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August 14, 2014

FILED ELECTRONICALLY

Marlene H. Dortch, Secretary
Federal Communications Commission
Office of the Secretary
445 12th Street, SW
Room TW-A325
Washington, DC 20554

Re: O3b Limited
File No. SES-MSC-20140318-00150

Dear Ms. Dortch:

In the above-referenced filing, O3b Limited ("O3b") has requested a waiver of the Ka-band Plan and the U.S. Table of Frequency Allocations. The waiver would apply to earth stations on up to three non-U.S. registered maritime vessels when they are in or near U.S. territorial waters. The earth stations covered by the waiver request (the "Earth Stations") would operate in the 18.3-18.6 and 28.35-28.4 GHz bands. O3b hereby provides the following additional information in connection with it waiver request:

1. The Earth Stations will employ a tracking algorithm that is resistant to capturing and tracking adjacent satellite signals, and will be capable of inhibiting its own transmission in the event it detects unintended satellite tracking.

2. The Earth Stations will be monitored and controlled by a ground-based network control and monitoring center. Such stations will be able to receive "enable transmission" and "disable transmission" commands from the network control center and will cease transmission immediately after receiving a "parameter change" command until receiving an "enable transmission" command from the network control center. The network control center will monitor operation of each earth station to determine if it is malfunctioning, and each maritime earth station will self-monitor and automatically cease transmission within 100 milliseconds of detecting an operational fault that could cause harmful interference.

3. O3b will maintain the following records for each of the Earth Stations: a record of the ship location (*i.e.*, latitude and longitude), transmit frequency, channel bandwidth, and satellite used. These records will be time annotated and maintained for a period of not less than one year. Records will be obtained at time intervals of no greater than every 20 minutes while the Earth Station is transmitting. O3b will make this data available on request to a coordinator, fixed system operator, fixed satellite system operator, or the Commission within 24 hours of the request.

4. Annex A to this letter contains an analysis of the EPFD(is) levels caused by the O3b system for two extreme interference geometries. This analysis, which was originally submitted as a supplement to O3b's Hawaii earth station application,[1] demonstrates that the O3b system will comply with the EPFD(is) limits in Article 22.5F of the ITU Radio Regulations for the 17.8-18.4 GHz frequency band for these two worst-case scenarios and all interference geometries in between.

Respectfully submitted,

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cc: Andrea Kelly, FCC (via email)
Kal Krautkramer (via email)
Alyssa Roberts (via email)

[1] *See* 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. The Hawaii Earth Station Application was granted on Sept. 25, 2012.

ANNEX A

(EPFD(is) Analysis for O3b)

EPFD(is) Analysis for O3b

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

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

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

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

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

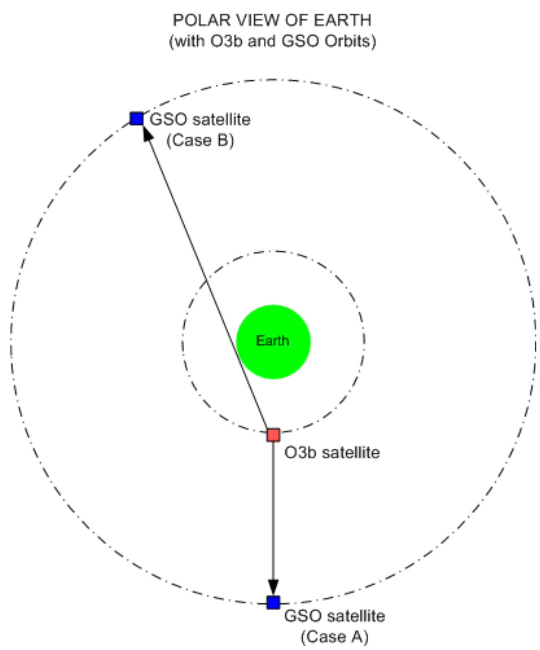
These limits apply to the O3b system in the 17.8-18.4 GHz band which is the band where the EPFD(down) limits also apply.

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

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

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

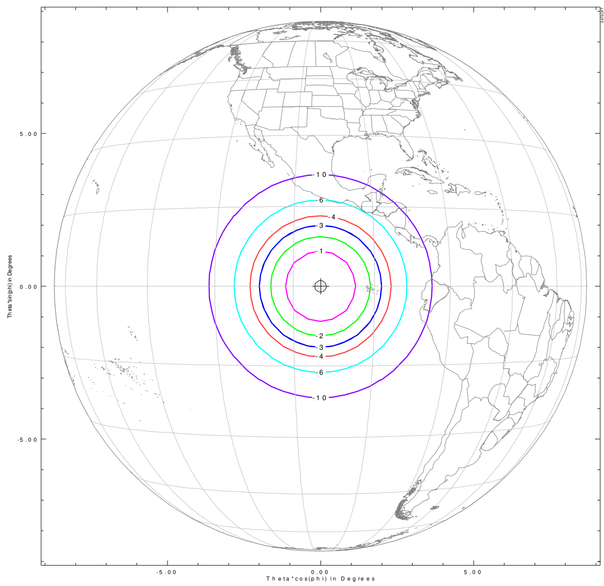
These two cases are shown on the diagram below.



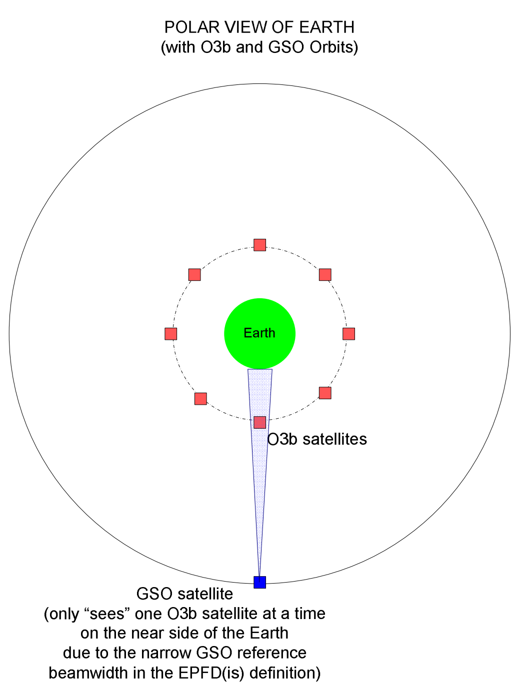
EPFD(is) analysis for Case A

For this case the path length between the O3b satellite and the GSO satellite is the difference in altitude of the two orbits, which is 27,724 km, corresponding to a free space spreading loss of 159.85 dB. The peak O3b satellite transmit EIRP is 49.7 dBW (consistent with the Schedule S data and Section A.9 of Attachment A of the O3b application) and the smallest bandwidth over which this EIRP is spread is 40 MHz (ditto). This results in a maximum beam peak EIRP density from the O3b satellite of 19.7 dBW/40kHz. The backlobe radiation from the O3b satellite is expected to be at least 50 dB below beam peak in the worst case, and much lower than that in most cases. Taking the conservative backlobe radiation level of -50 dB, the transmit EIRP density in the direction of the GSO satellite would be -30.3 dBW/40kHz resulting in a PFD at the GSO satellite of -190.15 dBW/m^2/40kHz (i.e., –30.3 – 159.85).

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



This means that such a reference GSO antenna only "sees" at most one O3b satellite at a time on the near side of the Earth (i.e., Case A) as shown in the diagram below.



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

EPFD(is) analysis for Case B

For this case the path length between the O3b satellite and the GSO satellite is 54,634.16 km, corresponding to a free space spreading loss of 165.74 dB which is approximately 6 dB more loss than for Case A above. Using the same assumptions for the peak O3b satellite transmit EIRP (49.7 dBW) and the smallest bandwidth over which this EIRP is spread (40 MHz), the beam peak EIRP density from the O3b satellite is no greater than 19.7 dBW/40kHz.

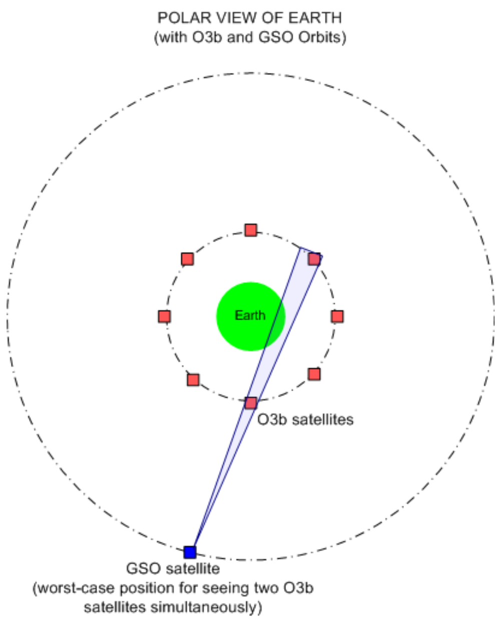
For this analysis we are assuming that the O3b satellite transmit antenna is directed close to the equator and close to the Earth limb. However, because the frequency range where EPFD(is) limits apply is also a range where EPFD(down) limits apply, O3b is not able to direct its steerable beams close to the equator and operate at the highest power densities in this frequency range otherwise it would violate the EPFD(down) limits. As explained in Section A.10.1 of Attachment A of the O3b application, the downlink EIRP density from the O3b satellites must be reduced significantly below the level used in the calculation above for latitudes typically less than 10°, and this would require a reduction in the maximum downlink EIRP density of at least 6 dB relative to the 19.7 dBW/40kHz value referred to in the previous paragraph, equal to a value of less than 13.7 dBW/40kHz.

For the purpose of this EPFD(is) analysis we will conservatively assume that the O3b satellite transmit antenna gain has dropped to only 15 dB below peak in directions corresponding to the Earth's limb at the equator if the beam peak EIRP density was 13.7 dBW/40kHz. In practice the O3b antenna gain in this direction must be lower than this, assuming this beam peak EIRP density, in order to comply with EPFD(down) limits. This would result in an EIRP density from the O3b satellite towards the Earth's limb at the equator of less than -1.3 dBW/40kHz (i.e., 13.7 – 15). Taking account of the spreading loss (165.74 dB) to the victim satellite, as referred to above, the resulting PFD level at the victim GSO satellite, due to the transmitting O3b satellite, would not exceed -167.04 dBW/m^2/40kHz.

In order to calculate the correct aggregate of the EPFD(is) for Case B due to frequency re-use by the O3b satellite, we can ignore the spatial frequency re-use as this requires the second beam to be pointed well away from the beam shown in the diagram above, and so it would contribute negligibly to the aggregate EPFD(is) level. However, the two-fold frequency re-use due to the dual polarization should be factored in to account for the worst case. This would effectively increase the EPFD(is) by 3 dB relative to the value calculated above, but the resulting worst case aggregate EPFD(is) for Case B is still 4.04 dB less than the -160 dBW/m^2/40kHz limit value in the Radio Regulations.

Combination of Cases A and B

There is a particular geometry where the effects of Case A and Case B, as analyzed above, can add together. This is illustrated in the diagram below which shows that in a particular pointing direction of the GSO satellite reference receive beam, where it is towards the Earth's limb, it will simultaneously see both the Case A and the Case B O3b satellites. As the analysis results above for both Case A and Case B produce EPFD(is) levels that are more than 3 dB below the EPFD(is) limit (in the case of Case A, with a 24 dB margin), then the aggregation of both Case A and Case B cannot exceed the EPFD(is) limit.



Intermediate geometries between Case A and Case B

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