above.

Regarding the potential contributions to the overall EPFD↓ levels from the other O3b satellites, Table A.8-3 below gives the number of simultaneously visible O3b satellites, and their associated off-axis angle from the worst-case pointing direction of the GSO receiving earth station. This shows data for the two latitudes (13°N and 43°N) considered in the EPFD↓ analysis above, and for the case of nine active O3b satellites which is relevant for the "9+3" configuration which will exist after the next O3b launch.

Table A.8-3: Off-axis angles of visible O3b satellites for worst-case geometry situation

O3b Satellite	Off-Axis Angle (deg) at Various Latitudes	
	13°N latitude	43°N latitude
1st adjacent O3b satellite to GSO location	5.0	13.5
2nd adjacent O3b satellite to GSO location	56.5	52.3
3rd adjacent O3b satellite to GSO location	120.8	105.0
4th adjacent O3b satellite to GSO location	(not visible)	(not visible)

Note that, for both latitudes considered, a maximum of three O3b satellites are simultaneously visible when the GSO earth station is pointed towards its corresponding GSO satellite at an elevation angle of 10°. However, the off-axis angles from the O3b satellites other than the closest one are extremely large and hence the EPFD↓ contribution from these other O3b satellites is small. To quantify this, consider that the off-axis gain of the GSO receiving earth station beyond 50° off-boresight is at least 20 dB lower than the off-axis gain used for the case of 13°N latitude and at least 10 dB lower than the off-axis gain used for the case of 43°N latitude.[19] Taking the worse of these two cases as far as multiple O3b satellite aggregation is concerned, which is the 43°N latitude case, the contribution from two additional O3b satellites at 10 dB lower levels than the closest O3b satellite used in the single-entry calculation of EPFD↓ above, results in worse case increase in the aggregate EPFD↓ of 0.8 dB compared to the single entry calculation. For the 13°N case the increase due to multiple O3b satellite aggregation is only 0.09 dB.

Therefore, the combined aggregation effect of the EPFD↓ from frequency re-use within a single O3b satellite and due to several simultaneously visible O3b satellites, is less than 1 dB (0.2 dB intra-satellite and 0.8 dB intra-system). This is comparable to the 1 dB of conservatism inherent in the EPFD calculation approach used above where the most stringent EPFD↓ limit value is compared against the short-term O3b EPFD↓ level.

<u>Compliance with EPFD↑ Limits</u>

The uplink EPFD limits ("EPFD↑") in the ITU Radio Regulations are defined in a simpler manner than the EPFD↓ limits as they are not statistical in nature – instead a level of EPFD↑ is stated which must never be exceeded. The EPFD↑ limit that applies to the 27.5-28.6 GHz band is given as an aggregate PFD level of -162 dBW/m^2/40kHz at the GSO.[20] The aggregate nature of the EPFD↑ limit is taken into account by defining a reference GSO satellite receive beam that can be pointed to any part of the visible Earth's surface.[21]

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[19] According to ITU-R Recommendation S.1428.1.

[20] *See* Table 22-2 in Article 22.5D of the ITU Radio Regulations.

[21] The GSO satellite reference antenna applicable to the ITU's EPFD↑ limit in the 27.5-28.6 GHz band has a -3 dB beamwidth of 1.55° and side lobes according to ITU-R Recommendation S.672-4 with the relative level of the first side lobe set to -10 dB.

The EPFD↑ analysis below is based on a single-entry approach which means the worst-case EPFD↑ caused by a single transmitting O3b earth station is calculated. The resulting single-entry EPFD↑ level is at least 3 dB below the EPFD↑ limit to allow for aggregation effects from multiple O3b transmitting earth stations into the GSO satellite antenna reference beam. This allowance of 3 dB between the single-entry and aggregate EPFD↑ level is more than sufficient for the following reasons (some of which have been discussed above in the context of the aggregation of EPFD↓ levels from the frequency re-use within the O3b system):

- Each O3b satellite only re-uses the same frequency on the same polarization between the gateway and user beams. No spatial frequency reuse takes place between user beams or between gateway beams on the same O3b satellite.
- There has to be considerable geographic separation between co-frequency, co-polar gateway and user beams on the same O3b satellite, otherwise the gateway beam and user beam would interfere with each other. This minimum geographic separation between beams centers corresponds to approximately the reference beamwidth of the GSO satellite antenna used to define EPFD↑ in the Radio Regulations. This ensures that the aggregate of both the user and gateway uplinks towards a single O3b satellite cannot be more than approximately 2 dB more than the single entry, even if they were both causing the same single-entry EPFD↑ level.
- Even with nine active operational O3b satellites, the geocentric angular separation between adjacent satellites is 40° which is large enough to ensure that the worst-case EPFD↑ level is dominated by O3b uplink transmissions to one O3b satellite at a time. The simultaneous transmissions to other O3b satellites involve a much larger off-axis angle and therefore much lower EPFD↑ level contribution.

Table A.8-4 below presents the single-entry EPFD↑ results for the transmissions from the O3b transmitting earth stations for the 13°N case, which is the lowest latitude in the service area applicable to the frequency bands where EPFD limits apply. The maximum power spectral density ("PSD") into a transmitting O3b earth station antenna at this latitude is -60 dBW/Hz under clear-sky conditions.[22] In the calculation below, the PFD at the GSO is calculated using the antenna gain at the worst-case off-axis angle and a spreading loss of 163 dB to the GSO which applies for the 10° elevation case. For a single entry interferor the PFD is equal to the EPFD↑. The resulting worst-case EPFD↑ level falls below the EPFD↑ limit value with a margin of 3.5 dB. This allows adequate margin for any aggregation effects due to multiple co-frequency transmitting O3b earth stations, as explained above.

Table A.8-4: Calculation of worst-case single-entry EPFD↑ level for 13°N

Value	Units	Comments
-60.0	dBW/Hz	Maximum PSD into O3b transmitting ES antenna (clear-sky)
-14.0	dBW/40kHz	Maximum PSD into O3b transmitting ES antenna (clear-sky)
5.0	deg	Minimum off-axis angle between O3b and GSO orbits at 13°N latitude (for 10° minimum elevation)
11.5	dBi	Off-axis gain of O3b transmitting ES antenna (meets 29-25log(θ))
163	dB	Assumed spreading loss from O3b transmitting ES to GSO orbit (at 10° elevation)
-165.5	dBW/m^2/40kHz	Resulting maximum PFD at GSO orbit from O3b transmitting ES (clear-sky or rain-fade conditions)
-162	dBW/m^2/40kHz	EPFD↑ limit
3.5	dB	Margin to EPFD↑ limit (single-entry)

Table A.8-5 below gives the corresponding EPFD↑ analysis for an Earth latitude of 43°N, and demonstrates that, at this latitude, a maximum PSD level of -50 dBW/Hz into the transmitting O3b earth station still results in compliance with the EPFD↑ limits with margin for any aggregation effects.

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[22] Under rain-fade conditions uplink power control may be used with an O3b transmitting earth station but this will not result in increased EPFD↑ levels at the GSO because the rain attenuation will apply equally to the wanted and interfering signal paths for such small off-axis angles.

Table A.8-5: Calculation of worst-case single-entry EPFD↑ level for 43°N

Value	Units	Comments
-50.0	dBW/Hz	Maximum PSD into O3b transmitting ES antenna (clear-sky)
-4.0	dBW/40kHz	Maximum PSD into O3b transmitting ES antenna (clear-sky)
13.5	deg	Minimum off-axis angle between O3b and GSO orbits at 43°N latitude (for 10° minimum elevation)
0.7	dBi	Off-axis gain of O3b transmitting ES antenna (meets 29-25log(θ))
163	dB	Assumed spreading loss from O3b transmitting ES to GSO orbit (at 10° elevation)
-166.2	$dBW/m^2/40kHz$	Resulting maximum PFD at GSO orbit from O3b transmitting ES (clear-sky or rain-fade conditions)
-162	$dBW/m^2/40kHz$	EPFD↑ limit
4.2	dB	Margin to EPFD↑ limit (single-entry)

Compliance with EPFD(is) Limits

The EPFD(is) limits in the ITU Radio Regulations are intended to protect frequency ranges that are allocated bi-directionally (i.e., for both uplinks and downlink) in the ITU Radio Regulations. In Ka-band, such allocations exist in the 17.8-18.4 GHz band, where a receiving satellite might experience interference from the unintended emissions of a transmitting satellite.

The EPFD(is) limits are similar to the EPFD↑ limits in that they consist of a single, never to be exceeded, EPFD level at the GSO. Details of the EPFD(is) limits and how O3b complies with them is given in Annex 2 of this document.

Ka-Band Frequency Ranges Where No EPFD Limits Exist

Note that the O3b satellite frequency plan includes 12 of the 20 transponders within the above listed frequency ranges where EPFD limits apply. The remaining eight transponders operate within the 28.6-29.1 GHz uplink and 18.8-19.3 GHz downlink frequency bands, which are allocated to NGSO satellites on a primary basis according to the FCC's Ka-band frequency plan, with GSO satellite networks operating on a secondary basis in the 28.6-29.1 GHz range and on a non-conforming basis in the 18.8-19.3 GHz range. According to ITU procedures applicable to these frequency ranges (No. 9.11A), coordination between NGSO and GSO networks is on a first-come, first-served basis, depending on the ITU date priority of the relevant ITU filings. O3b has made significant progress in pursuing bilateral coordination arrangements with other GSO satellite operators and their administrations concerning networks in these frequency ranges, with only a few cases remaining for completion.

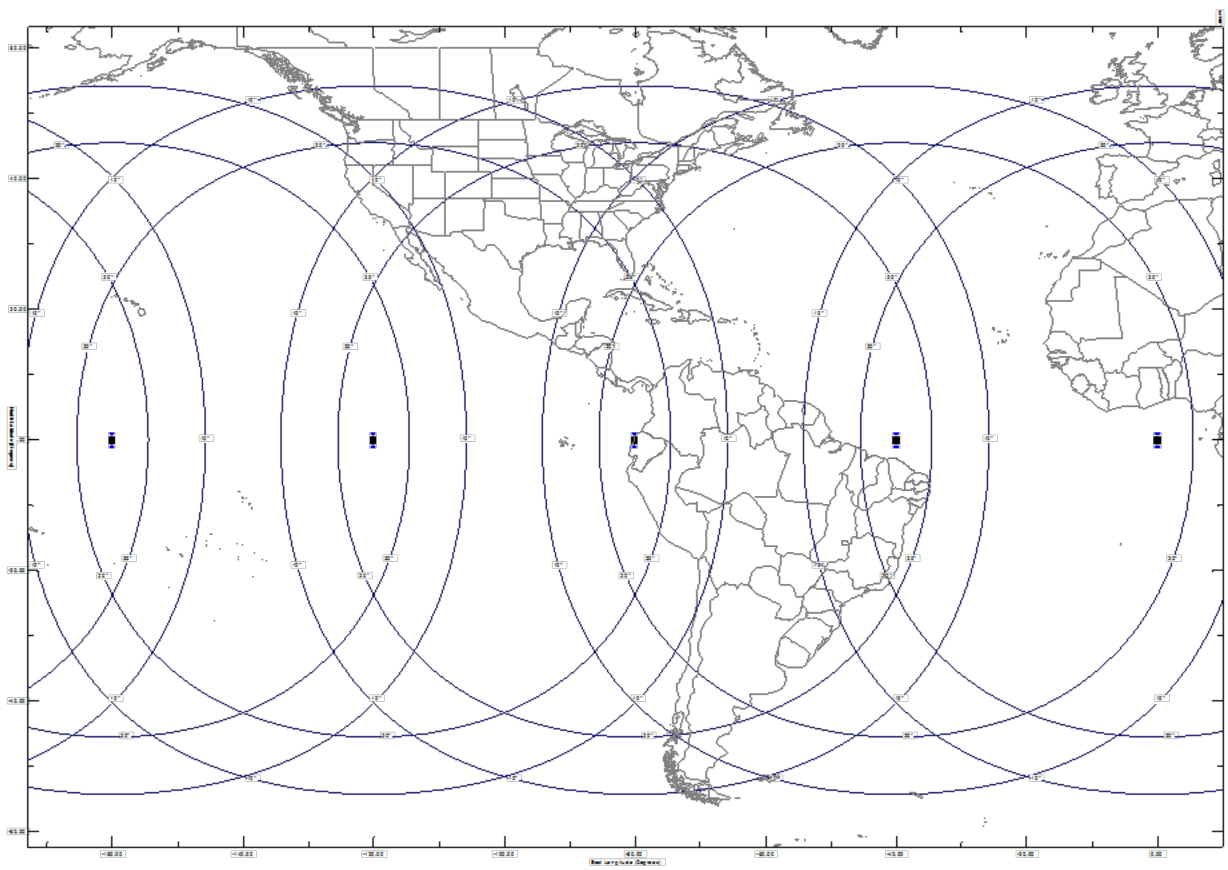
A.8.2 Interference with Respect to Other NGSO Satellite Systems

According to ITU procedures (No. 9.12), for all of the Ka-band frequency ranges to be used by O3b, coordination between NGSO systems and other NGSO systems is on a first-come, first-served basis, depending on the ITU date priority of the relevant ITU filings. O3b has made significant progress in pursuing bilateral coordination arrangements with other NGSO satellite operators and their administrations.

Under FCC rules (§25.261), sharing between NGSO satellite systems in the 28.6-29.1 GHz uplink and 18.8-19.3 GHz downlink bands should be achievable, using whatever means can be coordinated between the operators to avoid in-line interference events, or by resorting to band segmentation in the absence of any such coordination agreement. The O3b orbit is inherently well isolated from in-line interference events with respect to certain types of other NGSO orbits, particularly those involving highly elliptical orbit geometries, as explained further below. For more generic NGSO satellite systems, the O3b system is capable of employing satellite diversity in order to be able to share spectrum, as explained below.

After the next launch of four additional O3b satellites, the O3b constellation will be operated in a "9+3" configuration with nine active satellites spaced evenly around the O3b orbit, spaced 40° apart. As explained in Section A.12 below, the addition of four satellites will enhance O3b's ability to use satellite diversity to share spectrum with NGSO satellite networks, in addition to expanding the network's capacity and resiliency. Figure A.8-4 below shows the instantaneous elevation angle contours (10° and 20°) from the Earth's surface to the O3b constellation of nine evenly spaced satellites. From this, it can be seen that two or more O3b satellites are always visible over a wide range of latitudes (up to more than 40°N and S) with elevation angles in excess of 10°. With several O3b satellites simultaneously visible at all times the use of satellite diversity is technically feasible. As more satellites are launched into the equatorial O3b orbit, the ability to employ satellite diversity in the O3b system improves as more alternative path O3b satellites are visible.

Figure A.8-4: Instantaneous elevation angle contours for O3b constellation (9 evenly spaced satellites)



At higher latitudes, where O3b's satellite diversity capability is more limited, the most likely O3b earth station type will be large stations which have very narrow beamwidths. Therefore, in these cases, the probability of interference to or from the O3b earth station, with respect to other types of NGSO systems, will be extremely low and the potential periods of interference (particularly for LEOs which are moving very fast relative to the Earth surface) will be of extremely short duration. In these types of very rare situations, O3b is capable of implementing a band-segmentation scheme with respect to the other NGSO system in order to be compliant with §25.261. Therefore, O3b is confident that it can achieve the necessary coordination with other NGSO satellite systems, as necessary.

Currently, there are no other NGSO satellite systems licensed by the Commission, or granted market access in the USA, that operate within the Ka-band frequency ranges to be used by O3b. Despite no longer being active licenses, the most recent NGSO systems to be licensed by the Commission for operation in the O3b frequency ranges were ATCONTACT Communication's 3-satellite HEO-type NGSO system and Northrop Grumman's 3-satellite HEO-type NGSO system ("GESN"). From this, we conclude that a likely orbit configuration for other NGSO systems involves HEO-type orbits, and these are very compatible with the O3b orbit because there is an inherent large angular separation of the HEO and O3b orbits when viewed from the respective service areas of the two types of systems, as demonstrated in more detail below.

The ATCONTACT and GESN systems had similar technical characteristics, and they were in fact identical in some key respects pertinent to the assessment of compatibility with O3b. Both of these proposed HEO systems had a minimum operational altitude of 16,000 km, which corresponds to a minimum operational latitude of 32°N. This results in the minimum separation angle between the HEO orbit and the O3b orbit as viewed from the Earth's surface, for any possible earth station location within the visible service area of these HEO systems, of 32.7°. This angle occurs for the most southern point in the HEO service area (~20°S). For earth locations in the northern hemisphere, the minimum separation angle is 43.2°. Such a large separation angle would prevent interference between O3b and such HEO-type systems.

A.8.3 Interference with Respect to Terrestrial Networks in the 17.8-18.3 GHz Band

Part of the Ka-band spectrum to be used by the O3b system is the 17.8-18.3 GHz band, which is allocated on a primary or co-primary basis, according to the US table of frequency allocations, to terrestrial fixed service ("FS") systems in the USA.[23] These systems are individually site licensed by the FCC under Parts 74F, 78 and 101 of the FCC's rules. O3b is seeking authority to use this band on a non-conforming basis, as described in the legal narrative portion of the application.

In the 17.8-18.3 GHz band, which O3b uses in the space-to-Earth direction, the only potential interference path is from the transmitting FS station into the sidelobes of an O3b receiving earth station antenna. In the unlikely event that potential interference would be caused to the O3b earth station by FS activity in the area, O3b or the O3b customer will accept any such interference and take the necessary measures to prevent it from impacting the earth station operations. Such necessary technical measures may include adjusting the minimum operational elevation angles, frequency avoidance, power level adjustment, earth station shielding or some combination thereof.

Existing PFD limits in §25.208, which apply to the frequency range 18.3-18.8 GHz and to which the O3b satellites conform as demonstrated in Section A.7 of this document, are intended to adequately protect FS receivers in this band from harmful interference from satellite downlinks. As explained in Section A.7 above, the ITU PFD limits extend across the entire 17.8-18.8 GHz band with the objective of protecting terrestrial FS receivers, and therefore it can be assumed that O3b's compliance with these limits will protect FS receivers from O3b satellite downlink interference across the entire 17.8-18.3 GHz band.

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[23] From 18.3-18.58 GHz, according to §101.85(b)(1) of the FCC rules, terrestrial licensees were transitioned out of this band as of November 19, 2012. From 18.58-19.3 GHz, according to §101.85(b)(2), terrestrial licensees were transitioned out as of June 8, 2010 or October 31, 2011, depending on the type and frequency of operation of the FS system.

A.8.4 Interference with Respect to Terrestrial Networks in the 27.6-28.35 GHz Band

The O3b system also uses the 27.6-28.35 GHz band which is allocated by the Commission's 28 GHz First Report and Order, to the terrestrial LMDS (Local Multipoint Distribution System) service on a primary basis and to the fixed-satellite service on a secondary basis in the USA.[24] These systems are licensed by the FCC on a geographic area basis. As O3b uses this frequency band in the Earth-to-space direction with a minimum uplink elevation of 5°, the only potential interference path is from the sidelobes of the transmitting O3b earth station into the LMDS receivers.

Regarding §2.105(c)(2)(i), uplinks from gateway earth stations that are located in the United States must be operated in a manner such that they do not cause harmful interference to any current or future licensed LMDS station. O3b has procedures in place to protect LMDS operations in the 27.6-28.35 GHz frequency band.

Earth station applications that propose to transmit to O3b's system in the 27.6-28.35 GHz band routinely include a showing addressing LMDS protection. These showings have included a report from Comsearch confirming that LMDS licensees that potentially could be affected have been notified and have not objected to O3b's operations. In the unlikely event that an LMDS link could be interfered with, O3b will work cooperatively with the LMDS licensee to ensure that the LMDS link is protected. O3b is prepared to take necessary technical measures to avoid harmful interference such as adjusting the transmit elevation angles, frequency avoidance, uplink power adjustment, earth station shielding, or some combination thereof.

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[24] *See* 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 29.5-30.0 GHz Frequency Band, to Establish Rules and Policies for Local Multipoint Distribution Service and for Fixed Satellite Service, *First Report and Order and Fourth Notice of Proposed Rulemaking*, CC Docket No. 92-297, 11 FCC Rcd 19005 (1996) (*28 GHz First Report and Order*).

§2.105(c)(2)(ii) requires O3b, as a secondary user, to accept incoming interference from a primary user. Transmitting LMDS stations cannot cause harmful interference into the O3b receiving earth station since the earth station does not receive transmissions in the 27.6-28.35 GHz band. Harmful interference occurring from the aggregation of transmitting LMDS stations into a receiving spot beam of the satellite is considered to be very unlikely; however O3b undertakes to accept this risk and will not seek protection from such interference in the event it occurs.

A.9 ITU Filings for O3b

The O3b satellite system is registered with the ITU by the United Kingdom administration. The original Advance Publication Information ("API") filing for the O3B-A system was submitted to the ITU on 23 October 2007 and published in IFIC 2608 on 27 November 2007 as API/A/4800. The initial Coordination Request ("CR") filing was submitted to the ITU on 23 April 2008 and published in IFIC 2626 on 19 August 2008 as CR/C/2209 and in IFIC 2632 on 11 November 2008 as CR/C/2209 MOD-1. In addition, O3b has filed and had published the Resolution 49 information (IFIC 2757 dated 12 November 2013), and the United Kingdom Office of Communications (Ofcom) has submitted its Notification information to the ITU on 7 October 2014, which is expected to be published by the ITU as a Part I-S in IFIC 2782 on 11 November 2014.

A.10 Coordination with the US Government Satellite Networks (Footnote US334 in the FCC Table of Frequency Allocations)

US334 requires coordination of the O3b system with US government satellite networks, both GSO and NGSO.

Coordination between the O3B-A NGSO satellite system (allowing for up to 24 satellites), as filed with the ITU and as described in this application, and the US government satellite networks (including both GSO and NGSO networks, as well as their associated specific earth stations filed under 9.7A and 9.7B of the ITU Radio Regulations through other administrations) has been formally completed and the FCC is in possession of the confidential coordination agreement.

A.11 Cross-Polar Isolation of the Satellite Antennas (§25.210(i)(1))

Section S7 of the associated Schedule S submission states that the minimum cross-polar isolation ("XPI") of the O3b satellite transmit and receive antennas is 18.5 dB. This is less than the 30 dB requirement stated in §25.210(i)(1). This is a result of the innovative O3b satellite and system design which results in inevitable compromises in certain aspects to achieve overall optimum performance. The shortfall in the XPI relative to §25.210(i)(1) will not be a problem for O3b or other users of the spectrum for the following reasons:

(i) The XPI value of 18.5 dB is the worst case value for either of the gateway beams that will be used to communicate with the US gateway/TT&C earth stations. This minimum value occurs only in limited geographic areas and only for certain limited pointing directions of the beam.

(ii) For O3b's own links this level of XPI performance has been taken into account and there will be negligible degradation to service quality. Because of the nature of the ACM, during the short periods where the antenna XPI performance might degrade the link the ACM scheme is able to make a slight reduction in data rate to compensate, but this will have minimal impact on the overall average data rate, and will not impact the available data rates offered at higher availabilities. This degradation due to XPI will be so small as to still allow for a very efficient 8PSK modulation scheme to be used during these periods.

(iii) The XPI performance will not prevent full frequency re-use of the spectrum from being achieved, as required by §25.210(d).

(iv) As the O3b system uses both senses of circular polarization (RHCP and LHCP) then there is no scenario where a certain level of XPI performance would achieve interference isolation between the O3b system and any other space or terrestrial systems. It is the co-polar transmissions that will dictate the interference levels to and from other systems, not the level of cross-polar radiation.

(v) The only situation where the XPI performance of a satellite antenna can impact the interference between satellite networks (GSO or NGSO), or between satellite and terrestrial systems, is when the associated earth station (or terrestrial terminal) has its antenna pointed directly at the interfering or interfered-with satellite. Only then is the polarization purity of the earth station high enough for the XPI of the satellite antenna to be a significant factor on the interference level. In all interference situations where the satellite is located at some angle away from the boresight of the earth station (or terrestrial terminal) the very poor XPI of the earth station (or terrestrial terminal) dominates the interference calculation. This latter situation is the case for all interference interaction between the O3b system and other GSO networks or terrestrial systems. Therefore the shortfall in XPI for the O3b satellite antenna will have no impact on the interference to or from other networks and systems.

O3b therefore respectfully requests a waiver of the Commission's rule concerning XPI (§25.210(i)(1)) on the basis that it will not be a problem for O3b or impact any other user of the spectrum.

A.12 Impact of Adding More Satellites to the O3b Constellation

Increasing the number of satellites in the O3B-A constellation will not in practice consume more of the orbit-spectrum resource. This assertion is based on the following:

(i) The O3b system will comply, where necessary, with the ITU EPFD limits, which determine its ability to share spectrum with GSO satellite networks. This is the case whether there are eight or twelve or, for that matter, any number of O3b satellites in orbit. As demonstrated in Section A.8.1 above for the case of the "9+3" O3b constellation, which will exist after the next O3b launch, any aggregation effects due to multiple O3b satellites has a very minor impact on the overall EPFD levels produced by the O3b system, and the O3b system as a whole will comply with the EPFD limits. See Section A.8.1 above.

(ii) In frequency bands where EPFD limits do not apply, O3b's ability to share spectrum with GSO satellite networks will be improved when O3b has more satellites in orbit. This is because the O3b system will be more capable of using satellite diversity to overcome otherwise insurmountable interference situations with GSO satellite networks, because more O3b satellites will be simultaneously visible. See Section A.8.1 above.

(iii) The O3b system will similarly be in a better position to share spectrum with other NGSO satellite systems when it has more satellites in orbit. As for the GSO case mentioned in (ii) above, this is because the O3b system will be more capable of using satellite diversity to overcome otherwise insurmountable interference situations with other NGSO satellite systems. See Section A.8.2 above.

(iv) The O3b system in the "9+3" constellation configuration will comply with the ITU and FCC PFD limits that are designed to protect terrestrial FS systems from interference caused by satellite downlink transmissions. See Section A.7 above.

(v) The launch of additional O3b satellites in orbit will not impact any frequency sharing between earth stations using the O3b satellite system and terrestrial FS systems. More O3b satellites could potentially mean additional O3b earth stations, but the coordination of each O3b earth station is handled on a case-by-case basis with the FS where this is necessary.

A.13 Maximum Saturation Flux Density At Beam Peak (§25.114(c)(4)(v))

Schedule S, Section S7, column p shows the minimum saturation flux density ("SFD") values at beam peak for receiving beams fed into transponders. Three minimum SFD values are shown in Schedule S, Section S7, column p, *i.e.*, -98, -101 and -92 dBW/m^2. In each case, the corresponding maximum SFD value is 14 dB higher, *i.e.*, the corresponding maximum SFD values are -84, -87 and -78 dBW/m^2, respectively.[25]

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[25] Schedule S, Section S7 has a column for entering minimum saturation flux density values but Schedule S does not have a place for entering maximum saturation flux density values. For this reason, O3b is providing the maximum saturation flux density values in this technical supplement.

ANNEX 1

O3b Spacecraft Reconfigurability

The normal operating configuration of the O3b spacecraft is with two gateway beams that are each connected to five user beams. The gateway-to-user link is designated the "Forward" link and the user-to-gateway link is designated the "Return" link. This standard configuration is shown in the first two rows of Table A-1 below. Other spacecraft configurations are shown in the rows following which allow for up to four of the (normally user) beams to be configured as gateway beams to provide greater flexibility to address different traffic requirements. Whenever one of these flexible beams is configured as a gateway beam then there is one less user beam available. These additional gateway configuration possibilities, in terms of connectivity between gateway and user beams, are shown in rows 3 to 6 of Table A-1 below, resulting in a maximum of six gateway beams that can be operated, with each one connected to one user beam. An additional capability is denoted in Table A-1 where up to four of the user beams may be connected back to themselves to provide intra-beam connectivity. All of the possible configurations shown in Table A-1 are captured in Tab S10 of the associated Schedule S.

Table A-1: Gateway-to-user beam configuration possibilities for each O3b satellite

		User beams									
		1*	2	3*	4	5*	6	7	8*	9	10
Gateway beams	1	X	X	X	X	X					
	2						X	X	X	X	X
	3				X	X		X			
	4			X				X			
	5								X		
	6				X						

Notes:

1. An "X" in the above table indicates a possible connectivity between gateway and user beams.
2. Normal mode of operation consists of the first two rows of the table only.
3. Designated User beams denoted with "*" may be connected back to the same antenna with no gateway connectivity

ANNEX 2

EPFD(is) Analysis for O3b

In this annex we demonstrate that the O3b system complies with the EPFD(is) limits in the ITU Radio Regulations. These limits are contained in Article 22.5F, Table 22-3 of the Radio Regulations, which has been copied below:

22.5F 4) The equivalent power flux-density[18], $epfd_{is}$, produced at any point in the geostationary-satellite orbit by emissions from all the space stations in a non-geostationary-satellite system in the fixed-satellite service in the frequency bands listed in Table **22-3**, including emissions from a reflecting satellite, for all conditions and for all methods of modulation, shall not exceed the limits given in Table **22-3** for the specified percentages of time. These limits relate to the equivalent power flux-density which would be obtained under free-space propagation conditions into a reference antenna and in the reference bandwidth specified in Table **22-3**, for all pointing directions towards the Earth's surface visible from any given location in the geostationary-satellite orbit. (WRC-2000)

TABLE **22-3** (WRC-2000)

Limits to the $epfd_{is}$ radiated by non-geostationary-satellite systems in the fixed-satellite service in certain frequency bands[19]

Frequency band (GHz)	$epfd_{is}$ (dB(W/m^2))	Percentage of time during which $epfd_{is}$ level may not be exceeded	Reference bandwidth (kHz)	Reference antenna beamwidth and reference radiation pattern[20]
10.7-11.7 (Region 1) 12.5-12.75 (Region 1) 12.7-12.75 (Region 2)	–160	100	40	4° Recommendation ITU-R S.672-4, L_s = –20
17.8-18.4	–160	100	40	4° Recommendation ITU-R S.672-4, L_s = –20

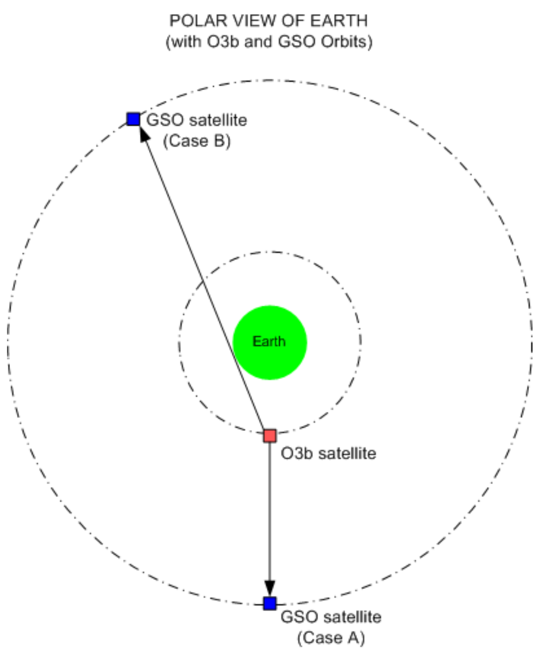
These limits apply to the O3b system in the 17.8-18.4 GHz band which is part of the frequency range where the EPFD↓ limits also apply.

There are two limiting geometrical cases to consider when analyzing compliance with the EPFD(is) limits, as follows:

Case A: This is where the O3b satellite is closest to the point on the GSO orbit where the EPFD(is) is being evaluated (i.e., the O3b satellite is immediately below the GSO satellite). In this case the emissions from the O3b satellite are due to backlobe radiation from the O3b satellite transmit antennas.

Case B: This is where the O3b satellite is furthest from the point on the GSO orbit where the EPFD(is) is being evaluated, and the interfering signal path just skims the surface of the Earth at the equator (the so-called "Earth limb" case). In this case the emission levels from the O3b satellite would be at their highest when the steerable transmit antenna of an O3b satellite is pointed close to the equator at the Earth limb.

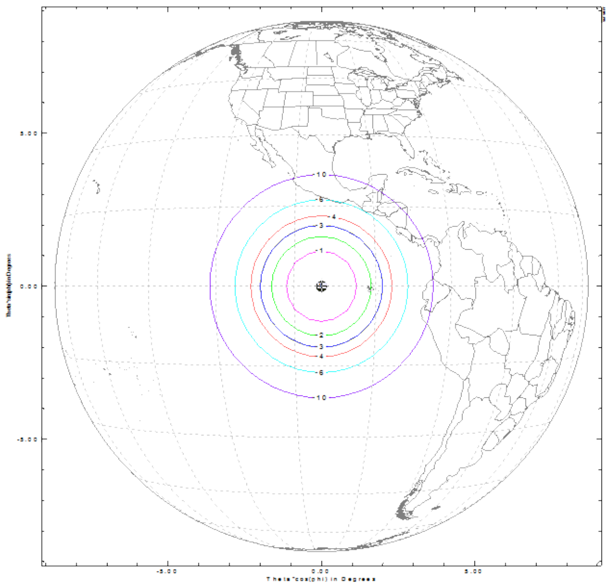
These two cases are shown on the diagram below.



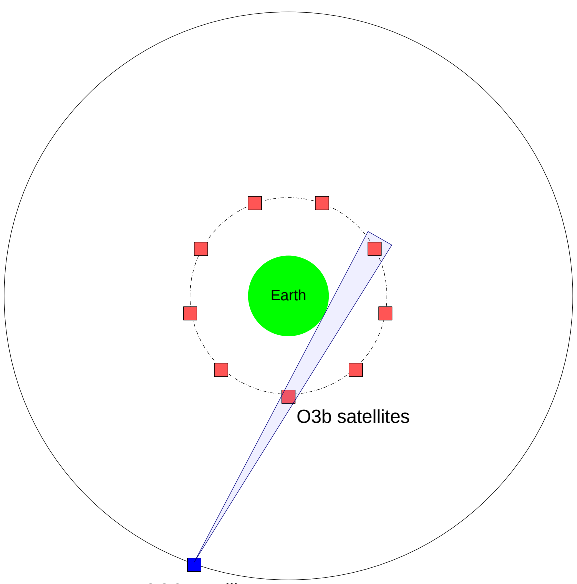
EPFD(is) analysis for Case A

For this case the path length between the O3b satellite and the GSO satellite is the difference in altitude of the two orbits, which is 27,724 km, corresponding to a spreading loss of 159.85 dB. The peak O3b satellite transmit EIRP is 49.7 dBW and the smallest bandwidth over which this EIRP is spread is 40 MHz (consistent with the accompanying Schedule S data). This results in a maximum beam peak EIRP density from the O3b satellite of 33.7 dBW/MHz or 19.7 dBW/40kHz. The backlobe radiation from the O3b satellite is expected to be at least 50 dB below beam peak in the worst case, and much lower than that in most cases. Taking the conservative backlobe radiation level of -50 dB, the transmit EIRP density in the direction of the GSO satellite would be -30.3 dBW/40kHz resulting in a PFD at the GSO satellite of -190.15 dBW/m^2/40kHz (i.e., –30.3 – 159.85).

To convert from PFD to EPFD(is) we have to determine the maximum number of simultaneous co-frequency interferers from the O3b constellation. The definition of EPFD(is) involves an assumed GSO satellite receive antenna with a beamwidth of 4° pointed towards any part of the Earth's surface visible from any given location in the GSO. The relative gain contours of this GSO reference antenna are shown in the diagram below, illustrating that such a small antenna beamwidth illuminates only a small proportion of the visible Earth's surface.



This means that such a reference GSO antenna only "sees" at most two O3b satellites simultaneously in the worst case geometry as shown in the diagram below.



This shows nine active, evenly-spaced, O3b satellites, which corresponds to the situation after the next O3b launch when the 9+3 constellation configuration will be implemented. With fewer active satellites than nine, there are still only a maximum of two O3b satellites simultaneously within the reference beamwidth of the GSO receiving satellite. Therefore, provided each O3b satellite produces a PFD at the GSO satellite that is at least 3 dB below the EPFD(is) limit, then compliance with those EPFD(is) limits is assured.

Each O3b satellite has four-fold frequency re-use (two-fold by polarization discrimination and two-fold by spatial separation), so for Case A a margin of 6 dB would be sufficient to account for the worst-case of four simultaneous interference entries from the same O3b satellite. Taking this into account, the worst case EPFD(is) from a single O3b satellite, as computed above, would be -184.15 $dBW/m^2/40kHz$ (i.e., –190.15 + 6 dB). This is more than 24 dB below the EPFD(is) limit in the Radio Regulations, which is a value of -160 $dBW/m^2/40kHz$, so compliance with the EPFD(is) limits is assured with significant margin.

<u>EPFD(is) analysis for Case B</u>

For this case the path length between the O3b satellite and the GSO satellite is 54,634.16 km, corresponding to a spreading loss of 165.74 dB which is approximately 6 dB more loss than for Case A above.

For the worst-case analysis we will assume that the peak of the O3b satellite transmit beam is pointed directly at the victim GSO satellite across the Earth's limb. In this case, and assuming the same maximum O3b satellite EIRP density as for Case A above (i.e., 33.7 dBW/MHz or 19.7 dBW/40kHz), the resulting PFD at the GSO receiving satellite would be -146.04 $dBW/m^2/40kHz$ (i.e., 19.7 – 165.74). This is 14.0 dB higher than the EPFD(is) limit value. A reduction of 20 dB in the EIRP density level towards the GSO satellite would therefore give 6 dB of positive margin against the EPFD(is) limit, and therefore allow for the possibility of multiple simultaneous O3b interferors as explained for Case A above. Achieving this level of EIRP density reduction for this case is very straightforward, as explained below.

For the worst-case analysis above we are assuming that the O3b satellite transmit antenna is directed close to the equator and close to the Earth limb. However, because the frequency range where EPFD(is) limits apply is also a range where EPFD↓ limits apply, O3b is not able to direct its steerable beams close to the equator and operate at the highest power densities in this frequency range otherwise it would violate the EPFD↓ limits. The downlink EIRP density from the O3b satellites must be reduced by at least the 20 dB referred to in the previous paragraph to ensure EPFD↓ compliance close to the equator. Therefore, by meeting the EPFD↓ limits O3b will automatically meet the EPFD(is) limits for the Case B scenario.

For intermediate interference geometries between Case A and Case B, involving the GSO satellite further around the GSO towards the O3b satellite, the reduction in interference level resulting from the roll-off of the O3b satellite transmit antenna is much greater than the slight increase in interference due to the reduced path length between the O3b and GSO satellites. Therefore those other cases will always result in less interference than Case B as analyzed above.

CERTIFICATION OF PERSON RESPONSIBLE FOR PREPARING ENGINEERING INFORMATION

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

_________/s/_________

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