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Environmental Assessment of RADHAZ for a Vertex RSI 3.9M Ka-band Satellite Earth Station Antenna

This report presents an analysis of the non-ionizing radiation levels for a Vertex RSI 3.9 Meter Ka-band Satellite Earth Station. The calculations used in this analysis were derived from and comply with the procedures outlined in the Federal Communication Commission, Office of Engineering and Technology Bulletin Number 65, which establishes guidelines for human exposure to Radio Frequency Electromagnetic Fields. Bulletin 65 defines exposure levels in two separate categories, the General Population/Uncontrolled Areas limits, and the Occupational/Controlled Area limits. The Maximum Permissible Exposure (MPE) limit of the General Population/Uncontrolled Area is defined in Table (1), and represents a maximum exposure limit averaged over a 30 minute period. The MPE limit of the Occupational/Controlled Area is defined in Table (2), and represents a maximum exposure limit averaged over a 6 minute period. The purpose of this report is to provide an analysis of the earth station power flux densities, and to compare those levels to the specified MPE's. This report provides predicted density levels in the near field, far field, transition region, main reflector surface area, area between the main reflector and sub reflector or feed assembly, as well as the area between the antenna edge and ground.

MPE Limits for General Population/Uncontrolled Area

<i>Frequency Range (MHz)</i>	<i>Power Density (mW/cm²)</i>
1500 – 100,000	1.0

Table 1

MPE Limits for Occupational/Controlled Area

<i>Frequency Range (MHz)</i>	<i>Power Density (mW/cm²)</i>
1500 – 100,000	5.0

Table 2

Boeing Proprietary Vertex 3.9M Antenna

Table 3 contains formulas, equations and parameters that were used in determining the Power Flux Density levels for the Vertex 3.9M Antenna:

<i>Data Type</i>	<i>Data Symbol</i>	<i>Data Formula</i>	<i>Data Value</i>	<i>Unit of Measure</i>
Power Input	P	Input	39	W
Antenna Size	D	Input	3.9	M
Antenna Area	A	$A = (\Pi D^2) \div 4$	11.95	M ²
Subreflector Size	Sub	Input	43	cm
Subreflector Area	A _{sub}	$A_{sub} = (\Pi Sub^2) \div 4$	1452.2	cm ²
Gain dBi	G _{ex}	Input	59.3	dBi
Gain Factor	G	$G = 10^{G_{ex}/10}$	851138.04	Gain Factor
Frequency	f	Input	29500	MHz
Wavelength	λ	$299.79 / f$	0.010162	Meters
Aperture Efficiency	η	$\eta = [(G\lambda^2) \div (4\Pi)] \div A$.59	n/a
Pi	Π	Input	3.14159	Numeric
Constant	M/Sec	Input	299,792,458	Numeric
Conversion W to mW	mW	$mW = W \times 1000$	n/a	n/a
Conversion M to cm	Cm	$cm = M \times 100$	n/a	n/a
Conversion M ² to cm ²	cm ²	$cm^2 = M^2 \times 10000$	n/a	n/a
Conversion W/M ² to mW/cm ²	mW/cm ²	$mW/cm^2 = W / M^2 \div 10$	n/a	n/a

Table 3

1. Far Field Analysis

The distance to the far field can be calculated using the following formula:

$$R_{ff} = \frac{0.6D^2}{\lambda} = 898.05 \text{ Meters}$$

The power density in the far field can be calculated using the following formula. Note: this formula requires the use of power in milliwatts and far field distance in centimeters, or requires a post calculation conversion from W/M²:

$$S_{ff} = \frac{PG}{4\Pi R_{ff}^2} = 0.328 \text{ mW/cm}^2$$

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2. Near Field Analysis

The extent of the Near Field region can be calculated using the following formula:

$$R_{nf} = \frac{D^2}{4\lambda} = 374.19 \text{ Meters}$$

The power density of the near field can be calculated using the following formula. Note: this formula requires the use of power in milliwatts and diameter in centimeters, or requires a post calculation conversion from W/M²:

$$S_{nf} = \frac{16\eta P}{\pi D^2} = 0.770 \text{ mW/cm}^2$$

3. Transition Region Analysis

The transition region extends from the end of the near field out to the beginning of the far field. The power density in the transition region decreases inversely with distance from the antenna, while power density in the far-field decreases inversely with the square of the distance. However the power density in the transition region will not exceed the density in the near field, and can be calculated for any point in the transition region (R), using the following formula. Note: This formula requires the use of distance in centimeters, or requires a post calculation conversion from W/M².

$$S_t = \frac{S_{nf} R_{nf}}{R} = 0.770 \text{ mW/cm}^2$$

4. Main Reflector Surface Area Analysis

The maximum power density at the antenna surface area can be calculated using the following formula. Note: this formula requires the use of Power in milliwatts and Area in centimeters squared, or requires a post calculation conversion from W/M².

$$S_{surface} = \frac{4P}{A} = 1.305 \text{ mW/cm}^2$$

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5. Subreflector Area Analysis

The area between the sub reflector and main reflector presents a potential hazard, with the highest density being located at the sub reflector area. The power density at the sub reflector can be calculated using the following formula. Note: this formula requires the use of Power in milliwatts and Area in centimeters squared, or requires a post calculation conversion from W/M².

$$Sub_{surface} = \frac{4P}{A_{sub}} = 107.423 \text{ mW/cm}^2$$

Tables 4 and 5 present a summary of the radiation hazard findings on the Vertex 3.9M Antenna terminal for both the General Population/Uncontrolled Area, as well as the Occupational/Controlled area environments.

MPE Limits for General Population/Uncontrolled Area

<i>Area</i>	<i>Range Meters</i>	<i>Power Density (mW/cm²)</i>	<i>Finding</i>
Far Field	898.05	0.328 mW/cm ²	Meets FCC Requirements
Near Field	374.19	0.770 mW/cm ²	Meets FCC Requirements
Transition Region	374.19 – 898.05	0.770 mW/cm ²	Meets FCC Requirements
Main Reflector Surface	N/A	1.305 mW/cm ²	Potential Hazard
Sub-reflector Surface	N/A	107.423 mW/cm ²	Potential Hazard

Table 4

Boeing Proprietary**MPE Limits for Occupational/Controlled Area**

<i>Area</i>	<i>Range Meters</i>	<i>Power Density (mW/cm²)</i>	<i>Finding</i>
Far Field	898.05	0.328 mW/cm ²	Meets FCC Requirements
Near Field	374.19	0.770 mW/cm ²	Meets FCC Requirements
Transition Region	374.19 – 898.05	0.770 mW/cm ²	Meets FCC Requirements
Main Reflector Surface	N/A	1.305 mW/cm ²	Meets FCC Requirements
Sub-reflector Surface	N/A	107.423 mW/cm ²	Potential Hazard

Table 5

Based on the above finding there is a potential hazard of radio frequency exposure with use of the Vertex 3.9M Antenna. In order to mitigate the risk of these hazards, this terminal will only be operated in a controlled area, and the unit will be shut down prior to performing maintenance in any of the occupational hazard areas.