REQUEST FOR SPECIAL TEMPORARY AUTHORITY

O3b Limited ("O3b"), pursuant to Section 25.120 of the Commission's rules, hereby respectfully requests special temporary authority ("STA") to operate an earth station to be located at the U.S. Navy SPAWAR/CODA Lab at the U.S. Navy Base in San Diego ("CODA II Earth Station") that will communicate with the satellite system operated by O3b. In this filing, O3b seeks a 30-day STA for the period between December 10, 2014 and January 9, 2015 pursuant to an STA.

The CODA II Earth Station will be used for non-commercial testing and demonstration purposes. The CODA II Lab Earth Station will simulate both shipboard installation and shipboard local network interfaces in order to model communications between 4G/LTE devices on U.S. Navy Ships. As discussed below, grant of the requested authority is in the public interest as it will allow O3b to test and evaluate O3b services that could benefit the U.S. Navy. O3b will operate the CODA II Earth Station concurrently with the O3b earth station that is currently operating at the CODA Lab ("CODA I Earth Station").[1]

Test Details and Public Interest Showing

The CODA II Earth Station will communicate with O3b's UK-authorized, Ka-band, Medium Earth Orbit, non-geostationary satellite orbit ("NGSO") Fixed-Satellite Service ("FSS") system[2] and O3b's gateway earth station in Vernon, TX.[3]

The frequencies to be used by the CODA II Earth Station are:

- 28.35-28.4 GHz, 28.6-29.1 GHz (uplink)
- 18.3-18.6 GHz, 18.8-19.3 GHz (downlink)

The CODA II Earth Station will consist of two (2) 1.2m Orbit antennas. O3b has previously been granted an STA to operate an identical earth station at the CODA Lab location in San Diego, California[4] and at the Data Technology Solution ("DTS") facility in Breaux Bridge, Louisiana[5] and has requested STAs to operate an identical earth station at Oil Comm 2014,[6] the AT&T facility in Houston, Texas[7] and at a U.S. Department of Defense facility.[8]

The CODA II Earth Station antennas will be mounted on a fixed pedestal at the CODA Lab facility and will be connected to a simulated shipboard network in the CODA Lab. Although the pointing angle

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[1] *See* O3b Limited, File No. SES-STA-20131228-01209, filed Dec. 23, 2013 ("O3b CODA I STA Application"), and which was placed on Public Notice on April 2, 2014 and granted on April 29, 2014.
[2] O3b's first four satellites were launched on June 25, 2013. O3b's next batch of four satellites was launched on July 10, 2014.
[3] *See* O3b Limited, Call Sign E130021, File No. SES-LIC-20130124-00089, granted June 20, 2013 ("O3b Texas License").
[4] *See* CODA I STA Application.
[5] *See* O3b Limited, File No. SES-STA-20140731-00627, filed July 31, 2014 ("O3b DTS STA Application") and granted on Sept. 16, 2014.
[6] *See* O3b Limited, File No. SES-STA-20140819-00666, filed Aug. 19, 2014 ("O3b Oil Comm STA Application").
[7] *See* O3b Limited, File No. SES-STA-20140912-00726, filed Sept. 11, 2014 ("O3b AT&T STA Application").
[8] *See* O3b Limited, File No. SES-STA-20140903-00686, filed Sep. 3, 2014 ("O3b Ft. Belvoir STA Application").

of the antennas will change as O3b's in-orbit satellites are tracked, the pedestal will remain stationary during the demonstration.

Grant of this application will serve the public interest, convenience, and necessity by allowing O3b to show how its system can effectively deliver 4G/LTE service to and from U.S. Navy ships and can be operated compatibly with end-to-end encryption. O3b will demonstrate the system's capabilities for providing a variety of valuable communications, including voice and video conferencing using mobile devices. As is shown below, moreover, other co-frequency services will be properly protected.

The O3b Satellite System

In its initial FCC application, which sought authority for a gateway earth station located in Hawaii, O3b stated that it planned to operate eight NGSO satellites that would be spaced equally, *i.e.,* at 45° intervals.[9] The Commission granted this application.[10]

O3b has filed an application seeking to modify its Hawaii license to give it the flexibility to operate up to two of its eight NGSO satellites as in-orbit spares.[11] The remaining satellites would be equally spaced in O3b's authorized orbital plane, and each in-orbit spare would be co-located with a non-spare satellite.[12] O3b has been granted an STA pending action on its modification application.[13]

Earth Station Technical Parameters

The following documents containing technical details of the operations proposed under the requested STA are attached:

- Annex 1: FCC Form 312, Schedule B. O3b proposes to operate the CODA II Earth Station during this 30-day term in accordance with the parameters specified in the attached Schedule B.[14]
- Annex 2: Link Budgets. Representative links for the CODA II Earth Station are provided.
- Annex 3: Characteristics of the 1.2m Orbit Antenna are provided for the Commission's convenience. O3b previously submitted this information to the Commission.[15]

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[9] *See* Application for Hawaii Earth Station, File No. SES-LIC-20100723-00952, Legal Narrative, Section III and Attachment A thereto (Technical Statement), Section A.2.

[10] *See* O3b Limited, Call Sign E100088, File No. SES-LIC-20130124-00089, granted Sept. 25, 2012 ("O3b Hawaii License").

[11] *See* O3b Limited, Call Sign E100088, File No. SES-STA-20140814-00656. *See also* O3b Limited, Call Sign E100088, File No. SES-MOD-20140814-00652.

[12] No changes were sought to the technical parameters identified in the licenses and STAs held by O3b and its customers. No changes were made to O3b's Schedule S, either, but O3b noted that the number of satellites and phase angles in Section S4 and S5 of Schedule S will vary to the extent that O3b operates one or more in-orbit spare satellites.

[13] *See* O3b Limited, Call Sign E100088, File No. SES-STA-20140814-00656.

[14] O3b is providing a Schedule B containing technical parameters for the Commission's convenience.

[15] *See* O3b blanket maritime earth station application, File No. SES-LIC-20130528-00455, Technical Attachment at A.6. *See also* O3b DTS STA Application; O3b Oil Comm STA Application; O3b AT&T STA Application; O3b Ft. Belvoir STA Application.

- Annex 4: Radiation Hazard Study. The radiation hazard analysis for the 1.2m Orbit antenna is attached. As described in Annex 4, O3b will follow procedures to mitigate potential radiation hazards to personnel in controlled and uncontrolled environments.
- Annex 5: Coordination Contours. O3b is providing a report prepared by Transfinite, which contains more detailed coordination contours. The Transfinite report was originally prepared for the CODA I Earth Station. Because the site of the CODA II Earth Station is located in close proximity to the CODA I Earth Station, the Transfinite report is equally applicable to the CODA II Earth Station.[16] Given that the methodology in ITU RR Appendix 7 is conservative, Transfinite demonstrates with well-established analytical tools that the size of the coordination contours around the O3b CODA Lab II Earth Station site can be reduced and the contours are smaller than those based on ITU RR Appendix 7. The Transfinite report demonstrates that the CODA Lab II Earth Station contours are within United States territory.

Further, O3b incorporates by reference the following technical parameters previously provided by O3b:

- Schedule S. In its application for a gateway earth station in Hawaii, O3b submitted a Schedule S describing its satellite system's technical characteristics.[17] The Schedule S correctly described the O3b satellite system for that application, and numerically enveloped all of the necessary parameters for future earth station applications. In order to assist the Commission in processing present and future applications, O3b subsequently provided a modified Schedule S that incorporates additional information submitted to the Commission since the Hawaii application was filed.[18] O3b will operate its CODA II Earth Station within the parameters described in O3b's modified Schedule S.
- U.S. Government Coordination. O3b has completed all necessary coordination with U.S. government satellite networks operating in Ka-band, including 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. O3b has also completed coordination, according to US footnote 334 of the FCC table of frequency allocations, with the U.S. government, and this US334 coordination agreement specifically provides for additional earth stations in U.S. territory operating with O3b's satellites, such as the CODA II Earth Station. As a result, O3b's existing US334 coordination agreement covers the use of the CODA II Earth Station as requested in this application.

[16] The CODA II Earth Station will be located approximately 150 feet from the CODA I Earth Station.
[17] *See* O3b Limited, Call Sign E100088, File No. SES-LIC-20100723-00952, granted Sept. 25, 2012 ("O3b Hawaii License").
[18] *See* O3b Limited, Call Sign E130098, File No. SES-AMD-20131025-01138 ("O3b ESV Answers").

- Antenna Patterns. O3b previously submitted measured 30 GHz band antenna performance data for the 1.2m Orbit antenna to the Commission in the Coda Lab and DTS STA requests[19] and the pending Oil Comm and AT&T STA requests.[20]

Proposed Spectrum Use

O3b's proposed CODA II Earth Station operations in shared bands are consistent with the Commission's rules and policies. O3b addresses each of these bands below.

UPLINK

28.35-28.4 GHz – Secondary uplink band shared with primary GSO FSS stations.

In the 28.35-28.4 GHz band, there is a primary allocation for GSO FSS systems and a secondary allocation for NGSO FSS systems. O3b's CODA II Earth Station transmissions in this band will be consistent with their secondary status vis-à-vis GSO FSS transmissions. 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 primary operations and can demonstrate that their proposed operations are not likely to cause harmful interference to primary operations.[21] O3b satisfies both of these standards.

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. As for O3b's uplink operations in the 28.35-28.4 GHz band, the ITU has developed uplink equivalent power flux density limits ("$EPFD_{up}$") limits to protect co-frequency GSO FSS operations from unacceptable interference from NGSO FSS systems operating in the same frequencies. 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. O3b demonstrated that its gateway located at Hawaii operating at the authorized power levels will meet the applicable ITU $EPFD_{up}$ limits in all frequency ranges where these limits apply, due to the inherent angular separation between the O3b and geostationary orbits when viewed from the Earth at latitudes away from the equator.[22]

The CODA II Earth Station is located further north in latitude than the Hawaii gateway,[23] which results in an even greater angular separation between the O3b and geostationary orbits as viewed from

[19] *See* O3b Limited, File No. SES-STA-20131228-01209, filed December 23, 2013 ("O3b CODA I STA Application"), and which was placed on Public Notice on April 2, 2014 and granted on April 29, 2014. *See also* O3b DTS STA Application.
[20]*See* O3b Oil Comm STA Application. *See also* O3b AT&T STA Application.
[21] *Northrop Grumman Space & Missions Systems Corporation*, 24 FCC Rcd 2330, at ¶¶ 72-73 (Int'l Bur. 2009); *contactMEO Communications*, LLC, 21 FCC Rcd 4035, at ¶¶ 23-24, (Int'l Bur., 2006).
[22] O3b Hawaii License Application, FCC File No. SES-LIC-20100723-00952, Technical Attachment at A.10.1.
[23] The O3b Hawaii gateway latitude is 21° 40' 17.8" N; the CODA II Earth Station latitude is 32° 40' 53.8".

the Earth and an even greater assurance that the applicable ITU $EPFD_{up}$ limits will be met by O3b's proposed operations. The proposed CODA II Earth Station operations, therefore, also will meet the applicable ITU $EPFD_{up}$ limits. 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.

<u>28.6-29.1 GHz – Primary uplink band for licensed NGSO FSS Systems.</u>

Under the Commission's Ka-band frequency plan, the frequencies 28.6-29.1 GHz may be used on a primary basis by licensed NGSO FSS systems.[24] O3b recognizes, however, that operations under an STA for the CODA II Earth Station demonstrations will be on a secondary, non-harmful interference basis. As shown below, the CODA II Earth Station demonstrations will provide the requisite protection to allocated services operating in this band.

Avoidance of interference to GSO FSS systems. The proposed demonstrations will not cause any interference into, or require protection from, any co-frequency GSO satellites. As previously shown,[25] there is an inherent angular separation between the O3b and GSO arcs from the perspective of earth stations located away from the equator. The CODA II Earth Station is located further north in latitude than the Hawaii gateway,[26] which results in an even greater angular separation between the O3b and geostationary orbits as viewed from the Earth. This means that the angular separation between the O3b and GSO arcs from the CODA II Earth Station will be greater than the 7 degree separation accepted by the Commission when it approved O3b's Hawaii gateway. This ensures that GSO FSS systems will be adequately protected.

Avoidance of interference to or from Fixed Service (i.e., terrestrial) stations. Interference from the O3b CODA II Earth Station transmissions into U.S. terrestrial Fixed Service ("FS") receivers in the 28 GHz band is a non-issue because there is no allocation in the Commission's Ka-band Frequency Plan for FS stations operating in the 28.6-29.1 GHz band in the United States.[27]

<u>DOWNLINK</u>

<u>18.3-18.6 GHz – Non-conforming downlink band shared with primary GSO FSS stations.</u>

The 18.3-18.6 GHz band is allocated in the United States on a primary basis to GSO FSS. In the 18.3-18.6 GHz downlink band, the ITU has developed downlink equivalent power flux density

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[24] *See 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, ¶¶59-62 and 79 (1996). *See also 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).
[25] O3b Hawaii License Application, FCC File No. SES-LIC-20100723-00952, Technical Attachment at A.10.1.
[26] *See* n. 25, *supra*.
[27] *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).

("$EPFD_{down}$") limits to protect GSO FSS networks from unacceptable interference from NGSO FSS systems operating in the same frequencies. Specifically, in accordance with Article 22 of the ITU Radio Regulations, if the applicable $EPFD_{down}$ limits are met, the NGSO FSS satellite system is considered to have met its obligations to protect GSO FSS networks from unacceptable interference. O3b confirms that its system will meet the applicable ITU $EPFD_{down}$ limits in all frequency ranges where these limits apply.[28]

As an example of how these limits will be satisfied, O3b provided $EPFD_{down}$ calculations for transmissions to its Hawaii gateway earth station.[29] O3b also showed how the $EPFD_{down}$ limits can be satisfied at all latitudes.[30] Compliance with the $EPFD_{down}$ limits is even more easily achieved in the case of transmissions to O3b's CODA II Earth Station than it is in the case of transmissions to O3b's Hawaii earth station. O3b is able to satisfy the limits by taking advantage of 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,[31] and O3b's CODA II Earth Station will be located further from the equator than O3b's Hawaii earth station. The CODA II Earth Station, therefore, will adequately protect GSO FSS networks.

18.8-19.3 GHz – Primary downlink band for licensed NGSO FSS Systems.

Under the Commission's Ka-band frequency plan, the frequencies 18.8-19.3 GHz may be used on a primary basis by licensed NGSO FSS systems.[32] O3b recognizes, however, that operations under an STA for the CODA II Earth Station demonstrations will be on a secondary, non-harmful interference basis. The CODA II Earth Station demonstrations will provide the requisite protection to GSO FSS networks and terrestrial stations operating in this band.

Avoidance of interference to GSO FSS systems. This band is not allocated for GSO FSS networks.[33] Nevertheless, the proposed demonstrations will not cause any interference into, or require protection from, any co-frequency GSO satellites. As previously shown,[34] there is an inherent angular separation between the O3b and GSO arcs from the perspective of earth stations located away from the equator. As mentioned above, the CODA II Earth Station is located further north in latitude than the Hawaii

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[28] *See* ITU Radio Regulations, Article 22. *See also* O3b Hawaii License Application, FCC File No. SES-LIC-20100723-00952, Technical Attachment at A.10.1 for a discussion of O3b's compliance with the operational limits in Article 22 of the ITU Radio Regulations. *See* also Letter from Brian D. Weimer, to Marlene H. Dortch, in re O3b Application for Hawaii Earth Station, File No. SES-LIC-20100723-00952 (Apr. 22, 2011), Annex A.
[29] O3b Hawaii License Application, FCC File No. SES-LIC-20100723-00952, Technical Attachment at A.10.1.
[30] *See* id.
[31] *See* id.
[32] *See 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, ¶¶59-62 and 79 (1996). *See also 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).
[33] *See* id.
[34] O3b Hawaii License Application, FCC File No. SES-LIC-20100723-00952, Technical Attachment at A.10.1.

gateway, which results in an even greater angular separation between the O3b and geostationary orbits as viewed from the Earth. This means that the angular separation between the O3b and GSO arcs from the CODA II Earth Station will be greater than the 7 degree separation accepted by the Commission when it approved O3b's Hawaii gateway. This ensures that GSO FSS systems will be adequately protected.

However, because the demonstrations O3b proposes in this STA request will be conducted on a secondary basis, O3b agrees to accept any interference that its CODA II Earth Station may receive from 18.8-19.3 GHz band GSO FSS networks.

Avoidance of interference to or from Fixed Service (i.e., terrestrial) stations. FS stations operating in the 18.8-19.3 GHz band are no longer co-primary with FSS users in this band.[35] However, because the demonstrations O3b proposes in this STA request will be conducted on a secondary basis, O3b agrees to accept any interference that its CODA II Earth Station may receive from 18.8-19.3 GHz band FS stations. O3b will protect the 18.8-19.3 GHz band FS stations by complying with the space station PFD limits specified in Section 25.208 of the FCC rules.

Conclusion

The requested STA will allow O3b to evaluate and demonstrate the O3b system's operational capabilities and will not result in harmful interference to other authorized spectrum users. Accordingly, and for good cause shown, O3b respectfully requests that its STA be granted in time for it to commence testing under this 30-day STA on December 10, 2014.

[35] *See* 47 C.F.R. § 101.85(b)(2).

ANNEX 1 – Form 312, Schedule B

The Form 312, Schedule B is provided on the following pages.

SATELLITE EARTH STATION AUTHORIZATIONS
FCC Form 312 - Schedule B:(Technical and Operational Description)

Location of Earth Station Site

E1: Site Identifier: US Navy SPAWAR CODA Lab at 32nd Street Naval Station	E5. Call Sign: N/A	
E2: Contact Name: Keith Thackery	E6. Phone Number: 619-556-6385	
E3. Street: 3533 Norman Scott Road, Bldg 3533 Room 300	E7. City: San Diego	
	E8. County: San Diego	

E4. State	CA	E9. Zip Code: 92136	
E10. Area of Operation:	Fixed		
E11. Latitude:	32° 40’ 53.8” N		
E12. Longitude:	117° 6’ 58.3” W		
E13. Lat/Lon Coordinates are:		○ NAD-27	◉ NAD-83
E14. Site Elevation (AMSL):	4 meters		N/A

E15. If the proposed antenna(s) operate in the Fixed Satellite Service (FSS) with geostationary satellites, do(es) the proposed antenna(s) comply with the antenna gain patterns specified in Section 25.209(a) and (b) as demonstrated by the manufacturer's qualification measurement? If NO, provide a technical analysis showing compliance with two-degree spacing policy.	Yes ◉ No N/A
E16. If the proposed antenna(s) do not operate in the Fixed Satellite Service (FSS), or if they operate in the Fixed Satellite Service (FSS) with non-geostationary satellites, do(es) the proposed antenna(s) comply with the antenna gain patterns specified in Section 25.209(a2) and (b) as demonstrated by the manufacturer's qualification measurements?	◉ Yes No N/A
E17. Is the facility operated by remote control? If YES, provide the location and telephone number of the control point.	○ Yes ◉ No
E18. Is frequency coordination required? If YES, attach a frequency coordination report as	Yes ◉ No
E19. Is coordination with another country required? If YES, attach the name of the country(ies) and plot of coordination contours as	◉ Yes ○ No
E20. FAA Notification - (See 47 CFR Part 17 and 47 CFR part 25.113(c)) Where FAA notification is required, have you attached a copy of a completed FCC Form 854 and or the FAA's study regarding the potential hazard of the structure to aviation? **FAILURE TO COMPLY WITH 47 CFR PARTS 17 AND 25 WILL RESULT IN THE RETURN OF THIS APPLICATION.**	○ Yes ◉ No

POINTS OF COMMUNICATION

Satellite Name:O3B-A | O3B-A | Eq. NGSO If you selected OTHER, please enter the following:	
E21. Common Name:	E22. ITU Name:
E23. Orbit Location:	E24. Country:

POINTS OF COMMUNICATION (Destination Points)

E25. Site Identifier:	

E26. Common Name:	E27. Country:

ANTENNA

Site ID	E28. Antenna Id	E29. Quantity	E30. Manufacturer	E31. Model	E32. Antenna Size	E41/42. Antenna Gain Transmit and/or Receive (____dBi at______GHz)
CODA II	Orbit 1.2m	2	Orbit Communications	AL-7103-Ka	1.2	45 dBi at 19.2
						48.0 dBi at 28.3 GHz

E28. Antenna Id	E33/34. Diameter Minor/Major(meters)	E35. Above Ground Level (meters)	E36. Above Sea Level (meters)	E37. Building Height Above Ground Level (meters)	E38. Total Input Power at antenna flange (Watts)	E39. Maximum Antenna Height Above Rooftop (meters)	E40. Total EIRP for al carriers (dBW)
Orbit 1.2m	1.2/1.2	2	4	0.0	20.0	2.0	60.5

FREQUENCY

E28. Antenna Id	E43/44. Frequency Bands(MHz)	E45. T/R Mode	E46. Antenna Polarization(H,V,L,R)	E47. Emission Designator	E48. Maximum EIRP per Carrier(dBW)	E49. Maximum EIRP Density per Carrier(dBW/4kHz)
Orbit 1.2m	18300 – 18600	R	Left and Right Circular	216MG7D	45.6	-1.7
E50. Various Modulations up to 32APSK; Digital Data Link						
Orbit 1.2m	18300 – 18600	R	Left and Right Circular	54MG7D	45.6	4.3
E50. Various Modulations up to 32APSK; Digital Data Link						
Orbit 1.2m	18800 – 19300	R	Left and Right Circular	216MG7D	45.6	-1.7
E50. Various Modulations up to 32APSK; Digital Data Link						
Orbit 1.2m	18800 – 19300	R	Left and Right Circular	54MG7D	45.6	4.3
E50. Various Modulations up to 32APSK; Digital Data Link						
Orbit 1.2m	28350 – 28400	T	Left and Right Circular	54MG7D	52.56	11.26
E50. Various Modulations up to 32APSK; Digital Data Link						
Orbit 1.2m	28600 - 29100	T	Left and Right Circular	216MG7D	59.6	12.3
E50. Various Modulations up to 32APSK; Digital Data Link						

Orbit 1.2m	28600 - 29100	T	Left and Right Circular	54MG7D	53.6	12.3
E50. Various Modulations up to 32APSK; Digital Data Link						

FREQUENCY COORDINATION

E28. Antenna Id	E51. Satellite Orbit Type	E52/53. Frequency Limits(MHz)	E54/55. Range of Satellite Arc E/W Limit	E56. Earth Station Azimuth Angle Eastern Limit	E57. Antenna Elevation Angle Eastern Limit	E58. Earth Station Azimuth Angle Western Limit	E59. Antenna Elevation Angle Western Limit	E60. Maximum EIRP Density toward the Horizon(dBW/4kHz)
Orbit 1.2	Non-Geostationary	18300 – 18600	NON-GEO	129	20.0	223	25.0	--
Orbit 1.2	Non-Geostationary	18800 – 19300	NON-GEO	129	20.0	223	25.0	--
Orbit 1.2	Non-Geostationary	28350 – 28400	NON-GEO	129	20.0	223	25.0	-39.8
Orbit 1.2	Non-Geostationary	28600 – 29100	NON-GEO	129	20.0	223	25.0	-39.8

REMOTE CONTROL POINT LOCATION

E61. Call Sign NOTE: Please enter the callsign of the controlling station, not the callsign for which this application is being filed.		E65. Phone Number	
E62. Street Address			
E63. City	E67. County	E64/68. State/Country	E66. Zip Code

ANNEX 2 – Link Budgets

Representative link budgets for the 1.2m Orbit antenna at the CODA II Earth Station are provided on the following two pages. Please see the chart below for reference.

Link Description	**Carrier**	**MODCOD**	**Table #**
1.2m at CODA Lab	216MHz in each direction, clear sky	8PSK/0.75 FWD QPSK/0.75 RTN	1,2
1.2m at CODA Lab	54MHz in each direction, clear sky	16APSK/0.83 FWD QPSK/0.75 RTN	3,4

O3b Network Link Analysis - Tier 2 Service For San Diego, United States			
Link Budget Creator - Rev 3.2.9: October 29, 2013		**Tier 2**	**Tier 2**
Ground Parameter		**Teleport**	**Telco**
Location		Vernon (RHCP), United States	San Diego, United States
Latitude	(°)	34.2	32.7
Longitude (East)	(°)	260.7	242.8
E/S Maximum Range to SV	(km)	10445.4	9742.0
E/S Minimmum Elevation to SV	(°)	26.2	36.0
E/S Altitude	(km)	0.3	0.2
SV Beam Identifier	(#)	13	
Minutes Into Pass (Sample #15)	(Min)	6:46	
Telco Spot Beam Off-Angle	(°)	0.20	
Telco Spot Beam Diameter	(km)	67.80	
Maximum Roundtrip Latency	(msec)	134.68	
Modulation Parameters		**Forward**	**Return**
Enter Receiver	Type	DVB-S2	
Modem Overhead	(%)	3.2%	
Number of Carriers per Channel	(#)	1	
Available Bandwidth	(Hz)	216,000,000	
Channel Symbol Rate	(sps)	180,000,000	
Channel Modulation Type		8PSK	
Channel FEC Rate		0.75	
Channel Spectral Efficiency	(bits/Sym)	2.25	
Channel Throughput (100% / 100% of Full Rate)	(bps)	391,954,582.32	
Uplink		**Forward**	**Return**
E/S Tx Channels per HPA	(#)	5	
E/S Tx Carrier Frequency	(MHz)	28,280	
E/S Tx HPA Power Level	(W)	500	
E/S Tx OBO	(dB)	-4.00	
E/S Tx Post-HPA Losses	(dB)	-2.24	
E/S Tx Antenna Gain (7.3 m / 1.2 m)	(dB)	64.90	
E/S Tx EIRP Per Channel	(dBW)	78.66	
E/S Tx Pointing Loss	(dB)	-0.50	
E/S Tx RF Link Availability	(%)	75.000	
E/S Tx Atmospheric Losses	(dB)	-1.42	
E/S Tx Spreading Loss	(dB)	-151.37	
Satellite		**Forward**	**Return**
SV Number of Channels per HPA	(#)	1	
SV Rx G/T	(dB/K)	5.32	
SV Rx Power Per Tier	(dBW)	-119.80	
SV Rx Flux Density Per Tier	(dBW/m^2)	-74.63	
SV Tx OBO (ALC / ALC)	(dB)	-3.80	
SV Tx Post-TWTA Losses	(dB)	-1.50	
SV Tx Antenna Gain	(dBi)	31.57	
SV Tx EIRP Per Channel/Carrier	(dBW)	44.40	
SV Tx Pointing Loss	(dB)	0.00	
Downlink		**Forward**	**Return**
E/S Rx Carrier Frequency	(MHz)	18,480	
E/S Rx Wavelength	(m)	0.016223	
E/S Rx RF Link Availability	(%)	70	
E/S Rx Atmospheric Losses	(dB)	-0.36	
E/S Rx Radome & Pointing Loss	(dB)	-1.00	
E/S Rx Antenna Gain (1.2 m / 7.3 m)	(dBi)	42.5	
E/S Rx Effective G/T	(dB/K)	19.1	
E/S Rx Power Per Channel	(dBW)	-112.0	
E/S Rx Flux Density Per Channel	(dBW/m^2)	-107.7	
Total Link		**Forward**	**Return**
Carrier / Noise Bandwidth	(dB)	82.55	
Carrier / Noise Uplink	(dB)	26.25	
Carrier / Noise Downlink	(dB)	10.61	
Carrier / Intermodulation Im (C/Im)	(dB)	23.53	
(C/N) - Total Actual	(dB)	10.14	
(C/N) - Total Required	(dB)	9.50	
(E_b/N_o) - Total Actual	(dB)	6.62	
(E_b/N_o) - Total Required	(dB)	5.98	
Excess Margin	**(dB)**	**0.64**	
Fade Margin	**(dB)**	**12.34**	

#1

O3b Network Link Analysis - Tier 2 Service For San Diego, United States			
Link Budget Creator - Rev 3.2.9: October 29, 2013		**Tier 2**	**Tier 2**
Ground Parameter		**Teleport**	**Telco**
Location		Vernon (RHCP), United States	San Diego, United States
Latitude	(°)	34.2	32.7
Longitude (East)	(°)	260.7	242.8
E/S Maximum Range to SV	(km)	10445.4	9742.0
E/S Minimmum Elevation to SV	(°)	26.2	36.0
E/S Altitude	(km)	0.3	0.2
SV Beam Identifier	(#)	13	
Minutes Into Pass (Sample #15)	(Min)	6:46	
Telco Spot Beam Off-Angle	(°)	0.20	
Telco Spot Beam Diameter	(km)	67.80	
Maximum Roundtrip Latency	(msec)	134.68	
Modulation Parameters		**Forward**	**Return**
Enter Receiver	Type		DVB-S2
Modem Overhead	(%)		3.2%
Number of Carriers per Channel	(#)		1
Available Bandwidth	(Hz)		216,000,000
Channel Symbol Rate	(sps)		180,000,000
Channel Modulation Type			QPSK
Channel FEC Rate			0.75
Channel Spectral Efficiency	(bits/Sym)		1.50
Channel Throughput (100% / 100% of Full Rate)	(bps)		261,373,715.52
Uplink		**Forward**	**Return**
E/S Tx Channels per HPA	(#)		1
E/S Tx Carrier Frequency	(MHz)		28,280
E/S Tx HPA Power Level	(W)		20
E/S Tx OBO	(dB)		-0.50
E/S Tx Post-HPA Losses	(dB)		-0.28
E/S Tx Antenna Gain (7.3 m / 1.2 m)	(dB)		46.3
E/S Tx EIRP Per Channel	(dBW)		58.56
E/S Tx Radome & Pointing Loss	(dB)		-1.00
E/S Tx RF Link Availability	(%)		70.000
E/S Tx Atmospheric Losses	(dB)		-0.59
E/S Tx Spreading Loss	(dB)		-150.77
Satellite		**Forward**	**Return**
SV Number of Channels per HPA	(#)		5
SV Rx G/T	(dB/K)		4.43
SV Rx Power Per Tier	(dBW)		-139.84
SV Rx Flux Density Per Tier	(dBW/m^2)		-93.79
SV Tx OBO (ALC / ALC)	(dB)		-5.80
SV Tx Post-TWTA Losses	(dB)		-1.50
SV Tx Antenna Gain	(dBi)		31.80
SV Tx EIRP Per Channel/Carrier	(dBW)		35.64
SV Tx Pointing Loss	(dB)		0.00
Downlink		**Forward**	**Return**
E/S Rx Carrier Frequency	(MHz)		18,480
E/S Rx Spreading Loss	(dB)		-151.37
E/S Rx RF Link Availability	(%)		75.000
E/S Rx Atmospheric Losses	(dB)		-0.84
E/S Rx Pointing Loss	(dB)		-0.50
E/S Rx Antenna Gain (1.2 m / 7.3 m)	(dBi)		62.04
E/S Rx Effective G/T	(dB/K)		38.68
E/S Rx Power Per Channel	(dBW)		-101.82
E/S Rx Flux Density Per Channel	(dBW/m^2)		-117.07
Total Link		**Forward**	**Return**
Carrier / Noise Bandwidth	(dB)		82.55
Carrier / Noise Uplink	(dB)		6.21
Carrier / Noise Downlink	(dB)		20.86
Carrier / Intermodulation Im (C/Im)	(dB)		18.35
(C/N) - Total Actual	(dB)		5.76
(C/N) - Total Required	(dB)		5.70
(E_b/N_o) - Total Actual	(dB)		4.00
(E_b/N_o) - Total Required	(dB)		3.94
Excess Margin	**(dB)**		**0.06**
Fade Margin	**(dB)**		**7.96**

#2

O3b Network Link Analysis - Tier 2 Service For San Diego, United States			
Link Budget Creator - Rev 3.2.9: October 29, 2013		**Tier 2**	**Tier 2**
Ground Parameter		**Teleport**	**Telco**
Location		Vernon (RHCP), United States	San Diego, United States
Latitude	(°)	34.2	32.7
Longitude (East)	(°)	260.7	242.8
E/S Maximum Range to SV	(km)	10445.4	9742.0
E/S Minimmum Elevation to SV	(°)	26.2	36.0
E/S Altitude	(km)	0.3	0.2
SV Beam Identifier	(#)	13	
Minutes Into Pass (Sample #15)	(Min)	6:46	
Telco Spot Beam Off-Angle	(°)	0.20	
Telco Spot Beam Diameter	(km)	67.80	
Maximum Roundtrip Latency	(msec)	134.68	
Modulation Parameters		**Forward**	**Return**
Enter Receiver	Type	DVB-S2	
Modem Overhead	(%)	3.3%	
Number of Carriers per Channel	(#)	1	
Available Bandwidth	(Hz)	54,000,000	
Channel Symbol Rate	(sps)	45,000,000	
Channel Modulation Type		16APSK	
Channel FEC Rate		0.83	
Channel Spectral Efficiency	(bits/Sym)	3.33	
Channel Throughput (100% / 100% of Full Rate)	(bps)	144,983,818.77	
Uplink		**Forward**	**Return**
E/S Tx Channels per HPA	(#)	5	
E/S Tx Carrier Frequency	(MHz)	28,280	
E/S Tx HPA Power Level	(W)	125	
E/S Tx OBO	(dB)	-4.00	
E/S Tx Post-HPA Losses	(dB)	-2.24	
E/S Tx Antenna Gain (7.3 m / 1.2 m)	(dB)	64.90	
E/S Tx EIRP Per Channel	(dBW)	72.64	
E/S Tx Pointing Loss	(dB)	-0.50	
E/S Tx RF Link Availability	(%)	75.000	
E/S Tx Atmospheric Losses	(dB)	-1.42	
E/S Tx Spreading Loss	(dB)	-151.37	
Satellite		**Forward**	**Return**
SV Number of Channels per HPA	(#)	1	
SV Rx G/T	(dB/K)	5.32	
SV Rx Power Per Tier	(dBW)	-125.82	
SV Rx Flux Density Per Tier	(dBW/m^2)	-80.65	
SV Tx OBO (ALC / ALC)	(dB)	-3.80	
SV Tx Post-TWTA Losses	(dB)	-1.50	
SV Tx Antenna Gain	(dBi)	31.57	
SV Tx EIRP Per Channel/Carrier	(dBW)	44.40	
SV Tx Pointing Loss	(dB)	0.00	
Downlink		**Forward**	**Return**
E/S Rx Carrier Frequency	(MHz)	18,480	
E/S Rx Wavelength	(m)	0.016223	
E/S Rx RF Link Availability	(%)	70	
E/S Rx Atmospheric Losses	(dB)	-0.36	
E/S Rx Radome & Pointing Loss	(dB)	-1.00	
E/S Rx Antenna Gain (1.2 m / 7.3 m)	(dBi)	42.5	
E/S Rx Effective G/T	(dB/K)	19.1	
E/S Rx Power Per Channel	(dBW)	-112.0	
E/S Rx Flux Density Per Channel	(dBW/m^2)	-107.7	
Total Link		**Forward**	**Return**
Carrier / Noise Bandwidth	(dB)	76.53	
Carrier / Noise Uplink	(dB)	26.25	
Carrier / Noise Downlink	(dB)	16.64	
Carrier / Intermodulation Im (C/Im)	(dB)	23.53	
(C/N) - Total Actual	(dB)	14.99	
(C/N) - Total Required	(dB)	13.70	
(E_b/N_o) - Total Actual	(dB)	9.77	
(E_b/N_o) - Total Required	(dB)	8.47	
Excess Margin	**(dB)**	**1.29**	
Fade Margin	**(dB)**	**17.19**	

#3

O3b Network Link Analysis - Tier 2 Service For San Diego, United States			
Link Budget Creator - Rev 3.2.9: February 21, 2014		**Tier 2**	**Tier 2**
Ground Parameter		**Teleport**	**Telco**
Location		Vernon (RHCP), United States	San Diego, United States
Latitude	(°)	34.2	32.7
Longitude (East)	(°)	260.7	242.8
E/S Maximum Range to SV	(km)	10445.4	9742.0
E/S Minimmum Elevation to SV	(°)	26.2	36.0
E/S Altitude	(km)	0.3	0.2
SV Beam Identifier	(#)	13	
Minutes Into Pass (Sample #15)	(Min)	6:46	
Telco Spot Beam Off-Angle	(°)	0.20	
Telco Spot Beam Diameter	(km)	67.80	
Maximum Roundtrip Latency	(msec)	134.68	
Modulation Parameters		**Forward**	**Return**
Enter Receiver	Type		DVB-S2
Modem Overhead	(%)		3.2%
Number of Carriers per Channel	(#)		1
Available Bandwidth	(Hz)		54,000,000
Channel Symbol Rate	(sps)		45,000,000
Channel Modulation Type			**QPSK**
Channel FEC Rate			0.75
Channel Spectral Efficiency	(bits/Sym)		**1.50**
Channel Throughput (100% / 100% of Full Rate)	(bps)		**65,343,428.88**
Uplink		**Forward**	**Return**
E/S Tx Channels per HPA	(#)		1
E/S Tx Carrier Frequency	(MHz)		28,280
E/S Tx HPA Power Level	(W)		20
E/S Tx OBO	(dB)		**-6.50**
E/S Tx Post-HPA Losses	(dB)		-0.28
E/S Tx Antenna Gain (7.3 m / 1.2 m)	(dB)		46.3
E/S Tx EIRP Per Channel	(dBW)		52.56
E/S Tx Radome & Pointing Loss	(dB)		-1.00
E/S Tx RF Link Availability	(%)		70.000
E/S Tx Atmospheric Losses	(dB)		-0.59
E/S Tx Spreading Loss	(dB)		-150.77
Satellite		**Forward**	**Return**
SV Number of Channels per HPA	(#)		5
SV Rx G/T	(dB/K)		4.43
SV Rx Power Per Tier	(dBW)		-145.84
SV Rx Flux Density Per Tier	(dBW/m^2)		-99.79
SV Tx OBO (ALC / ALC)	(dB)		-5.80
SV Tx Post-TWTA Losses	(dB)		-1.50
SV Tx Antenna Gain	(dBi)		31.80
SV Tx EIRP Per Channel/Carrier	(dBW)		35.64
SV Tx Pointing Loss	(dB)		0.00
Downlink		**Forward**	**Return**
E/S Rx Carrier Frequency	(MHz)		18,480
E/S Rx Spreading Loss	(dB)		-151.37
E/S Rx RF Link Availability	(%)		75.000
E/S Rx Atmospheric Losses	(dB)		-0.84
E/S Rx Pointing Loss	(dB)		-0.50
E/S Rx Antenna Gain (1.2 m / 7.3 m)	(dBi)		62.04
E/S Rx Effective G/T	(dB/K)		38.68
E/S Rx Power Per Channel	(dBW)		-101.82
E/S Rx Flux Density Per Channel	(dBW/m^2)		-117.07
Total Link		**Forward**	**Return**
Carrier / Noise Bandwidth	(dB)		76.53
Carrier / Noise Uplink	(dB)		**6.23**
Carrier / Noise Downlink	(dB)		26.88
Carrier / Intermodulation Im (C/Im)	(dB)		23.28
(C/N) - Total Actual	(dB)		**6.05**
(C/N) - Total Required	(dB)		**5.70**
(E_b/N_o) - Total Actual	(dB)		**4.29**
(E_b/N_o) - Total Required	(dB)		**3.94**
Excess Margin	**(dB)**		**0.35**
Fade Margin	**(dB)**		**8.25**

#4

ANNEX 3 –Terminal Characteristics

The O3b 1.2 meter ("1.2m") terminals offers service data rates of up to 150 Mbps. The figure below shows this terminal.

Figure: O3b's 1.2 meter terminal

The 1.2m terminal is fully stabilized to account for the movement of the O3b satellite in its orbit. Each antenna is enclosed within a radome to protect it from the environment.

The Commission's rules for C-band and Ku-band maritime terminals include a pointing accuracy requirement and a shut-off requirement. In these bands, there must be a pointing error of less than 0.2° between the orbital location of the target satellite and the axis of the main lobe of each maritime terminals antenna.[36] O3b observes these requirements with its 1.2m Orbit terminal operations, and the manufacturer of O3b's 1.2m terminals has certified that the terminals comply with these requirements.

The internal controller software continuously monitors the instantaneous antenna tracking error and will cease transmissions within 100ms if an unexpected event occurs that causes the tracking error to exceed 0.5 degrees. Transmissions will not restart until the tracking error, relative to the target O3b satellite, is less than 0.2 degrees.

The 1.2m terminals are no smaller in antenna size than the range of antenna sizes that O3b has previously described to the Commission as its "Tier 2" service.[37] Therefore these 1.2m terminals present no new technical issues in terms of interference with respect to GSO or other NGSO satellite networks or terrestrial operators.

[36] *See* 47 C.F.R. §§ 25.221(a)(6) and 25.222(a)(6).
[37] *See* O3b's Hawaii application, FCC File No. SES-LIC-20100723-00952, Technical Attachment at Section A.5.

Annex 4 – Radiation Hazard Study

O3b is providing a radiation hazard study for the 1.2m Orbital antenna O3b will operate at the CODA II Earth Station. As appropriate, O3b will use fencing, signage, and other measures to limit access to the relevant area. Procedures will be in place requiring that transmit power be turned off before work on the 1.2m Orbital antenna is performed.

Radiation Hazard Study

The study in this section analyzes the potential RF human exposure levels caused by the Electro Magnetic (EM) fields of an Orbit AL-7103-Ka, 1.20 m antenna, operating with a maximum power at the flange of 20 Watts. The mathematical analysis performed below complies with the methods described in the FCC Office of Engineering and Technology (OET) Bulletin No. 65 (1985 rev. 1997) R&O 96-3 26 in "Evaluating Compliance with FCC Guideliness for Human Exposure to RF EM Fields, OET Bulletin 65 (Edition 97-01), Supplement B, FCC Office of Engineering & Technology, November 1997".

Maximum Permissible Exposure

There are two separate levels of exposure limits. The first applies to persons in the general population who are in an uncontrolled environment. The second applies to trained personnel in a controlled environment. According to 47 C.F.R. § 1.1310, the Maximum Permissible Exposure (MPE) limits for frequencies above 1.5 GHz are as follows:

* General Population / Uncontrolled Exposure: 1.0 mW/cm^2
* Occupational / Controlled Exposure: 5.0 mW/cm^2

The purpose of this study is to determine the power flux density levels for the earth station under study as compared with the MPE limits. This comparison is done in each of the following regions:

1. Far-field region
2. Near-field region
3. Transition region
4. The region between the feed and the antenna surface
5. The main reflector region
6. The region between the antenna edge and the ground

Input Parameters

The following input parameters were used in the calculations:

Input Parameter	Value	Unit	Symbol
Antenna Diameter	1.20	m	D
Antenna Transmit Gain	48.50	dBi	G
Transmit Frequency	29100.0	MHz	f
Antenna Feed Flange Diam.	6.00	cm	d
Power Input to the Antenna	20.00	Watts	P

Calculated Parameters

The following values were calculated using the above input parameters and the corresponding formula:

Calculated Parameter	Value	Unit	Symbol	Formula
Antenna Surface Area	1.13	m^2	A	$\pi D^2/4$
Area of Antenna Flange	28.3	cm^2	a	$\pi d^2/4$
Antenna Efficiency	0.53	real	η	$g\lambda^2/(\pi^2 D^2)$
Gain Factor	70795	real	g	10^(G/10)
Wavelength	0.010	m	λ	300/f

Behavior of EM Fields as a Function of Distance

The behavior of the characteristics of EM fields varies depending on the distance from the radiating antenna. These characteristics are analyzed in three primary regions: the near-field region, the far-field region and the transition region. Of interest also are the region between the antenna main reflector and the subreflector, the region of the main reflector area and the region between the main reflector and ground.

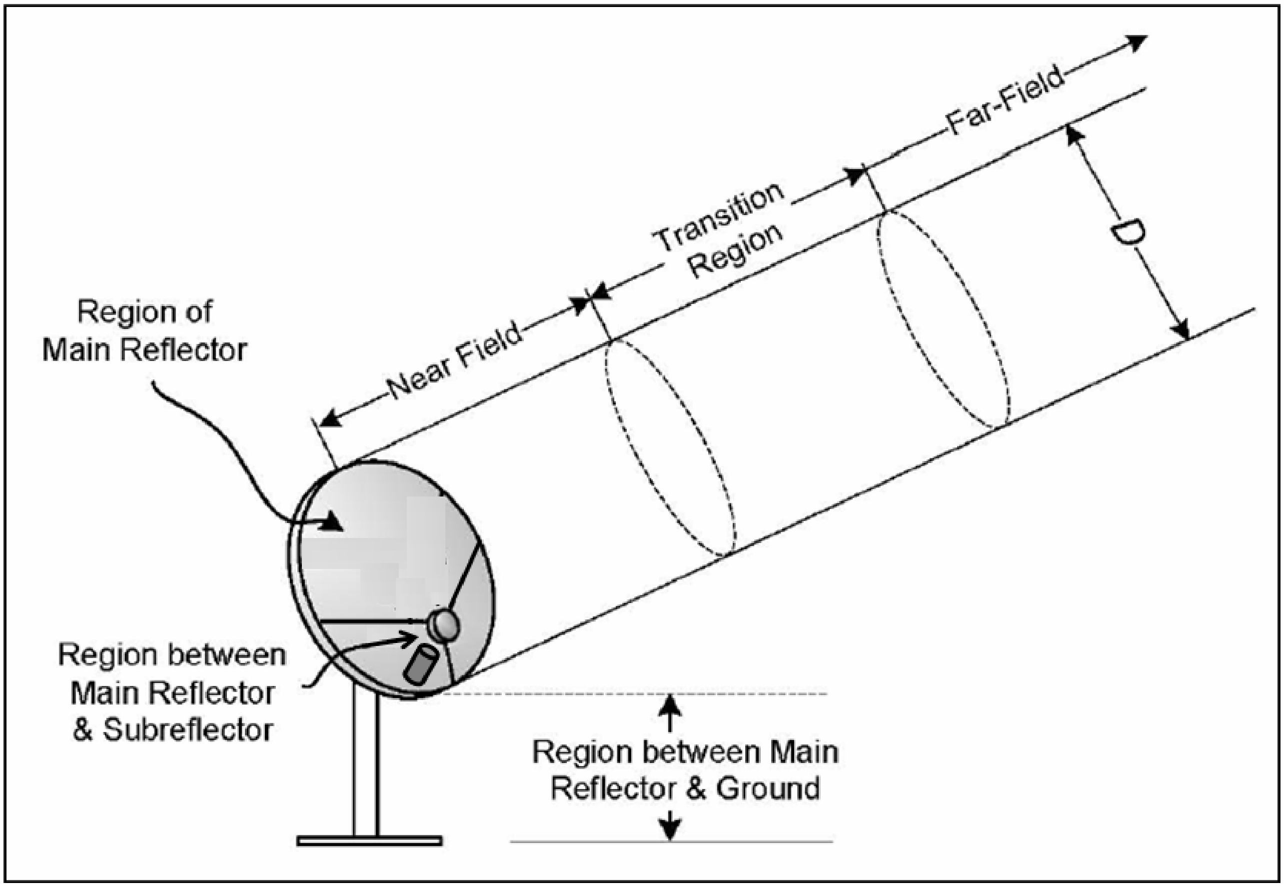

Figure 1. Electro-Magnetic Fields as a Function of Distance

For parabolic aperture antennas with circular cross sections, such as the antenna under study, the near-field, far-field and transition region distances are calculated as follows:

Calculated Parameter	Value	Unit	Symbol	Formula
Near-Field Distance	34.92	m	Rnf	$D^2/(4\lambda)$
Distance to Far-Field	83.81	m	Rff	$0.6D^2/\lambda$
Distance of Transition Region	34.92	m	Rt	Rt=Rnf

The distance in the transition region is between the near and far fields. Thus, Rnf ≤ Rt ≤ Rff . However, the power density in the transition region will not exceed the power density in the near-field. Therefore, for purposes of the present analysis, the distance of the transition region can equate the distance to the near-field.

Power Flux Density Calculations

The power flux density is considered to be at a maximum through the entire length of the near-field. This region is contained within a cylindrical volume with a diameter, *D*, equal to the diameter of the antenna. In the transition region and the far-field, the power density decreases inversely with the square of the distance. The following equations are used to calculate power density in these regions:

Calculated Parameter	Value	Unit	Symbol	Formula
Power Density in the Near-Field	3.74	mW/cm^2	Snf	$16\eta P/(\pi D^2)$
Power Density in the Far-Field	1.60	mW/cm^2	Sff	$gP/(4\pi Rff^2)$
Power Density in the Transition Region	3.74	mW/cm^2	St	Snf*Rnf/Rt

The region between the main reflector and the subreflector is confined to within a conical shape defined by the feed assembly. The most common feed assemblies are waveguide flanges. This energy is determined as follows:

Calculated Parameter	Value	Unit	Symbol	Formula
Power Density at the Feed Flange	2829.4	mW/cm^2	Sfa	4P/a

The power density in the main reflector is determined similarly to the power density at the feed flange; except that the area of the reflector is used.

Calculated Parameter	Value	Unit	Symbol	Formula
Power Density at Main Reflector	7.07	mW/cm^2	Ssurface	4P/A

The power density between the reflector and ground, assuming uniform illumination of the reflector surface, is calculated as follows:

Calculated Parameter	Value	Unit	Symbol	Formula
Power Density between Reflector & Gnd	1.77	mW/cm^2	Sg	P/A

Summary of Calculations

Table 1 below summarizes the calculated power flux density values for each region. In a controlled environment, the only regions that exceed FCC limitations are the regions between the main reflector and the sub-reflector as well as the main reflector region. These regions are only accessible by trained technicians who, as a matter of procedure, turn off transmit power before performing any work in these areas.

Table 1. Power Flux Density for Each Region:

Calculated Parameter	Unit	Exposure Limit	Exposure Limit
		Uncontrolled	Controlled
Power Densities	mW/cm^2	Environment	Environment
		$\leq 1\ mW/cm^2$	$\leq 5\ mW/cm^2$
Far Field Calculation	1.60	Exceeds limitations	Satisfies FCC MPE
Near Field Calculation	3.74	Exceeds limitations	Satisfies FCC MPE
Transition Region	3.74	Exceeds limitations	Satisfies FCC MPE
Region between Main & Subreflector	2829.4	Exceeds limitations	Exceeds limitations
Main Reflector Region	7.07	Exceeds limitations	Exceeds limitations
Region between Main Reflector & Gnd	1.77	Exceeds limitations	Satisfies FCC MPE

In conclusion, the results show that the antenna, in a controlled environment, and under the proper mitigation procedures, meets the guidelines specified in § 1.1310 of the Regulations.

Annex 5 – Coordination Contours

The report prepared by Transfinite containing coordination contours is provided on the following pages.

Technical Note
O3b San Diego Gateway Coordination

Date: Revised 5th March 2014

1 Document Scope

This describes analysis undertaken by Transfinite Systems Ltd for O3b to generate a coordination contour for an Earth Station (ES) of O3b's non-GSO network in San Diego.

In addition more detailed interference zones were generated using terrain data and interference criteria from Recommendation ITU-R SF.1006.

Finally a Monte Carlo analysis was undertaken to identify the scope to use that methodology to convolve ES antenna pointing and propagation statistics.

2 Scenario Parameters

2.1 Earth Station Parameters Used

The ES parameters were taken from:

1. Email of 25th November 2013 with location and height parameters
2. Box files shared on 25th November 2013 with antenna gain patterns
3. FCC application emailed on 21st November 2013

2.2 O3b ES Location

From reference 1:

Latitude:	32° 40' 54.3" N
Longitude:	117° 7' 0.1" W
Antenna height:	12.5m above ground level
Ground height :	5.33m above sea level
Total antenna height	17.83m above sea level

Table 1: O3b ES Location

2.3 O3b ES Antenna Gain Pattern

From reference 2 the ES antenna gain pattern has been measured at 29.1 GHz and is shown in the figure below:

TRANSFINITE SYSTEMS

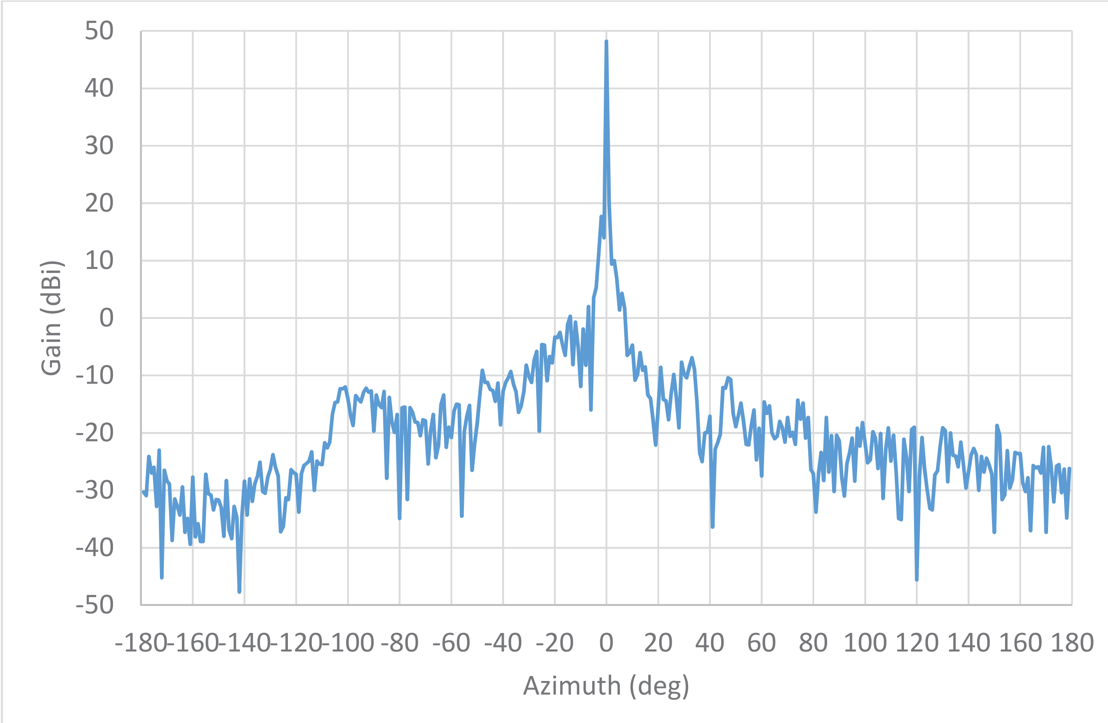

Figure 1: ES Antenna Gain Pattern Slice

The peak gain in the measured data file was 48.2 dBi and the minimum operating elevation angle was taken as 20º.

For generation of the Appendix 7 coordination contour the following simplified assumptions were made:

Gain pattern:	ITU-R Rec. S.580-6
Peak gain:	48 dBi
Beamwidth:	0.6°

Table 2: O3b ES Simplified Antenna Pattern for Appendix 7 Calculations

It is assumed the measurement missed the very narrow beam's peak gain and hence the highest gain value in the table was 0.3 dB below the specified peak gain. However this wouldn't impact the analysis as the minimum elevation angle constraint implies that gain values below 20 degrees off-axis would not be used.

2.4 O3b Transmit Link

From References 1, 2 and 3:

Transmit frequency:	29.1 GHz
Transmit power:	13 dBW
Reference bandwidth:	216 MHz

Table 3: O3b ES Transmit Link Parameters

2.5 O3B Constellation

The following parameters were used for the O3b non-GSO satellite constellation:

Type and service:	Non-GSO FSS
Orbit inclination:	0°
Orbit height:	8,062 km

Table 4: O3b Constellation

2.6 Appendix 7 Parameters

The values for transmit ES are shown in the table below from RR Appendix 7:

TABLE 7c (Rev.WRC-12)

Parameters required for the determination of coordination distance for a transmitting earth station

Transmitting space radiocommunication service designation		Fixed-satellite	Fixed-satellite [2]	Fixed-satellite [3]	Space research	Earth exploration-satellite, space research	Fixed-satellite, mobile-satellite, radionavigation-satellite	Fixed-satellite [2]
Frequency bands (GHz)		24.65-25.25 27.0-29.5	28.6-29.1	29.1-29.5	34.2-34.7	40.0-40.5	42.5-47 47.2-50.2 50.4-51.4	47.2-50.2
Receiving terrestrial service designations		Fixed, mobile	Fixed, mobile	Fixed, mobile	Fixed, mobile, radiolocation	Fixed, mobile	Fixed, mobile, radionavigation	Fixed, mobile
Method to be used		§ 2.1	§ 2.2	§ 2.2		§ 2.1, § 2.2	§ 2.1, § 2.2	§ 2.2
Modulation at terrestrial station [1]		N	N	N		N	N	N
Terrestrial station interference parameters and criteria	p_0 (%)	0.005	0.005	0.005		0.005	0.005	0.001
	n	1	2	1		1	1	1
	p (%)	0.005	0.0025	0.005		0.005	0.005	0.001
	N_L (dB)	0	0	0		0	0	0
	M_s (dB)	25	25	25		25	25	25
	W (dB)	0	0	0		0	0	0
Terrestrial station parameters	G_x (dBi) [4]	50	50	50		42	42	46
	T_e (K)	2 000	2 000	2 000		2 600	2 600	2 000
Reference bandwidth	B (Hz)	10^6	10^6	10^6		10^6	10^6	10^6
Permissible interference power	$P_r(p)$ (dBW) in B	–111	–111	–111		–110	–110	–111

Figure 2: Extract from Appendix 7 for Transmit ESs

Footnotes:

2. Non-geostationary satellites in the fixed-satellite service.

3 Appendix 7 Coordination Contour

The Visualyse Coordinate tool can be used to generate ES coordination contours according to the algorithm in ITU-R RR Appendix 7. The algorithm ensures that the contour is never less than around 100 km in radius, as shown in the figure below:

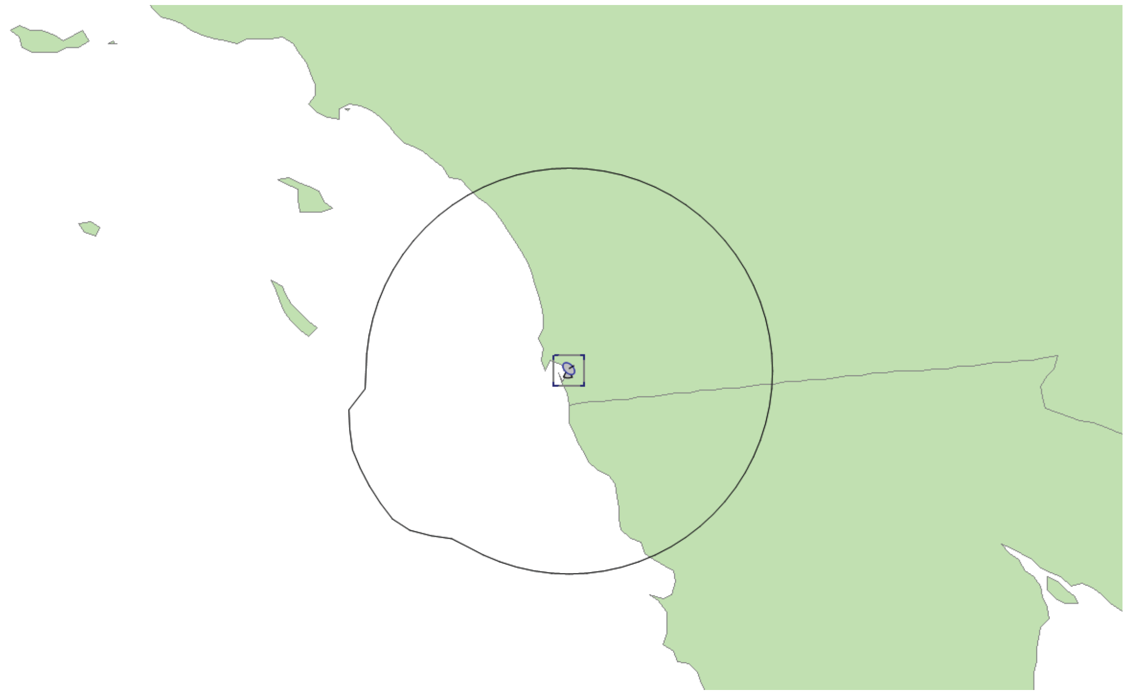

Figure 3: Transmit Coordination Contour

With the ES less than 20 km inside the US and a minimum contour size of 100 km, the coordination contour can be expected to cross the border into Mexico.

4 Recommendation ITU-R SF.1006 Interference Zone

4.1 Sharing Criteria

The approach in Appendix 7 is to use an agreed set of parameters in the Radio Regulations that can only be changed at World Radiocommunication Conferences. These are by nature conservative as they are used as coordination triggers and in detailed coordination actual parameters would be used.

Given that the methodology in Appendix 7 is conservative there are three mechanisms that can be used to reduce the size of the coordination contour:

1. Remove the requirement for a minimum distance of 100 km

2. Use actual or at least more realistic parameters including sharing criteria and ES antenna gain pattern
3. Include the effect of terrain

This approach can be undertaken by using the thresholds in:

- Rec. SF. 1006: Determination of the interference potential between earth stations of the fixed-satellite service and stations in the fixed service

In addition it is worth reviewing typical usages of the band and equipment types.

4.2 Recommendation ITU-R SF. 1006

This recommendation provides a methodology and table of parameters to calculate sharing criteria, and in general the values are similar to those in Appendix 7, as shown in the table below:

Parameters	From SF.1006	From App.7
Frequency band	29 GHz	29 GHz
Interferer	FSS	FSS
Victim	FS	FS
p1 (%)	20	n/a
p2 (%)	0.005	0.005
n2	1	2
B (Hz)	1.00E+06	1.00E+06
J (dB)	0	n/a
W (dB)	0	0
Tr (K)	3200	2000
Ms (dB)	25	25
Nl (db)	0	0

Table 5: Rec. SF.1006 vs. Appendix 7 Parameters

SF.1006 gives long term thresholds as well as short term ones, plus there is also a difference in the receive temperature for the FS.

The following interference thresholds were used:

Threshold	Short term	Long term
p (%)	0.005	20
I (dBW)	-108.6	-133.5

Table 6: Interference Thresholds from SF.1006

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4.3 FS Antenna Sizes

The primary use of these bands is for mobile backhaul where a significant factor is to keep costs low. This means that operators are unlikely to use antennas larger than 30cm, which corresponds to peak gains of 37 dBi at 29 GHz.

4.4 Terrain Database

The ASTER2 database was used. This has a horizontal resolution of 30m between pixels and is a surface database so it includes some of the effects of buildings. However its resolution means it is unable to identify specific buildings and cannot in this case be considered to include local clutter around the ES.

The figure below shows the ASTER2 terrain / surface details around San Diego:

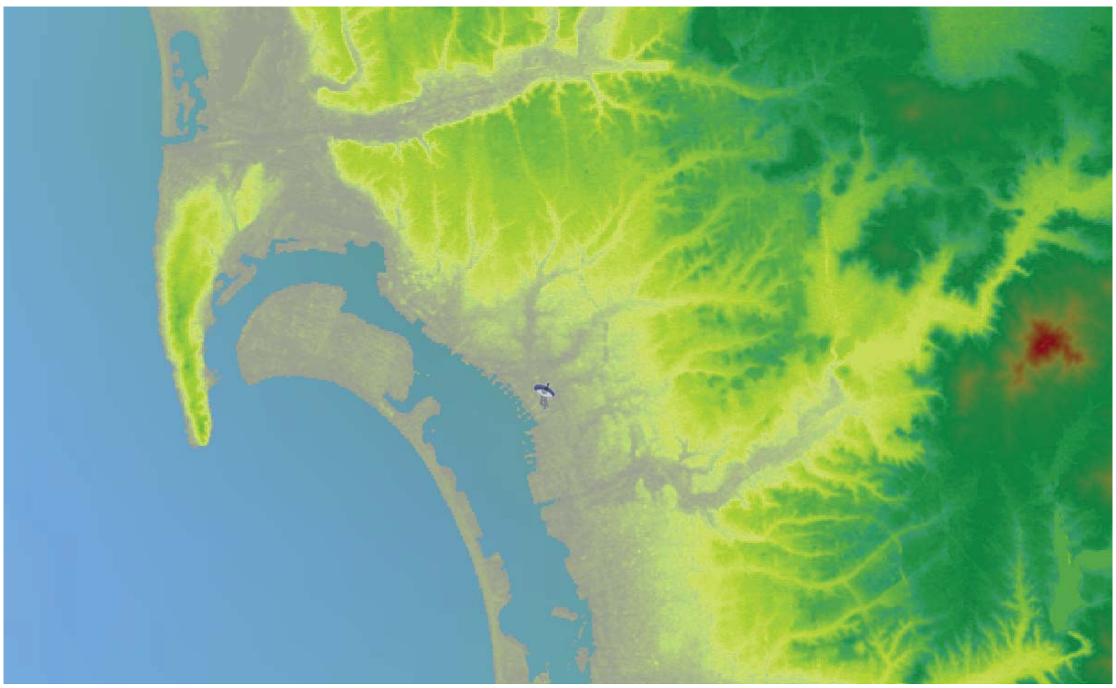

Figure 4: ASTER2 Surface Data

This surface data is freely available from the following web site:

http://earthexplorer.usgs.gov/

Data is provided subject to terms and conditions available on this web site which includes:

- When presenting or publishing ASTER GDEM data, users are required to include a citation stating, "ASTER GDEM is a product of METI and NASA."
- The data are provided "as is" and neither NASA nor METI/ERSDAC will be responsible for any damages resulting from use of the data.

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4.5 O3b Horizon Gain

Another factor to consider is how the O3b ES gain towards the horizon varies as the constellation moves.

It was noted that this pattern was not symmetric around the zero degrees azimuth line and hence an average pattern was created assuming symmetry around the zero degree azimuth as shown in the figure below:

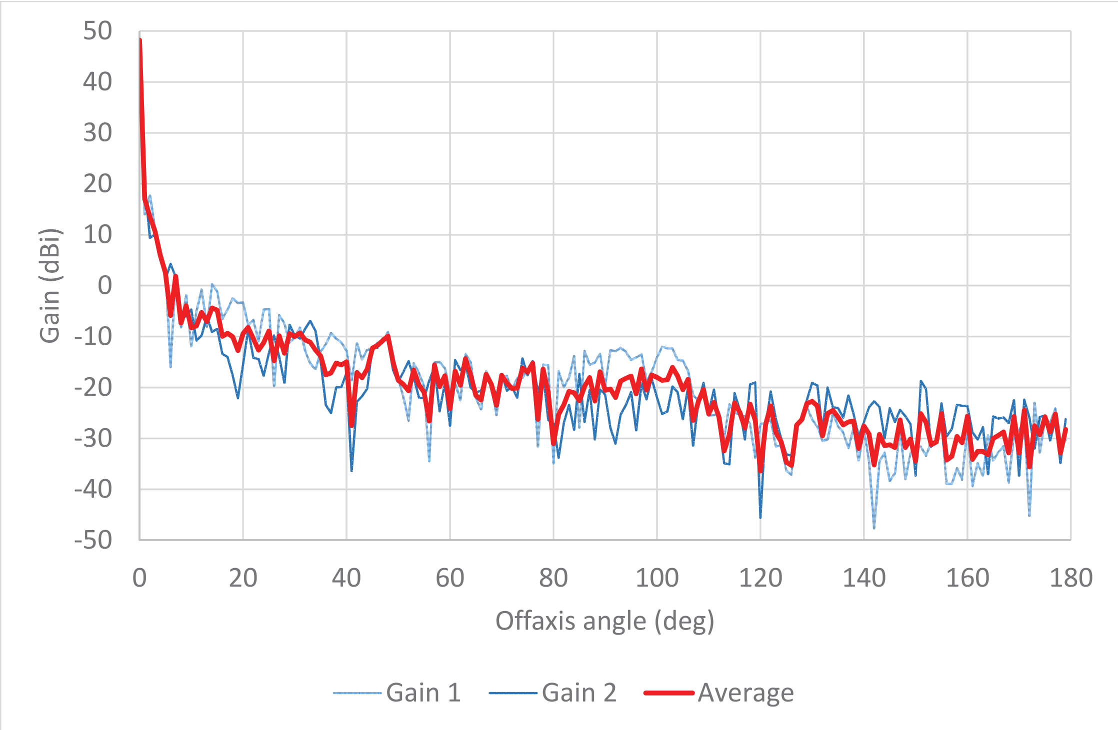

Figure 5: ES Antenna Gain Pattern Symmetric Pattern

This symmetric pattern was used in a simulation to work out the peak gain towards the horizon for the O3b constellation with minimum elevation angle of 20° as shown in the figure below:

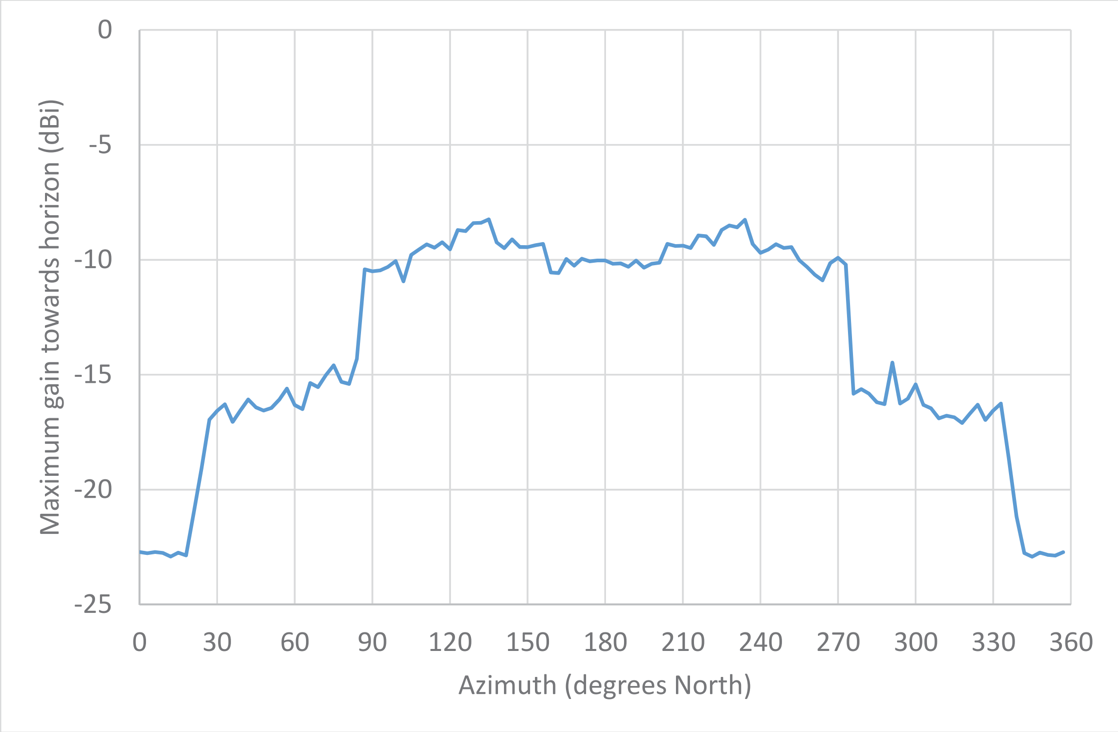

Figure 6: Horizon Gain for O3b

4.6 Mitigation Methods

A number of mitigation methods could be used to reduce the impact of the O3b ES on FS links in adjacent countries including:

- Include use of the auxiliary contours. As described by Appendix 7, it is unlikely that there will be the worst case geometrical alignment in which the FS antenna is pointing directly at the ES, there is likely to be some antenna gain discrimination. A value of 5 dB is typically used in these cases
- Include the FS antenna feed loss: a value of 1 dB would be typical for systems in this band.

4.7 Short Term and Long Term Interference Zones

From the parameters in the previous section the following areas where the short and long term interference thresholds are exceeded were generated and then displayed in Google Earth:

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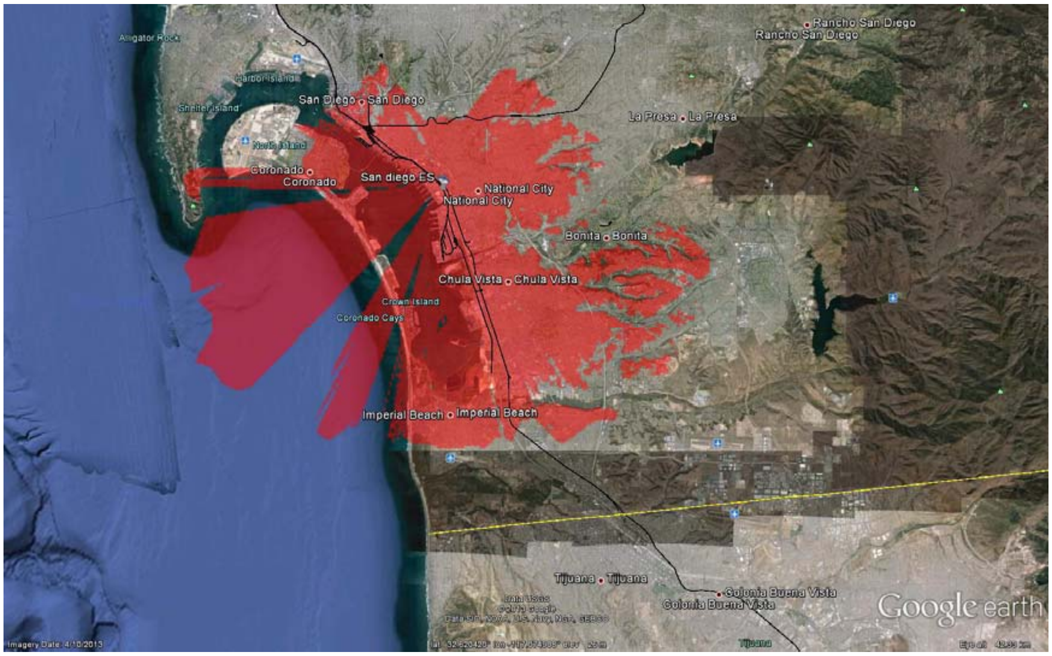

Figure 7: O3b Long Term Interference Zone

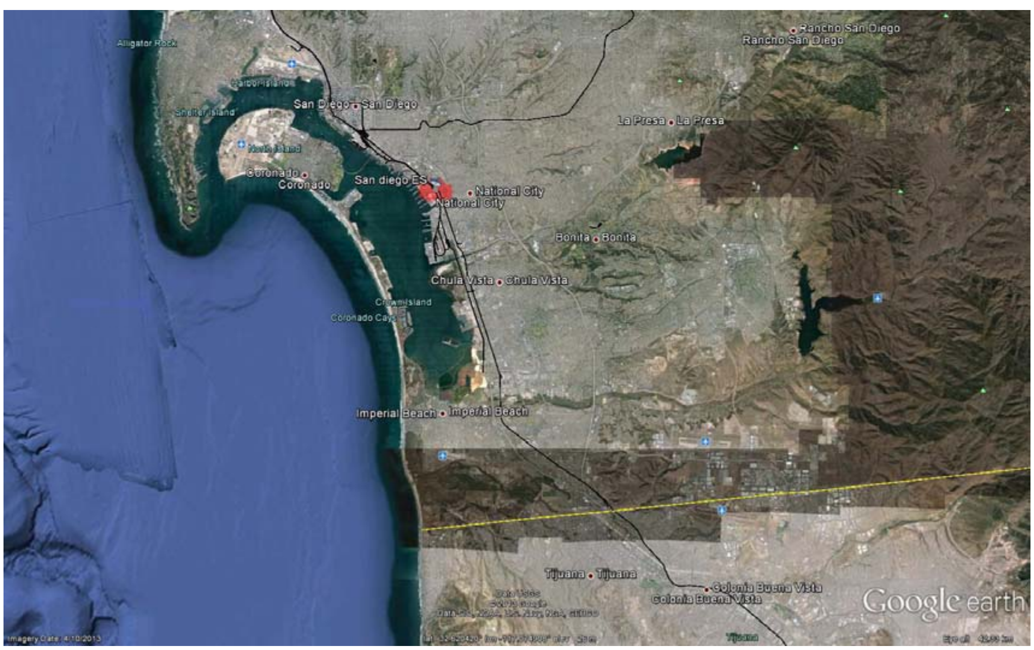

Figure 8: O3b Short Term Interference Zone

4.8 Comments

It was noted that the interference zones were significantly smaller than those generated assuming Appendix 7. This was because:

- The O3b transmit power is relatively low, resulting in an interference zone significantly less than the minimum 100 km contour in Appendix 7.
- The assumed FS antenna peak gain in Appendix 7 of 50 dBi was considered larger than would be typically used in this band
- The measured antenna gain pattern had lower far off-axis sidelobes than those assumed in Rec. ITU-R S.580-6

Taking into consideration the above, it was noted that both the short term and long term interference zones are fully contained within the U.S. borders.