O3b Networks USA, LLC
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REPORT TITLE:

Non-Ionizing Radiation Hazard Analysis

PREPARED BY:	DATE	APPROVED BY:	DATE
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SCOPE/TEXT (ATTACH ADDITIONAL SHEETS AS REQUIRED)

This report analyzes non-ionizing radiation levels for O3b's 7.3m 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, subreflector surface, 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

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1 Formulas and Parameters Used

The following data is used throughout the analysis:

Parameters	Symbol	Value	Units	Notes/Formulas
Transmit Power[1]	P	447.23	W	RH traffic + LH traffic + LH CMD (TT&C)
Frequency	F	29089	MHz	
Wavelength	λ	0.010	m	299.792458 / F
Antenna Diameter	Dref	7.300	m	
Antenna Surface Area	Aref	41.854	m²	π Dref² / 4
Subreflector Diameter	Asub	0.610	m	
Subreflector Surface Area	Asub	0.292	m²	π Dsub² / 4
Feed Flange Diameter	Dflange	0.137	m	Viasat spec
Feed Flange Area	Aflange	0.015	m²	π Dflange² / 4
Antenna Gain	Ges	65.66	dBi	Viasat Data
Antenna Gain	G	3681289.736		10^(Ges / 10)
Antenna Efficiency	η	0.743		G λ² / π² Dref²
Pi	π	3.142		

Note 1: Each of the three uplink paths has a dedicated 500W TWT amplifier and associated amplifier-to-feed losses; the “Transmit Power” indicated is the total RF power at the flange with all three amplifiers operating at maximum drive levels.

2 Density at Feed Flange

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

Parameters	Symbol	Value	Units	Notes/Formulas
Density @ flange		121355.623	W/m²	4 P / Aflange
	Sflange	12135.562	mW/cm²	

3 Density at Subreflector

The maximum power flux density at the surface of the Cassegrain subreflector is as follows:

Parameters	Symbol	Value	Units	Notes/Formulas
Density @ subreflector		6121.268	W/m²	4 P / Asub
	Ssub	612.127	mW/cm²	

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4 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		42.742	W/m²	4 P / Aref
	Ssurface	4.274	mW/cm²	

5 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		10.686	W/m²	P / Aref
	Sground	1.069	mW/cm²	

6 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	1292.688	m	$D^2 / 4 \lambda$
Density within the Near Field		31.776	W/m²	$16.0 \eta P / \pi D^2$
	Snf	3.178	mW/cm²	

7 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	1292.688	m	Occurs at near field extent
Density @ Transition		31.776	W/m²	Snf Rnf / Rt
	Snf	3.178	mW/cm²	

8 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	3102.452	m	$0.6\ D^2 / \lambda$
Density @ Far Field Boundary		13.612	W/m^2	$P\ G / 4\ \pi\ Rff^2$
	Sff	1.361	mW/cm^2	

9 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 show the range at which the Far Field General Population MPE limit occurs:

Parameters	Symbol	Value	Units	Notes/Formulas
Range to 1 mW/cm^2		4107	m	Range to General Population Limit
		10.001	W/m^2	
		1.000	mW/cm^2	

10 Non-Ionizing Radiation Summary

Flux Densities & Exposure Limits

General Population Exposure Limit = 1.0 mW/cm²
Occupational Exposure Limit = 5.0 mW/cm²

Region	Symbol	Level	Units	Hazard Assessment
Density @ Antenna Flange	Sflange	12135.562	mW/cm²	Exceeds General Population Exposure limit Exceeds Occupational Exposure limit
Density @ Subreflector	Ssub	612.127	mW/cm²	Exceeds General Population Exposure limit Exceeds Occupational Exposure limit
Density @ Main Reflector	Ssurface	4.274	mW/cm²	Exceeds General Population Exposure limit Does not exceed Occupational Exposure limit
Density Between Main Reflector and Ground	Sground	1.069	mW/cm²	Exceeds General Population Exposure limit Does not exceed Occupational Exposure limit
Max Density @ Near Field Extent	Snf	3.178	mW/cm²	Exceeds General Population Exposure limit Does not exceed Occupational Exposure limit
Max Density @ Transition Region	St	3.178	mW/cm²	Exceeds General Population Exposure limit Does not exceed Occupational Exposure limit
Density @ Beginning of Far Field	Sff	1.361	mW/cm²	Exceeds 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	1292.688	m	Main lobe offset greater than 1 diameter
Range to Far Field Boundary	Rff	3102.451	m	Main lobe offset greater than 1 diameter
Range to 1 mW/cm² MPE Limit		4107	m	Main lobe offset greater than 1 diameter

11 Conclusion

The above analysis confirms the presence of hazardous power flux densities at the O3b Gateway terminal which will require physical and operational protections to manage General Population and Occupational exposure.

The O3b Gateway Antennas at the Vernon, Texas facility will be enclosed in a fence designed to control access to the antenna area for RF safety, physical safety, and security purposes. The size of the enclosed area will consider the RF hazards, moving antenna 'swept volume', and the surrounding terrain. In addition to fencing, the area will contain signage which clearly states the standard Radiation Hazard warning.

O3b will ensure antenna tracking geometry maintains angular limits which equates to at least one antenna diameter of separation between the antenna's main beam and nearby buildings and other occupied areas where the calculated General Population MPE levels may be exceeded.

Finally, each antenna contains two safety features to protect operators and maintenance personnel:

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1. All High Power Amplifiers are automatically inhibited at elevations of <5 degrees

2. Each antenna has an “Emergency Stop” safety switch located at the base of each structure. Personnel with access to the antenna area will be trained to ensure that HPA's are off and system motion is disabled via the Emergency Stop switch before working in the vicinity or on the antenna systems directly.