O3b Networks USA, LLC
Balls Ford Rd, Suite 300
Manassas, VA 20109

REPORT TITLE:

Non-Ionizing Radiation Hazard Analysis

PREPARED BY:	DATE	APPROVED BY:	DATE
Randy Taylor	18 April 2013	Gary Mattie	18 April 2013

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		

O3b Networks USA, LLC
Balls Ford Rd, Suite 300
Manassas, VA 20109

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	m²	π Dref² / 4
Subreflector Diameter	Dsub	N/A	m	Offset feed antenna
Subreflector Surface Area	Asub	N/A	m²	π Dsub² / 4
Feed Flange Diameter	Dflange	0.0445	m	Direct measurement
Feed Flange Area	Aflange	0.002	m²	π Dflange² / 4
Antenna Gain	Ges	55.20	dBi	Mfg spec
Antenna Gain	G	331131.121		10^(Ges / 10)
Antenna Efficiency	η	0.650		G λ² / π² Dref²
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/m²	4 P / Aflange
	Sflange	9232.304	mW/cm²	

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/m²	4 P / Aref
	Ssurface	3.174	mW/cm²	

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/m²	P / Aref
	Sground	0.794	mW/cm²	

O3b Networks USA, LLC
Balls Ford Rd, Suite 300
Manassas, VA 20109

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 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		307.541	m	Range to General Population Limit
		10.001	W/m^2	
		1.000	mW/cm^2	

9. 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	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 hazardous power flux densities at the O3b Tier 2 MEO terminal which will require physical and operational protections to manage General Population and Occupational exposure.

The O3b Tier 2 Antennas at the Bristow, Virginia 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, to mitigate the risk of hazardous emissions exposure to operators and maintenance personnel, the antenna system will have an “Emergency Stop” safety switch located on an outdoor enclosure adjacent to both antennas. 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.