LEGAL NARRATIVE AND
RESPONSE TO QUESTIONS 35:
WAIVER OF THE RULES

O3b Limited ("O3b") operates a U.K.-authorized, non-geostationary orbit ("NGSO") Fixed-Satellite Service ("FSS") system in the Ka-band.[1] O3b's first four satellites were launched on June 25, 2013, and an additional four satellites were launched on July 10, 2014.

In this application, O3b seeks a license permitting it to operate two (2) 2.4m General Dynamics Satcom antennas at the O3b facility in Haleiwa, Hawaii ("Hawaii 2.4m Earth Station"). O3b has previously been granted an STA to operate the same earth station model at the O3b facility in Bristow, Virginia[2] and has filed an application for a license at the same location.[3]

Public Interest Showing

The Hawaii 2.4m Earth Station will communicate with O3b's system and provide support and redundancy for the telemetry, tracking and command ("TT&C") and data feed functions that are handled by O3b's previously-licensed gateway terminal (the "Hawaii Gateway Earth Station"), which is located at the same facility as the Hawaii 2.4m Earth Station.[4] The Hawaii 2.4m Earth Station will also permit O3b to conduct customer demonstrations should the need arise. The Hawaii 2.4m Earth Station will make the O3b system more resilient and ensure that its customers around the globe continue to receive high quality service from O3b.

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.[5] The Commission granted this application.[6]

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[1] In September 2012, the Commission granted O3b a license to operate one of the gateways for this system in Haleiwa, Hawaii. *See* FCC File No. SES-LIC-20100723-00952 (granted Sept. 25, 2012) (the "Hawaii Gateway 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).
[2] *See* O3b Limited, Call Sign E130107, File No. SES-STA-20130617-00497, granted August 27, 2013 ("O3b Bristow STA")
[3] *See* O3b Limited, Call Sign E130107, File No. SES-LIC-20130618-00516, filed June 18, 2013 ("O3b Bristow License Application"), and which was placed on Public Notice on December 18, 2013.
[4] *See* File No. SES-LIC-20100723-00952.
[5] *See* Application for Hawaii Gateway Earth Station, File No. SES-LIC-20100723-00952, Legal Narrative, Section III and Attachment A thereto (Technical Statement), Section A.2.
[6] *See* O3b Hawaii Gateway License.

O3b has filed an application seeking to modify its Hawaii Gateway license to give it the flexibility to operate up to two of its eight NGSO satellites as in-orbit spares.[7] 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.[8] O3b has been granted an STA pending action on its modification application.[9]

U.S. Market Access

Under the Commission's "DISCO II" procedure, a company may obtain U.S. "landing rights" for a non-U.S. licensed space station by filing an initial earth station application that lists the space station as a "point of communication," and demonstrating that the space station meets applicable Commission requirements.[10] O3b provided such a showing, which it hereby incorporates by reference, as part of its application for a license to operate a gateway earth station in Haleiwa, Hawaii.[11] In September 2012, the Commission, by granting the Hawaii Gateway License and associated waivers, determined that O3b meets the criteria for U.S. market access.[12]

In its DISCO II decision, the Commission adopted requirements that apply once an initial application seeking U.S. market access for a non-U.S. satellite system has been granted. There is no need, the Commission found, for a new DISCO II showing to be made by future earth station applicants requesting authority to communicate with the non-U.S. satellite system.[13] Rather, it is sufficient that any such earth station applicant cite to the initial grant of market access; confirm that there has been no change in the services the satellite system will be used to provide; and represent that there has been no change to the satellite system's operating parameters.[14] Consistent with these requirements, O3b hereby cites to its O3b Hawaii Gateway License; confirms that there has been no change in the services its satellite system will be used to provide; and represents that there has been no change to its satellite system's operating parameters.

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[7] *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.

[8] 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.

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

[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 ("DISCO II")*, 15 FCC Rcd 7207, ¶ 5 (1999).

[11] *See* O3b's application for a Hawaii gateway license ("O3b Hawaii Application"), FCC File No. SES-LIC-20100723-00952, narrative at Section V.

[12] *See* Hawaii Gateway License. The Commission subsequently issued the Texas License (*see* n.1) and a blanket license for O3b's maritime earth stations (*see* FCC File No. SES-LIC-20130528-00455 (granted May 13, 2014) (the "Blanket Maritime License")).

[13] *DISCO II,* 15 FCC Rcd 7207 at ¶ 192.

[14] *Id.*

Frequency Plan

The Hawaii 2.4m Earth Station will communicate with O3b's NGSO system.[15]

The frequencies to be used by the Hawaii 2.4m Earth Station are:

- 27.6-28.4 GHz, 28.6-29.1 GHz (uplink)
- 17.8-18.6 GHz, 18.8-19.3 GHz (downlink)

The Hawaii 2.4m Earth Station antennas will be mounted on a fixed platform. Although the pointing angle of the antennas will change as O3b's in-orbit satellites are tracked, the platform will remain stationary. O3b's proposed Hawaii 2.4m Earth Station operations in shared bands are consistent with the Commission's rules and policies. O3b addresses each of these bands below.

UPLINK

27.6-28.35 GHz – Secondary uplink band shared with primary LMDS.

The 27.6-28.35 GHz uplink band is allocated to the local multipoint distribution service ("LMDS") on a primary basis. FSS operations are allocated on a secondary basis in the same band. Accordingly, O3b's proposed operations in this band must not cause harmful interference to primary LMDS stations.

The attached Comsearch coordination report demonstrates that O3b can operate its Hawaii 2.4m Earth Station on a secondary basis in this band without causing harmful interference to LMDS licensees. Comsearch sent a coordination notice to all existing and proposed terrestrial licensees within the Comsearch coordination contours of the Hawaii 2.4m Earth Station site. No objections were received from any of the incumbent licensees.

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 Hawaii 2.4m 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.[16] O3b satisfies both of these standards.

[15] O3b's first four satellites were launched on June 25, 2013. O3b's next batch of four satellites was launched on July 10, 2014.

[16] *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).

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.[17]

The Hawaii 2.4m Earth Station will be located at the same site as the Hawaii Gateway Earth Station,[18] which results in the same angular separation between the O3b and geostationary orbits as viewed from the Earth and an equivalent assurance that the applicable ITU $EPFD_{up}$ limits will be met by O3b's proposed operations. The proposed Hawaii 2.4m 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.

DOWNLINK

17.8-18.3 GHz – Primary downlink band for licensed FS Systems.

This frequency band is allocated on a primary basis to FS, and there is no secondary allocation for NGSO FSS in the band. Accordingly, 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 noted above, in analyzing requests for non-conforming spectrum uses, the Commission has indicated it will generally grant such waivers where there is not potential for interference into any service authorized under the Table of Frequency Allocations and when the non-conforming operator accepts any interference from allocated services.

In this case, O3b's proposed non-conforming use of the 17.8-18.3 GHz frequency band for downlink operations will not cause harmful interference to FS operations in the same band. This is because O3b will meet the PFD limits at the earth's surface prescribed by the ITU for the protection of terrestrial services in this band. In addition, as a non-conforming user, O3b will accept interference from FS operations in the band.

In addition, an Interference Analysis Report from Comsearch indicates that there will be no restrictions of O3b's operations due to interference considerations.

[17] O3b Hawaii Gateway License Application, FCC File No. SES-LIC-20100723-00952, Technical Attachment at A.10.1.
[18] The O3b Hawaii Gateway Earth Station latitude is 21° 40' 17.8" N.

In light of the foregoing, a waiver of Section 2.106 of the Commission's rules and the Ka-Band Plan is warranted because no harmful interference will result to incumbent FS operations, O3b can operate satisfactorily within the 18 GHz microwave environment, and the public interest is otherwise served by permitting O3b to support its commercial operations.

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

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 ("$EPFD_{down}$") 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.[19]

As an example of how these limits will be satisfied, O3b provided $EPFD_{down}$ calculations for transmissions to its Hawaii Gateway Earth Station.[20] O3b also showed how the $EPFD_{down}$ limits can be satisfied at all latitudes.[21] 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.[22] Based on these prior showings, it can be seen that transmissions to O3b's Hawaii 2.4m Earth Station will be within the $EPFD_{down}$ limits.

Waivers Sought by O3b

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.[23] The Commission has waived Section 25.145(c) for O3b's Hawaii and Texas gateway earth stations and its maritime terminals but has reserved judgment on granting a waiver of Section 25.145(c) for any other O3b applications.[24]

The Commission based the waiver for the Hawaii Gateway Earth Station on the fact that the Hawaii authorization "is limited to a single earth station that is providing gateway and TT&C services

[19] *See* ITU Radio Regulations, Article 22. *See also* O3b Hawaii Gateway 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 Gateway Earth Station, File No. SES-LIC-20100723-00952 (Apr. 22, 2011), Annex A.
[20] O3b Hawaii Gateway License Application, FCC File No. SES-LIC-20100723-00952, Technical Attachment at A.10.1.
[21] *See* id.
[22] *See* id.
[23] 47 C.F.R. § 25.145(c).
[24] *See* Hawaii Gateway License, Condition 90044; Texas License, Condition 90044; and Blanket Maritime License, Condition 6597.

only."[25] The waiver is "without prejudice to action on any waiver request filed in connection with an application to provide additional services to, from, or within the United States."[26] The Commission granted a similar waiver for O3b's Texas earth station[27] and granted a waiver in connection with the grant of O3b's blanket maritime earth station application because O3b's maritime service area is "less extensive than the geographic coverage areas required in Section 25.145(c)."[28] These grants also were without prejudice to action on future waiver requests.

O3b requests a waiver of Section 25.145(c) for its Hawaii 2.4m Earth Station.

The Hawaii 2.4m Earth Station is intended to support and replicate the functions of the Hawaii Gateway Earth Station. The Commission has already determined that these purposes justify a waiver of Section 25.145(c) when it granted a waiver for the Hawaii Gateway Earth Station. There is also good cause, therefore, for the Commission to also grant a waiver for the Hawaii 2.4m Earth Station.

Space Station Cross-polarization Isolation and Relief of Pressure Vessels. In granting the Hawaii Gateway License, the Commission found good cause to grant the O3b constellation (1) a waiver of the requirement in Section 25.210(i)(1) for FSS space station antennas to have a minimum cross-polarization isolation of 30 dB in their primary coverage area; and (2) a waiver of that portion of Section 25.283(c) relating to relief of pressure vessels aboard the O3b spacecraft at their end of life. These waiver grants were not limited to the Hawaii Gateway License. Accordingly, O3b should not need to request or obtain these waivers again for the spacecraft in the O3b constellation. However, out of an abundance of caution and to the extent necessary, O3b hereby incorporates by reference the waiver requests in its Hawaii application related to Sections 25.210(i)(1) and 25.283(c).[29] For the reasons stated therein, which apply with equal force here, those waivers, if needed again, should be granted in this case as well.

Bond Requirement. O3b respectfully requests that it not be required, in connection with a grant of its Hawaii 2.4m Earth Station application, to post a bond to secure the implementation of the O3b satellite system. The Commission previously determined that O3b has satisfied all system milestones and authorized O3b to release the bond it had posted for the Hawaii Gateway License.[30] Given this history, there is no basis for requiring that a bond be posted.

Even if the Commission had not determined that all milestones have been satisfied and the bond for the Hawaii Gateway License remained outstanding, there would be no reason to require a second bond in connection with this application. The Commission previously determined that it would

[25] *Id.*
[26] *Id.*
[27] *See* Texas License, Condition 90044.
[28] *See* Blanket Maritime License, Condition 6597
[29] *See* Application for Hawaii Gateway License, Legal Narrative, Section D(2)(ii) at 22-23 and Section D(2)(iii) at 24; *see also* Attachment A (Technical Information) thereto, Section A.14 at 40-42 and Section A.13.2 at 34-36.
[30] *See* Public Notice, Report No. SES-01681 (Sept. 10, 2014), p. 12.

be inappropriate to impose a bond requirement for a foreign-licensed satellite entrant that would have necessitated the posting of a duplicative bond.[31]

Earth Station Technical Parameters

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

- Annex 1: Link Budgets. Representative links for the Hawaii 2.4m Earth Station are provided.
- Annex 2: Antenna Characteristics. Characteristics of the 2.4m General Dynamics Antenna are provided for the Commission's convenience.
- Annex 3: Radiation Hazard Study. The radiation hazard analysis for the 2.4m General Dynamics antenna is attached. As described in Annex 3, O3b will follow procedures to mitigate potential radiation hazards to personnel in controlled and uncontrolled environments.
- Annex 4: Comsearch Reports. Comsearch Reports are provided for bands in which terrestrial frequencies have primary allocations. Comsearch notified operators within a coordination zone calculated using the ITU RR Appendix 7 guidelines.
    - 27.6-28.35 GHz band. As stated in the attached Frequency Coordination Report, Comsearch has notified all existing and proposed LMDS licensees that are within the coordination contours of the Hawaii 2.4m Earth Station and that potentially could be affected by O3b's transmissions in the 27.6-28.35 GHz portion of the Ka-band. No objections were received from any of these parties.
    - 18.3-18.6 GHz band. As stated in the attached Interference Analysis Report, for operations in the 18.3-18.6 GHz band, the Hawaii 2.4m Earth Station will operate satisfactorily within the 18 GHz microwave environment, and there will be no restrictions of its operation due to interference considerations.
- Annex 5: Comsearch and O3b Field Strength Analysis. O3b is aware that there is a FCC monitoring station at Waipahu, Hawaii. To demonstrate compliance with Section 25.203(g)(1) of the Commission's rules, O3b is providing the attached Field Strength Analysis conducted by Comsearch and a more recent analysis conducted by O3b to demonstrate that the monitoring station at Waipahu will be adequately protected.

[31] *See Telesat Canada*, DA 07-118, *Orde*r, File No. SAT-PPL-20060516-00061, at ¶ 14 (Jan. 19, 2007) ("We agree with Telesat that it is not necessary to have more than one bond posted with respect to ANIK F3 to fulfill the purposes of the bond requirement.").

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.[32] 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.[33] O3b will operate its Hawaii 2.4m 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 Hawaii 2.4m Earth Station. As a result, O3b's existing US334 coordination agreement covers the use of the Hawaii 2.4m Earth Station as requested in this application.
- Antenna Patterns. O3b previously submitted measured 30 GHz band antenna performance data for the 2.4m General Dynamics Satcom antenna to the Commission in the pending Hawaii 2.4m License Application.[34]

[32] *See* O3b Hawaii Gateway License.
[33] *See* O3b Limited, Call Sign E130098, File No. SES-AMD-20131025-01138 ("O3b ESV Answers").
[34] *See* O3b Bristow License Application.

Conclusion

O3b has demonstrated that its Hawaii 2.4m Earth Station will enhance O3b's service and provide critical system redundancies. Grant of O3b's application, therefore, is in the public interest.

Respectfully submitted,

O3b Limited

By: /s/Suzanne Malloy

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October 22, 2014

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ANNEX 1 – Link Budgets

Representative link budgets for the 2.4m General Dynamic antenna at the Hawaii 2.4m Earth Station are provided on the following two pages.

O3b Networks Link Analysis - Tier2 Service for Sunset Beach/U.S.A.

ECM Link Budget Rpt - 9/25/2014		Tier2	Tier2
Parameters	Unit	**Clear Sky**	
Ground parameters		**Teleport**	**Telco**
Location		Sunset Beach/U.S.A.	Sunset Beach/U.S.A.
Latitude	(deg)	21.67	21.67
Longitude (East)	(deg)	201.97	201.97
E/S Range to SV	(km)	9318.98	9318.91
E/S Elevation to SV	(deg)	43.13	43.13
E/S Altitude	(km)	0.00	108.00
SV Beam Identifier	(#)	21	
Telco Offset to Beam Center	(km)	0.00	
Modulation Parameters		**Forward**	
Enter Reciever	Type	MEOLink	
Percentage of Bandwidth	(%)	100%	
Allocated Bandwidth	(MHz)	216	
Channel Symbol Rate	(Msps)	180	
Channel Modulation Type		32APSK	
Channel FEC Rate		0.83	
Channel Throughput	(Mbps)	747.77	
Uplink		**Forward**	
E/S Carrier Frequencies	(MHz)	27760	
E/S Tx HPA Power Level	(W)	500	
E/S Tx OBO	(dB)	-10	
E/S Tx Antenna Gain (7.3m)	(dB)	65.23	
E/S Tx EIRP Per Channel	(dBW)	74.03	
E/S Tx RF Link Availability	(%)	Clear	
E/S Tx Spreading Loss	(dB)	-150.38	
Satellite		**Forward**	
SV Rx G/T	(dB/K)	5.69	
SV Tx OBO	(dB)	-3.80	
SV Tx EIRP Per Channel/Carrier	dBW	45.06	
Downlink		**Forward**	
E/S Rx Carrier Frequency	(MHz)	17960	
E/S Rx Rf Link Availability	(%)	Clear	
E/S Rx Antenna Gain (2.4m)	(dBi)	51.84	
E/S Rx Effective G/T	(dB/K)	28.33	
Total Link		**Forward**	
Carrier/Noise Bandwidth	(dB)	51.93	
Carrier/Noise Uplink	(dB)	24.13	
Carrier/Noise Downlink	(dB)	21.63	
Carrier/Intermodulation Im (C/Im)	(dB)	25.00	
(C/N)- Total Actual (Es/No)	(dB)	16.18	
(C/N)-Total Required	(dB)	15.58	
(Eb/No)-Total Actual	(dB)	10.00	
(Eb/No)-Total Required	(dB)	9.40	
Excess Margin	(dB)	**0.60**	
Fade Margin	(dB)	**18.43**	

#1

O3b Networks Link Analysis - Tier2 Service for Sunset Beach/U.S.A.

ECM Link Budget Rpt - 9/25/2014		Tier2	Tier2
Parameters	Unit	**Clear Sky**	
Ground parameters		**Teleport**	**Telco**
Location		Sunset Beach/U.S.A.	Sunset Beach/U.S.A.
Latitude	(deg)	21.67	21.67
Longitude (East)	(deg)	201.97	201.97
E/S Range to SV	(km)	9318.98	9318.91
E/S Elevation to SV	(deg)	43.13	43.13
E/S Altitude	(km)	0.00	108.00
SV Beam Identifier	(#)	21	
Telco Offset to Beam Center	(km)	0.00	
Modulation Parameters		**Return**	
Enter Reciever	Type	MEOLink	
Percentage of Bandwidth	(%)	100%	
Allocated Bandwidth	(MHz)	216	
Channel Symbol Rate	(Msps)	180	
Channel Modulation Type		16APSK	
Channel FEC Rate		0.66	
Channel Throughput	(Mbps)	478.22	
Uplink		**Return**	
E/S Carrier Frequencies	(MHz)	27760	
E/S Tx HPA Power Level	(W)	40	
E/S Tx OBO	(dB)	-9	
E/S Tx Antenna Gain (2.4m)	(dB)	55.39	
E/S Tx EIRP Per Channel	(dBW)	61.62	
E/S Tx RF Link Availability	(%)	Clear	
E/S Tx Spreading Loss	(dB)	-150.38	
Satellite		**Return**	
SV Rx G/T	(dB/K)	5.84	
SV Tx OBO	(dB)	-13.44	
SV Tx EIRP Per Channel/Carrier	dBW	35.25	
Downlink		**Return**	
E/S Rx Carrier Frequency	(MHz)	17960	
E/S Rx Rf Link Availability	(%)	Clear	
E/S Rx Antenna Gain (7.3m)	(dBi)	61.79	
E/S Rx Effective G/T	(dB/K)	40.51	
Total Link		**Return**	
Carrier/Noise Bandwidth	(dB)	51.93	
Carrier/Noise Uplink	(dB)	11.37	
Carrier/Noise Downlink	(dB)	23.99	
Carrier/Intermodulation Im (C/Im)	(dB)	25.00	
(C/N)- Total Actual (Es/No)	(dB)	10.58	
(C/N)-Total Required	(dB)	10.08	
(Eb/No)-Total Actual	(dB)	6.34	
(Eb/No)-Total Required	(dB)	5.84	
Excess Margin	(dB)	**0.50**	
Fade Margin	(dB)	**12.84**	

ANNEX 2 –Terminal Characteristics

The figure below shows the O3b 2.4 meter ("2.4m") General Dynamic terminal.

Figure: O3b's 2.4 meter terminal

The 2.4m terminal is fully stabilized to account for the movement of the O3b satellite in its orbit.

Each terminal comprises a pair of tracking antennas under the control of a dedicated antenna control unit. One antenna acquires and follows a rising O3b satellite in MEO orbit while the second antenna is parked in a home position for the next rising satellite. The O3b service is maintained by the antenna pair acquiring and tracking alternate satellites in the O3b constellation.

The 2.4m terminal is certified by the manufacturer to meet or exceeds all the standards of 47 C.F.R. 25.209. The terminal's tracking accuracy and rate is better than +/- 0.08 degrees with a .5dB beam peak.

Annex 3 – Radiation Hazard Study

The Radiation Hazard study for the General Dynamics 2.4 meter antenna is provided on the following pages.

REPORT TITLE:

Non-Ionizing Radiation Hazard Analysis

PREPARED BY:		APPROVED BY:	
Randy Taylor		Gary Mattie	

SCOPE/TEXT (ATTACH ADDITIONAL SHEETS AS REQUIRED)

This report analyzes non-ionizing radiation levels for O3b's 2.4m Tier 2 MEO earth stations. Calculations are performed in accordance with FCC Office of Engineering and Technology's "Bulletin No. 65 Edition 01-01 Supplement C" with regard to the frequencies and antenna types being used. Maximum Permissible Exposure (MPE) limits at O3b uplink frequencies include two exposure situations with limits as described below.

General Population/Uncontrolled Exposure (MPE), averaging window of 30 minutes or less:

1500-100,000 (MHz) = **1.0 mW/cm²**

Occupational/Controlled Exposure (MPE), averaging window of 6 minutes or less:

1500-100,000 (MHz) = **5.0 mW/cm²**

This analysis compares MPE limits to the calculated power flux densities at the antenna feed, main reflector surface, between the edge of the main reflector and the ground, near-field region, transition region, and the beginning of the far field.

The result of the analysis is a summary table which describes the power flux densities at key locations and the strategy for limiting General Population and Occupational exposure.

Non-Technical Data. Authorized for Export.

DISTRIBUTION

B. Holz J. Bloom S. Blumenthal G. Mattie M. Carpenter	J. Mowat K. Mentasti		

1. Formulas and Parameters Used

The following data is used throughout the analysis:

Parameters	Symbol	Value	Units	Notes/Formulas
Transmit Power	P	35.90	W	
Frequency	F	28388	MHz	
Wavelength	λ	0.011	m	299.792458 / F
Antenna Diameter	Dref	2.4	m	
Antenna Surface Area	Aref	4.524	m^2	π $Dref^2$ / 4
Subreflector Diameter	Dsub	N/A	m	Offset feed antenna
Subreflector Surface Area	Asub	N/A	m^2	π $Dsub^2$ / 4
Feed Flange Diameter	Dflange	0.0445	m	Direct measurement
Feed Flange Area	Aflange	0.002	m^2	π $Dflange^2$ / 4
Antenna Gain	Ges	55.20	dBi	Mfg spec
Antenna Gain	G	331131.121		10^(Ges / 10)
Antenna Efficiency	η	0.650		G λ^2 / π^2 $Dref^2$
Pi	π	3.142		

2. Density at Feed Flange

The maximum power flux density at the surface of the feed flange is as follows:

Parameters	Symbol	Value	Units	Notes/Formulas
Density @ flange		92330.362	W/m^2	4 P / Aflange
	Sflange	9232.304	mW/cm^2	

3. Density at Main Reflector

The maximum power flux density at the surface of the main reflector is as follows:

Parameters	Symbol	Value	Units	Notes/Formulas
Density @ Main Reflector		31.740	W/m^2	4 P / Aref
	Ssurface	3.174	mW/cm^2	

4. Density between Main Reflector and Ground

The maximum power flux density in the area between the edge of the main reflector and the ground is as follows

Parameters	Symbol	Value	Units	Notes/Formulas
Density, Main Reflector/Ground		7.935	W/m^2	P / Aref
	Sground	0.794	mW/cm^2	

5. Density within the Near Field

The Near Field environment for a parabolic reflector antenna is contained within a cylinder with the same diameter as the main reflector which extends to a distance called the Near Field Extent

Power within the Near Field is constant with the following maximum flux density:

Parameters	Symbol	Value	Units	Notes/Formulas
Range to Near Field Extent	Rnf	136.357	m	$Dref^2 / 4 \lambda$
Density within the Near Field		20.619	W/m^2	$16.0 \eta P / \pi Dref^2$
	Snf	2.062	mW/cm^2	

6. Density at Transition Region

The Transition Region is the area between the Near Field and Far Field regions where power decreases linearly with distance.

The maximum power flux density within the Transition Region is located at the Near Field extent range and is calculated as follows:

Parameters	Symbol	Value	Units	Notes/Formulas
Range to Transition Region	Rt	136.357	m	Occurs at near field extent
Density @ Transition		20.619	W/m^2	Snf Rnf / Rt
	Snf	2.062	mW/cm^2	

7. Density at Beginning of the Far Field

The Far Field region is the range at which power decreases inversely with the square of the distance. The maximum power flux density within the Far Field region occurs at the Far Field Boundary and is calculated as follows:

Parameters	Symbol	Value	Units	Notes/Formulas
Range to Far Field Boundary	Rff	327.256	m	$0.6 D^2 / \lambda$
Density @ Far Field Boundary		8.832	W/m^2	$P G / 4 \pi Rff^2$
	Sff	0.883	mW/cm^2	

8. Range to Far Field General Population Exposure Limit

In addition to the power flux density calculations at key locations, it's valuable to locate the specific range at which MPE limits are reached to aid in managing exposure control.

The following calculation shows the range at which the Far Field General Population MPE limit occurs:

Parameters	Symbol	Value	Units	Notes/Formulas
Range to 1 mW/cm²		307.541	m	Range to General Population Limit
		10.001	W/m²	
		1.000	mW/cm²	

9. Non-Ionizing Radiation Summary

Flux Densities & Exposure Limits

General Population Exposure Limit = 1.0 mW/cm^2
Occupational Exposure Limit = 5.0 mW/cm^2

Region	Symbol	Level	Units	Hazard Assessment
Density @ Antenna Flange	Sflange	9232.304	mW/cm²	Exceeds General Population Exposure limit
				Exceeds Occupational Exposure limit
Density @ Main Reflector	Ssurface	3.174	mW/cm²	Exceeds General Population Exposure limit
				Does not exceed Occupational Exposure limit
Density Between Main Reflector and Ground	Sground	0.794	mW/cm²	Does not exceed General Population Exposure limit
				Does not exceed Occupational Exposure limit
Max Density @ Near Field Extent	Snf	2.062	mW/cm²	Exceeds General Population Exposure limit
				Does not exceed Occupational Exposure limit
Max Density @ Transition Region	St	2.062	mW/cm²	Exceeds General Population Exposure limit
				Does not exceed Occupational Exposure limit
Density @ Beginning of Far Field	Sff	0.883	mW/cm²	Does not exceed General Population Exposure limit
				Does not exceed Occupational Exposure limit

Range to Key Points and General Population Exposure Limit Avoidance Methods

Distance from Antenna	Symbol	Value	Units	Protection Method
Antenna Immediate Area				Fencing and Signage, no public access
Range to Near Field Extent	Rnf	136.357	m	Main lobe offset greater than 1 diameter
Range to Far Field Boundary	Rff	327.256	m	Main lobe offset greater than 1 diameter
Range to 1 mW/cm² MPE Limit		307.541	m	Main lobe offset greater than 1 diameter

10. Conclusion

The above analysis confirms the presence of potentially hazardous power flux densities at the O3b Tier 2 MEO terminals which will require physical and operation protections to manage General Population and Occupational Exposure.

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 2.4m antenna is performed. Where an enclosed area is necessary, the size of the enclosed area will consider the RF hazards and the surrounding terrain. The signage will clearly state the standard Radiation Hazard warning.

Personnel with access to the antenna will be trained to ensure that the antennas are off before working in the vicinity or on the antenna systems directly.

Annex 4 – The Comsearch Reports

The Comsearch reports for the 18 GHz band and the 28 GHz band are provided on the following pages.

INTERFERENCE ANALYSIS REPORT

Prepared for
O3b Networks USA, LLC.
HALEIWA, HI
(2.4 meter)
Satellite Earth Station

Prepared By:
COMSEARCH
19700 Janelia Farm Boulevard
Ashburn, VA 20147
September 29, 2014

TABLE OF CONTENTS

1. CONCLUSIONS

An interference study considering all existing, proposed and prior coordinated microwave facilities within the coordination contours of the proposed earth station demonstrates that this site will operate satisfactorily with the 18 GHz common carrier microwave environment. Further, there will be no restrictions of its operation due to interference considerations.

2. SUMMARY OF RESULTS

A number of great circle interference cases were identified during the interference study of the proposed earth station. Each of the cases, which exceeded the interference objective on a line-of-sight basis, was profiled and the propagation losses estimated using NBS TN101 (Revised) techniques. The losses were found to be sufficient to reduce the signal levels to acceptable magnitudes in every case.

3. SUPPLEMENTAL SHOWING

Pursuant to Part 25.203(c) of the FCC Rules and Regulations, the satellite earth station proposed in this application was coordinated by Comsearch using computer techniques and in accordance with Part 25 of the FCC Rules and Regulations.

Coordination data for this earth station was sent to the below listed carriers with a letter dated 08/25/2014.

Company
Cellco Parttnership - Hawaii
Clearwire Hawaii Partners Spectrum LLC
Coral Wireless Licenses, LLC
HONOLULU CITY & COUNTY
HONOLULU CITY & COUNTY DEPT OF INFO TECH
Hawaii State
Hawaiian Telcom, Inc.
Honolulu Board of Water Supply
MID PACIFIC COMMUNICATIONS INC
New Cingular Wireless PCS LLC - Hawaii
Sprint Spectrum L.P.
T-MOBILE LIC LLC - VOICESTREAM PCS BTA I
T-Mobile License LLC
Trex Broadband
US Internet Wireless
Verizon Wireless VAW LLC - (Hawaii)

4. EARTH STATION COORDINATION DATA

This section presents the data pertinent to frequency coordination of the proposed earth station that was circulated to all carriers within its coordination contours.

COMSEARCH

Earth Station Data Sheet

19700 Janelia Farm Boulevard, Ashburn, VA 20147
(703)726-5500 http://www.comsearch.com

Date: 09/29/2014
Job Number: 140825COMSGE09

Administrative Information

Status	ENGINEER PROPOSAL
Call Sign	E100088
Licensee Code	O3BNET
Licensee Name	O3b Networks USA, LLC.

Site Information — HALEIWA, HI

Venue Name	
Latitude (NAD 83)	21° 40' 17.8" N
Longitude (NAD 83)	158° 1' 54.9" W
Climate Zone	B
Rain Zone	4
Ground Elevation (AMSL)	139.96 m / 459.2 ft

Link Information

Satellite Type	Low Earth Orbit
Mode	TR - Transmit-Receive
Modulation	Digital
Minimum Elevation Angle	5.0°
Azimuth Range	0.0° to 360°
Antenna Centerline (AGL)	2.74 m / 9.0 ft

Antenna Information		Receive - FCC32		Transmit - FCC32	
Manufacturer		GD Satcom		GD Satcom	
Model		2.4 Meter		2.4 Meter	
Gain / Diameter		52.6 dBi / 2.4 m		55.8 dBi / 2.4 m	
3-dB / 15-dB Beamwidth		0.23° / 0.60°		0.14° / 0.32°	
Max Available RF Power	(dBW/4 kHz)			-14.0	
	(dBW/MHz)			10.0	
Maximum EIRP	(dBW/4 kHz)			41.8	
	(dBW/MHz)			65.8	
Interference Objectives:	Long Term	-156.0 dBW/MHz	20%	-151.0 dBW/4 kHz	20%
	Short Term	-146.0 dBW/MHz	0.01%	-128.0 dBW/4 kHz	0.0025%

Frequency Information	Receive 18.0 GHz	Transmit 28.0 GHz
Emission / Frequency Range (MHz)	1M00G7D - 216MG7D / 17852.0 - 18068.0	1M00G7D - 216MG7D / 27652.0 - 27868.0
	1M00G7D - 216MG7D / 18112.0 - 18328.0	1M00G7D - 216MG7D / 27912.0 - 28128.0
	1M00G7D - 216MG7D / 18372.0 - 18588.0	1M00G7D - 216MG7D / 28172.0 - 28388.0
	1M00G7D - 216MG7D / 18801.0 - 19017.0	1M00G7D - 216MG7D / 28601.0 - 28817.0
	1M00G7D - 216MG7D / 19055.0 - 19271.0	1M00G7D - 216MG7D / 28855.0 - 29071.0
	1M00G7D - 216MG7D / 19296.2 - 19299.9	1M00G7D - 216MG7D / 29087.8 - 29089.1
Max Great Circle Coordination Distance	285.8 km / 177.6 mi	198.0 km / 123.0 mi
Precipitation Scatter Contour Radius	100.0 km / 62.1 mi	100.0 km / 62.1 mi

COMSEARCH

Earth Station Data Sheet

19700 Janelia Farm Boulevard, Ashburn, VA 20147
(703)726-5500 http://www.comsearch.com

Coordination Values	**HALEIWA, HI**			
Licensee Name	O3b Networks USA, LLC.			
Latitude (NAD 83)	21° 40' 17.8" N			
Longitude (NAD 83)	158° 1' 54.9" W			
Ground Elevation (AMSL)	139.96 m / 459.2 ft			
Antenna Centerline (AGL)	2.74 m / 9.0 ft			
Antenna Model	GD Satcom 2.4 Meter			
Antenna Mode	Receive 18.0 GHz		Transmit 28.0 GHz	
Interference Objectives: Long Term	-156.0 dBW/MHz	20%	-151.0 dBW/4 kHz	20%
Short Term	-146.0 dBW/MHz	0.01%	-128.0 dBW/4 kHz	0.0025%
Max Available RF Power			-14.0 (dBW/4 kHz)	

			Receive 18.0 GHz		Transmit 28.0 GHz	
Azimuth (°)	Horizon Elevation (°)	Antenna Discrimination (°)	Horizon Gain (dBi)	Coordination Distance (km)	Horizon Gain (dBi)	Coordination Distance (km)
0	0.00	72.41	-10.00	151.60	-10.00	100.00
5	0.00	70.74	-10.00	151.60	-10.00	100.00
10	0.00	69.21	-10.00	151.60	-10.00	100.00
15	0.00	67.83	-10.00	151.60	-10.00	100.00
20	0.00	66.61	-10.00	151.60	-10.00	100.00
25	0.00	65.58	-10.00	151.60	-10.00	100.00
30	0.00	64.73	-10.00	151.60	-10.00	100.00
35	0.00	64.09	-10.00	151.60	-10.00	100.00
40	0.00	63.65	-10.00	129.30	-10.00	100.00
45	0.00	63.44	-10.00	122.30	-10.00	100.00
50	0.00	63.43	-9.52	100.00	-9.52	100.00
55	0.00	63.65	-8.28	102.30	-8.28	100.00
60	0.00	64.08	-6.88	119.70	-6.88	100.00
65	0.00	64.72	-5.25	108.30	-5.25	100.00
70	0.00	65.56	-3.35	100.60	-3.35	100.00
75	0.00	66.60	-1.04	101.20	-1.04	100.00
80	0.00	67.81	1.86	108.90	1.86	100.00
85	0.00	69.19	5.88	108.50	5.88	100.00
90	0.00	70.72	11.64	134.60	11.64	100.00
95	0.00	72.39	20.50	283.30	20.50	196.50
100	0.00	74.17	14.54	124.60	14.54	100.00
105	0.00	76.07	7.51	100.00	7.51	100.00
110	0.00	78.06	3.46	100.00	3.46	100.00
115	0.00	80.12	0.30	100.00	0.30	100.00
120	0.00	82.25	-1.99	100.00	-1.99	100.00
125	0.00	84.43	-3.96	100.00	-3.96	100.00
130	0.00	86.64	-5.60	100.00	-5.60	100.00
135	0.00	88.87	-7.00	100.00	-7.00	100.00
140	0.00	91.10	-8.21	100.00	-8.21	100.00
145	0.00	93.34	-9.29	100.00	-9.29	100.00
150	0.00	95.55	-10.00	100.00	-10.00	100.00
155	0.00	97.72	-10.00	100.00	-10.00	100.00
160	0.00	99.85	-10.00	100.00	-10.00	100.00
165	0.00	101.92	-10.00	100.00	-10.00	100.00
170	0.00	103.90	-10.00	100.00	-10.00	100.00
175	0.00	105.80	-10.00	100.00	-10.00	100.00
180	0.00	107.59	-10.00	100.00	-10.00	100.00
185	0.00	109.26	-10.00	100.00	-10.00	100.00

COMSEARCH

Earth Station Data Sheet

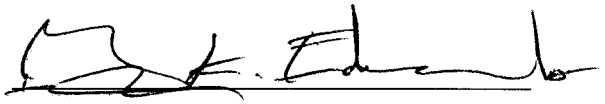
19700 Janelia Farm Boulevard, Ashburn, VA 20147
(703)726-5500 http://www.comsearch.com

Coordination Values	**HALEIWA, HI**			
Licensee Name	O3b Networks USA, LLC.			
Latitude (NAD 83)	21° 40' 17.8" N			
Longitude (NAD 83)	158° 1' 54.9" W			
Ground Elevation (AMSL)	139.96 m / 459.2 ft			
Antenna Centerline (AGL)	2.74 m / 9.0 ft			
Antenna Model	GD Satcom 2.4 Meter			
Antenna Mode	Receive 18.0 GHz		Transmit 28.0 GHz	
Interference Objectives: Long Term	-156.0 dBW/MHz	20%	-151.0 dBW/4 kHz	20%
Short Term	-146.0 dBW/MHz	0.01%	-128.0 dBW/4 kHz	0.0025%
Max Available RF Power			-14.0 (dBW/4 kHz)	

			Receive 18.0 GHz		Transmit 28.0 GHz	
Azimuth (°)	Horizon Elevation (°)	Antenna Discrimination (°)	Horizon Gain (dBi)	Coordination Distance (km)	Horizon Gain (dBi)	Coordination Distance (km)
190	0.00	110.79	-10.00	100.00	-10.00	100.00
195	0.00	112.17	-10.00	100.00	-10.00	100.00
200	0.00	113.39	-10.00	100.00	-10.00	100.00
205	0.00	114.42	-10.00	100.00	-10.00	100.00
210	0.00	115.27	-10.00	100.00	-10.00	100.00
215	0.00	115.91	-9.51	100.00	-9.51	100.00
220	0.00	116.35	-8.51	119.10	-8.51	100.00
225	0.00	116.56	-7.33	119.80	-7.33	100.00
230	0.00	116.57	-6.01	142.60	-6.01	100.00
235	0.00	116.35	-4.39	120.70	-4.39	100.00
240	0.00	115.92	-2.67	175.20	-2.67	122.30
245	0.00	115.28	-0.43	184.00	-0.43	128.90
250	0.00	114.44	2.42	196.70	2.42	133.70
255	0.00	113.40	6.36	212.80	6.36	142.70
260	0.00	112.19	11.41	244.70	11.41	160.60
265	0.00	110.81	13.84	285.80	13.84	198.00
270	0.00	109.28	9.78	238.10	9.78	156.90
275	0.00	107.61	5.12	210.40	5.12	141.40
280	0.00	105.83	1.55	192.60	1.55	134.30
285	0.00	103.93	-1.21	180.80	-1.21	126.70
290	0.00	101.94	-3.44	175.20	-3.44	119.90
295	0.00	99.88	-5.31	168.50	-5.31	113.90
300	0.00	97.75	-6.91	162.70	-6.91	108.50
305	0.00	95.57	-8.31	157.70	-8.31	100.30
310	0.00	93.36	-9.55	153.20	-9.55	100.00
315	0.00	91.13	-10.00	151.60	-10.00	100.00
320	0.00	88.90	-10.00	151.60	-10.00	100.00
325	0.00	86.66	-10.00	151.60	-10.00	100.00
330	0.00	84.45	-10.00	151.60	-10.00	100.00
335	0.00	82.28	-10.00	151.60	-10.00	100.00
340	0.00	80.15	-10.00	151.60	-10.00	100.00
345	0.00	78.08	-10.00	151.60	-10.00	100.00
350	0.00	76.10	-10.00	151.60	-10.00	100.00
355	0.00	74.20	-10.00	151.60	-10.00	100.00

5. CERTIFICATION

I HEREBY CERTIFY THAT I AM THE TECHNICALLY QUALIFIED PERSON RESPONSIBLE FOR THE PREPARATION OF THE FREQUENCY COORDINATION DATA CONTAINED IN THIS APPLICATION, THAT I AM FAMILIAR WITH PARTS 101 AND 25 OF THE FCC RULES AND REGULATIONS, THAT I HAVE EITHER PREPARED OR REVIEWED THE FREQUENCY COORDINATION DATA SUBMITTED WITH THIS APPLICATION, AND THAT IT IS COMPLETE AND CORRECT TO THE BEST OF MY KNOWLEDGE AND BELIEF.

BY: _ 

Gary K. Edwards
Senior Manager
COMSEARCH
19700 Janelia Farm Boulevard
Ashburn, VA 20147

DATED: September 29, 2014

Ka-Band Earth Station – Haleiwa, HI

Frequency Coordination Report

28 GHz

Prepared on Behalf of
O3b Networks USA, LLC

September 29, 2014

COMSEARCH®
A CommScope Company

Table of Contents

1. Summary of Results

On behalf of Ob3 Networks, Comsearch performed a coordination notice for all existing and proposed terrestrial licenses within the coordination contours of their proposed Ka-Band earth station in Haleiwa, HI, which will transmit at 28 GHz[1]. Prior-notification letters were sent to the licensees and a copy of the notification data is provided in section four of this report. The earth station coordination was finalized on September 29, 2014.

No objections were received from any of the incumbent 28 GHz licensees.

2. 28 GHz Common Carrier and LTTS Coordination

In accordance with FCC Rules and Regulations, the Ka-Band earth station in Haleiwa, Hawaii was prior-coordinated by Comsearch. A notification letter and datasheet for this earth station were sent to the following 28 GHz common carrier fixed microwave licensee on August 25, 2014. This licensee is authorized to operate temporary fixed operations from 28.5 to 29.5 GHz.

Licensee	Authorized Geographic Area
Princeton Scientific Capital Management	1 Fixed Location: Honolulu, HI

28 GHz local television transmission licensees are similarly authorized to operate temporary fixed operations in the 27.5 – 29.5 GHz portion of the spectrum, but this is limited to the continental United States. Therefore, no LTTS coordination was needed.

Licensee	Authorized Geographic Area
-- No LTTS licensees found --	

No objections were received from the one common carrier incumbent.

[1] The proposed earth station will operate in the 27.6 – 29.1 GHz portion of the Ka-Band.

3. 28 GHz LMDS Coordination

The proposed earth station will operate on frequencies that overlap Block A of 28 GHz LMDS services. The total frequency allocation for Block A of the LMDS spectrum appears below.

Block A: 27.500-28.350 GHz
29.100-29.250 GHz
31.075-31.225 GHz

Licensee	Market	Market Name	Status	Cancellation Date
BTA Associates, LLC	BTA192	Honolulu, HI	Terminated	6/1/2012
BTA Associates, LLC	BTA222	Kahului-Wailuku-Lahaina, HI	Terminated	6/1/2012
Windstream Lakedale Link, Inc.	BTA254	Lihue, HI	Terminated	6/1/2012

No active LMDS services were found within the coordination contour of the earth station.

4. Earth Station Coordination Data

This section presents the data pertinent to the proposed Ka-Band earth station in Haleiwa, HI. This data was circulated to all incumbent licensees in the shared 28 GHz frequency ranges.

5. Contact Information

For questions or information regarding the 28 GHz Frequency Coordination Report, please contact:

Contact person:	Joanna Lynch
Title:	Manager, Spectrum & Data Solutions
Company:	Comsearch
Address:	19700 Janelia Farm Blvd., Ashburn, VA 20147
Telephone:	703-726-5711
Fax:	703-726-5599
Email:	jlynch@comsearch.com
Web site:	www.comsearch.com

Annex 5 – Comsearch and O3b Field Strength Analysis

The Comsearch analysis that follows shows that O3b's Hawaii Gateway Earth Station adequately protects the FCC monitoring station at Waipahu, Hawaii and operates within the limits defined by Section 25.203(g)(1). This analysis is supplemented by O3b's analysis, which also follows, and which shows that the FCC monitoring station at Waipahu, Hawaii is adequately protected from cumulative impact of the Hawaii Gateway Earth Station and the Hawaii 2.4m Earth Station.

19700 Janelia Farm Boulevard
Ashburn, VA 20147 USA
(703) 726-5500
Fax (703) 726-5600
http://www.comsearch.com

COMSEARCH®

April 6, 2011

RE: O3b Limited
Haleiwa, HI Gateway Earth Station Application
IBFS File Number: SES-LIC-20100723-00952
Call Sign: E100088
Protection of FCC Monitoring Station at Waipahu, HI
Power Flux Density Calculation With Respect to 47 C.F.R. §25.203(g)(1) Limit

This analysis demonstrates that the proposed Haleiwa, HI earth station will protect the FCC Monitoring Station at Waipahu, HI by satisfying the limits stated in §25.203(g)(1).

The FCC Monitoring Station at Waipahu is 32.9 km at an azimuth of 173.4º from the location of the proposed earth station. Each of the two antennas that would transmit simultaneously at the earth station facility has a total input power of 447 W and the maximum antenna gain towards the horizon in the direction of Waipahu is -10 dBi. Thus the total EIRP of the earth station antennas towards Waipahu is 89.5 W (19.5 dBW).

Power flux density (*PFD*) is calculated for free-space propagation from:

$$PFD(dBW/m^2) = 10\log_{10}\left[\frac{EIRP}{4\pi D^2}\right]$$

where *EIRP* is in Watts and *D* is the distance in meters. Using this relationship the free-space power flux density of -81.8 dBW/m^2 is below the §25.203(g)(1) limit of -65.8 dBW/m^2. In addition the path from Haleiwa to Waipahu is significantly blocked by terrain and at 28 GHz there are appreciable losses due to absorption by atmospheric gases. The attached path profile shows additional long-term over-the-horizon loss of 81.2 dB and atmospheric absorption loss of 3.4 dB.

Based on this discussion the power flux density calculations are listed in the following table:

Earth Station Name	**Haleiwa, HI**
ES Latitude (D-M-S) North	21-40-15.8
ES Longitude (D-M-S) West	158-01-56.1
ES Transmit Frequency Band (MHz)	27,600 to 29,100
ES Transmitter Power (W)	447.23
Number of Transmitting Antennas	2
Total ES Transmitter Power (W)	894.46
Total ES Transmitter Power (dBW)	29.5
FCC Monitoring Station Name	**Waipahu, HI**
FCC Monitoring Station Latitude (D-M-S) North	21-22-33.6
FCC Monitoring Station Longitude (D-M-S) West	157-59-44.1
ES Antenna to FCC Monitoring Station Distance (km)	32.89
ES Antenna Azimuth towards FCC Monitoring Station (deg)	173.36
ES Antenna Horizon Gain @ 173.36 deg Az (dBi)	-10
ES EIRP towards the Horizon @173.36 deg Az (dBW)	19.5
ES EIRP towards the Horizon @173.36 deg Az (W)	89.45
Free Space Power Flux Density at FCC Monitoring Station (W/m^2))	6.58E-09
Free Space Power Flux Density at FCC Monitoring Station (dBW/m^2)	**-81.8**
§25.203(g)(1) Power Flux Density Objective (dBW/m^2)	**-65.8**
Margin - Free Space (dB)	**16.0**
Over-the-Horizon Loss (dB)	81.2
Atmospheric Absorption Loss (dB)	3.4
Power Flux Density at FCC Monitoring Station (dBW/m^2)	**-166.4**
Margin - With OH and Absorption Losses (dB)	**100.6**

The proposed O3b Limited earth station facility at Haleiwa, HI satisfies the §25.203(g)(1) limits with respect to the FCC Monitoring Station at Waipahu, HI.

Respectfully Submitted,

Comsearch

William W. Perkins
Principal Engineer
(703) 726-5681

Pathloss Calculation (NSMA Tropo)

Path data for case # 1	HALEIWA		WAIPAHU	
Latitude	21 40 15.8		21 22 33.6	
Longitude	158 1 56.1		157 59 44.1	
Antenna Center Agl	12.14 ft.	3.70 m.	20.01 ft.	6.10 m.
Site Elevation Amsl	452.02 ft.	137.77 m.	6.50 ft.	1.98 m.
Antenna Center Amsl	464.16 ft.	141.47 m.	26.51 ft.	8.08 m.
Effective Antenna Ht ...	12.14 ft.	3.70 m.	20.01 ft.	6.10 m.
Horizon Distance	1.68 mi.	2.71 km.	5.13 mi.	8.26 km.
Horizon Elevation Amsl .	858.90 ft.	261.78 m.	721.82 ft.	220.00 m.
Ray Crossover Angle	73.37 mr.			
Terrain Delta Ht	364.74 ft.	111.17 m.		
Effective Distance	83.88 mi.	134.96 km.		
Pathlength	20.44 mi.	32.89 km.		
Azimuth	173.36 deg.		353.37 deg.	
Frequency	28350 MHz			
K Factor	1.33 (K)			

Radio Climate Phrase ... Maritime Temperate Climate Over Land
Type of Path ..... Irregular Terrain
Free Space Path Loss ... 151.8 dB Atmospheric Loss ... 3.400 dB
Diff. Loss .... 557.1 dB (708.9 dB) Tropo. Loss ... 91.0 dB (242.8 dB)
Terrain data type ..... 1.0 ARC Second

Losses	L-Fspl	Sigma	Controlling Propagation Mode	
233.0 dB	81.2 dB	4.1 dB	20. %	Tropospheric Scatter
212.6 dB	60.8 dB	7.9 dB	1. %	Tropospheric Scatter
199.0 dB	47.2 dB	10.7 dB	0.1 %	Tropospheric Scatter
182.0 dB	30.2 dB	14.4 dB	0.01 %	Tropospheric Scatter
163.8 dB	12.0 dB	18.3 dB	0.0025%	Tropospheric Scatter

The OH loss calculations considered a terrain profile of 232 points.
The list below shows the highest point in each fiftieth of the path length.

Dist. (km.)	Elev. (m.)	Obstr. (m.)	K=Inf. Clrnce. (m.)	K= 1.33 Clrnce. (m.)	Dist. (km.)	Elev. (m.)	Obstr. (m.)	K=Inf. Clrnce. (m.)	K= 1.33 Clrnce. (m.)
0.00	137.8	3.7	0.0	0.0	16.66	341.9	0.0	-268.0	-283.9
0.57	154.7	0.0	-15.5	-16.6	17.51	335.0	0.0	-264.6	-280.4
0.71	134.7	0.0	3.9	2.5	17.80	326.9	0.0	-257.6	-273.5
1.57	149.9	0.0	-14.7	-17.6	18.51	313.8	0.0	-247.4	-263.1
2.56	217.9	0.0	-86.9	-91.4	19.08	307.7	0.0	-243.6	-259.1
2.71	261.8	0.2	-131.5	-136.3	19.93	289.4	0.0	-228.8	-244.0
3.27	280.0	0.0	-151.8	-157.5	20.50	280.2	0.0	-221.9	-236.9
3.42	251.3	0.0	-123.7	-129.6	21.07	270.8	0.0	-214.8	-229.5
4.56	226.6	0.0	-103.6	-111.2	21.78	249.1	0.0	-195.9	-210.2
5.13	244.2	0.0	-123.5	-131.9	22.49	226.0	0.0	-175.8	-189.6
5.27	260.5	0.0	-140.4	-148.9	23.35	226.0	0.0	-179.2	-192.4
6.55	258.9	0.0	-144.0	-154.2	24.20	221.0	0.0	-177.7	-190.1
6.98	320.3	0.0	-207.2	-217.8	24.63	220.0	0.0	-178.4	-190.4
7.83	342.0	0.0	-232.3	-243.9	25.06	198.1	0.0	-158.2	-169.8
8.40	355.2	0.0	-247.8	-259.9	26.05	158.0	0.0	-122.2	-132.7
8.68	358.2	0.0	-252.0	-264.4	26.48	153.0	0.0	-118.9	-128.9
9.40	328.5	0.0	-225.1	-238.1	27.19	141.1	0.0	-110.0	-119.1
9.97	311.6	0.0	-210.5	-224.0	27.76	129.0	0.0	-100.1	-108.5
10.96	359.1	0.0	-262.1	-276.3	28.33	113.0	0.0	-86.4	-94.1
11.67	371.6	0.0	-277.4	-292.0	29.04	91.0	0.0	-67.3	-73.9
12.24	368.7	0.0	-276.9	-291.8	29.61	74.0	0.0	-52.6	-58.4
12.53	368.5	0.0	-277.8	-292.8	30.33	41.0	0.0	-22.5	-27.1
13.38	369.9	0.0	-282.7	-298.1	31.04	15.9	0.0	-0.3	-3.7
13.95	369.3	0.0	-284.4	-300.0	31.89	14.0	0.0	-1.9	-3.7
14.66	346.2	0.0	-264.2	-280.0	32.60	4.0	0.0	5.2	4.7
15.23	343.0	0.0	-263.3	-279.2	32.89	2.0	6.1	0.0	0.0
16.37	343.1	0.0	-268.0	-284.0					

Power Flux Density Calculations for the O3b Hawaii Earth Stations
O3b Limited October 21, 2014

	7.3m	2.4m	Combined	
Transmit power	447.23	40	487.23	W
Transmit power	26.51	16.02	26.88	dBW
Number of Ants	2	2	2	two TX on during handovers
Total Transmit Power	29.52	19.03	29.89	dBW
E/S Horizon Gain @173.36	-10	-10	-10	dBW
E/S EIRP Towards Horizon	19.52	9.03	19.89	dBW
distance E/S to Waipahu	32.89	32.89	32.89	km
	32890	32890	32890	m
4*pi*R^2	1.36E+10	1.36E+10	1.36E+10	free-space spreading
Free Space PFD @ Waipahu	-81.82	-92.30	-81.45	dBW/m^2
PFD Objective	-65.8	-65.8	-65.8	dBW/m^2
Free-Space margin	16.02	26.50	15.65	dB
OTH Losses (terrain loss)	-81.2	-81.2	-81.2	dB
Atmos Losses	-3.4	-3.4	-3.4	dB
Final PFD @ Waipahu	**-166.42**	**-176.90**	**-166.05**	**dB**
Final Margin	**100.62**	**111.10**	**100.25**	**dB**