Radiation Hazard Report

Analysis of Non-Ionizing Radiation for a 9 m Earth Station

This analysis provides the calculated non-ionizing radiation levels for a 9-meter earth station system.

The methods and calculations performed in this analysis are based on the FCC Office of Engineering and Technology Bulletin, No.65, October1985 as revised in 1997 in Edition 97-01. The radiation safety limits used in the analysis are in conformance with the FCC R&O 96-326 (Summarized in Annex 1). There are separate exposure limits applicable to the General Population/Uncontrolled Environment and the Occupational/Controlled Environment. The Maximum Permissible Exposure (MPE) limits for persons in a General Population/Uncontrolled environment for the frequency band of this antenna, is 1 mW/cm2 for a 30 minute or lower time period as shown in Annex 1 (a). The MPE limit for persons in an Occupational/Controlled environment for the frequency band of this antenna is 5 mW/cm2 for a 6 minute time or lower period as shown in Annex 1 (b). The purpose of this analysis described is to determine the power flux density levels of the earth station at the main reflector surface, the near-field, transition region, far-field, between the sub-reflector or feed and, at the main reflector surface, and between the antenna edge and the ground and to compare these levels to the specified MPEs.

The parameters of the antenna that is the subject of this analysis are shown in Table 1. Intermediate calculated values and constants are provided in Table 2.

Table 1. Input Parameters Used for Determining Power Flux Densities

Parameter	Symbol	Formula	Value	Units
Antenna Diameter	D	Input	9	m
Sub-reflector Diameter	D_{sr}	Input	116.84	cm
Frequency	F	Input	6175	MHz
Transmit Power	P	Input	2000	W
Antenna Gain (dBi)	G_{es}	Input	53.7	dBi

Table 2. Calculated Values and Constants

Parameter	Symbol	Formula	Value	Units
Antenna Surface Area	$A_{surface}$	$\pi D^2/4$	63.62	m^2
Area of Sub-reflector	A_{sr}	$\pi D_{sr}^2/4$	10721.93	cm^2
Wavelength	λ	300/F	0.048583	m
Antenna Gain (factor)	G	$10^{Ges/10}$	234422.88	n/a
Pi	π	Constant	3.1415927	n/a
Antenna Efficiency	η	$G\lambda^2/(\pi^2 D^2)$	0.69	n/a

1. Antenna Main Reflector Surface

The power density in the main reflector is determined from the Power level and the area of the main reflector aperture. This is determined from the following equation:

Power Density at the Main Reflector Surface:

$$S_{surface} = 4P/A_{surface} \quad (1)$$

$$= 125.752 \quad W/m^2$$

$$= 12.575 \quad mW/cm^2$$

2. Near Field Calculation

Power Flux density is considered to be at a maximum value throughout the entire length of the defined Near Field region. The region is contained within a cylindrical volume having the same diameter as the antenna. Past the boundary of the Near Field region, the power density from the antenna decreases linearly with respect to increasing distance. The distance to the end of the Near Field is determined from the following equation:

Extent of the Near Field:

$$R_{nf} = D^2 / (4\lambda) \quad (2)$$

$$= 416.81 \quad m$$

The maximum power density in the Near Field is determined from the following equation:

Near Field Density:

$$S_{nf} = 16.0\ \eta\ P / (\pi\ D^2) \quad (3)$$

$$= 8.704 \quad mW/cm^2$$

3. Transition Region Calculation

The Transition Region is located between the Near and Far Field regions. The power density begins to decrease linearly with increasing distance in the Transition region. While the power density decreases inversely with distance in the Transition region, the power density decreases inversely with the square of the distance in the Far Field region. The power density calculated in Section 1 is the highest power density the antenna can produce in any of the regions away from the antenna. The power density at a distance R_t is determined from the following equation:

Transition Region Power Density:

$$S_t = S_{nf} R_{nf} / R_t \quad (4)$$

$$= 8.704 \quad mW/cm^2$$

4. Far Field Distance Calculation

The distance to the Far Field Region is calculated using the following equation:

Distance to Far Field Region:

$$R_{ff} = 0.6\ D^2 / \lambda \qquad (5)$$

$$= \quad 1000.350 \quad m$$

The maximum main beam power density in the far field is determined from the following equation:

On-axis Power Density in the Far Field:

$$S_{ff} = G\ P / (4\ \pi\ R_{ff}^2) \qquad (6)$$

$$= \quad 3.728 \quad mW/cm^2$$

5. Region between the Main Reflector and the Ground

Assuming uniform illumination of the reflector surface, the power density between the antenna and the ground is determined from the following equation:

Power Density between Reflector and Ground:

$$S_g = P / A_{surface} \qquad (7)$$

$$= \quad 3.144 \quad mW/cm^2$$

6. Power Density at the Sub-reflector

Transmissions from the feed assembly are directed toward the sub-reflector surface, and are reflected back toward the main reflector. The most common feed assemblies are waveguide flanges, horns or sub-reflectors. The energy between the sub-reflector and the reflector surfaces is calculated by determining the power density at the sub-reflector surface. This is determined from the following equation:

Power Density at the Subreflector:

$$S_{sr} = 4000\ P / A_{sr} \qquad (8)$$

$$= \quad 746.134 \quad mW/cm^2$$

7. Summary of Calculations

Table 3. Summary of Expected Radiation levels for Uncontrolled Environment

Region	Symbol	Calculated Maximum Radiation Power Density Level (mW/cm^2)	Hazard Assessment
1. Main Reflector	$S_{surface}$	12.575	Potential Hazard
2. Near Field (R_{nf} = 416.81 m)	S_{nf}	8.704	Potential Hazard
3. Transition Region ($R_{nf} < R_t < R_{ff}$)	S_t	8.704	Potential Hazard
4. Far Field (R_{ff} = 1000.35 m)	S_{ff}	3.728	Potential Hazard
5. Between Main Reflector and Subreflector	S_{sr}	746.134	Potential Hazard
6. Between Main Reflector and Ground	S_g	3.144	Potential Hazard

Table 4. Summary of Expected Radiation levels for Controlled Environment

Region	Symbol	Calculated Maximum Radiation Power Density Level (mW/cm^2)	Hazard Assessment
1. Main Reflector	$S_{surface}$	12.575	Potential Hazard
2. Near Field (R_{nf} = 416.81 m)	S_{nf}	8.704	Potential Hazard
3. Transition Region ($R_{nf} < R_t < R_{ff}$)	S_t	8.704	Potential Hazard
4. Far Field (R_{ff} = 1000.35 m)	S_{ff}	3.728	Satisfies FCC MPE
5. Between Main Reflector and Subreflector	S_{sr}	746.134	Potential Hazard
6. Between Main Reflector and Ground	S_g	3.144	Satisfies FCC MPE

It is the applicant's responsibility to ensure that the public and operational personnel are no exposed to harmful levels of radiation.

8. Conclusion

Based upon the above analysis, it is concluded that harmful levels of radiation may exist in those regions noted for the Uncontrolled (Table 3) Environment and the Controlled Environment (Table 4).

The antenna is located at an Intelsat License LLC's teleport facility in Hagerstown, MD.
The teleport is a gated and fenced facility with secured access in and around the proposed antenna. The earth station will be marked with the standard radiation hazard warnings, as well as the area in the vicinity of the earth station to inform those in the general population, who might be working or otherwise present in or near the direct path of the main beam.

The applicant will ensure that the main beam of the antenna will be pointed at least one diameter away from any building, or other obstacles in those area that exceed the MPE levels. Since one diameter removed from the center of the main beam the levels are down by at least 20 dB, or by a factor of 100, these potential hazards do not exist for either the public, or for earth station personnel.

Finally, the earth station's operating personnel will not have access to areas that exceed the MPE levels, while the earth station is in operation. The transmitter will be turned off during those periods of maintenance, so that the MPE standard of 5.0 mW/cm^2 will be complied with for those regions in close proximity to the main reflector, which could be occupied by operating personnel.

"The licensee shall take all necessary measures to ensure that the antenna does not create potential exposure of humans to radiofrequency radiation in excess of the FCC exposure limits defined in 47 CFR 1.1307(b) and 1.1310 wherever such exposures might occur. Measures must be taken to ensure compliance with limits for both occupational/controlled exposure and for general population/uncontrolled exposure, as defined in these rule sections. Compliance can be accomplished in most cases by appropriate restrictions such as fencing. Requirements for restrictions can be determined by predictions based on calculations, modeling or by field measurements. The FCC's OET Bulletin 65 (available on-line at www.fcc.gov/oet/rfsafety) provides information on predicting exposure levels and on methods for ensuring compliance, including the use of warning and alerting signs and protective equipment for workers."

ANNEX 1

(MPE Levels)

a) Limits for General Population/Uncontrolled Exposure (MPE)

Frequency Range (MHz)	**Power Density (mW/cm^2)**
30-300	0.2
300-1500	Frequency(MHz)*(4.0/1200)
1500-100,000	1

b) Limits for Occupational/Controlled Exposure (MPE)

Frequency Range (MHz)	**Power Density (mW/cm^2)**
30-300	1
300-1500	Frequency(MHz)*(4.0/1200)
1500-100,000	5

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Parameter	Symbol	Formula	Value	Units
Antenna Diameter	D	Input	9	m
Sub-reflector Diameter	D_{sr}	Input	116.84	cm
Frequency	F	Input	6195	MHz
Transmit Power	P	Input	2250	W
Antenna Gain (dBi)	G_{es}	Input	53.7	dBi

Table 2. Calculated Values and Constants

Parameter	Symbol	Formula	Value	Units
Antenna Surface Area	$A_{surface}$	$\pi D^2/4$	63.62	m^2
Area of Sub-reflector	A_{sr}	$\pi D_{sr}^2/4$	10721.93	cm^2
Wavelength	λ	300/F	0.048426	m
Antenna Gain (factor)	G	$10^{Ges/10}$	234422.88	n/a
Pi	π	Constant	3.1415927	n/a
Antenna Efficiency	η	$G\lambda^2/(\pi^2 D^2)$	0.69	n/a

1. Antenna Main Reflector Surface

The power density in the main reflector is determined from the Power level and the area of the main reflector aperture. This is determined from the following equation:

Power Density at the Main Reflector Surface:

$$S_{surface} = 4P/A_{surface} \quad (1)$$

$= 141.471 \ W/m^2$

$= 14.147 \ mW/cm^2$

2. Near Field Calculation

Power Flux density is considered to be at a maximum value throughout the entire length of the defined Near Field region. The region is contained within a cylindrical volume having the same diameter as the antenna. Past the boundary of the Near Field region, the power density from the antenna decreases linearly with respect to increasing distance. The distance to the end of the Near Field is determined from the following equation:

Extent of the Near Field:

$$R_{nf} = D^2 / (4\lambda) \quad (2)$$

$= 418.16 \ m$

The maximum power density in the Near Field is determined from the following equation:

Near Field Density:

$$S_{nf} = 16.0 \ \eta \ P / (\pi \ D^2) \quad (3)$$

$= 9.728 \ mW/cm^2$

3. Transition Region Calculation

The Transition Region is located between the Near and Far Field regions. The power density begins to decrease linearly with increasing distance in the Transition region. While the power density decreases inversely with distance in the Transition region, the power density decreases inversely with the square of the distance in the Far Field region. The power density calculated in Section 1 is the highest power density the antenna can produce in any of the regions away from the antenna. The power density at a distance R_t is determined from the following equation:

Transition Region Power Density:

$$S_t = S_{nf} R_{nf} / R_t \quad (4)$$

$= 9.728 \ mW/cm^2$

4. Far Field Distance Calculation

The distance to the Far Field Region is calculated using the following equation:

Distance to Far Field Region:

$$R_{ff} = 0.6\ D^2 / \lambda \qquad (5)$$

$$= \quad 1003.590 \quad \text{m}$$

The maximum main beam power density in the far field is determined from the following equation:

On-axis Power Density in the Far Field:

$$S_{ff} = G\ P / (4\ \pi\ R_{ff}^{2}) \qquad (6)$$

$$= \quad 4.167 \quad \text{mW/cm}^2$$

5. Region between the Main Reflector and the Ground

Assuming uniform illumination of the reflector surface, the power density between the antenna and the ground is determined from the following equation:

Power Density between Reflector and Ground:

$$S_g = P / A_{surface} \qquad (7)$$

$$= \quad 3.537 \quad \text{mW/cm}^2$$

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Power Density at the Subreflector:

$$S_{sr} = 4000\ P / A_{sr} \qquad (8)$$

$$= \quad 839.401 \quad \text{mW/cm}^2$$

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1. Main Reflector	$S_{surface}$	14.147	Potential Hazard
2. Near Field (R_{nf} = 418.16 m)	S_{nf}	9.728	Potential Hazard
3. Transition Region ($R_{nf} < R_t < R_{ff}$)	S_t	9.728	Potential Hazard
4. Far Field (R_{ff} = 1003.59 m)	S_{ff}	4.167	Potential Hazard
5. Between Main Reflector and Subreflector	S_{sr}	839.401	Potential Hazard
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1500-100,000	1

b) Limits for Occupational/Controlled Exposure (MPE)

Frequency Range (MHz)	**Power Density (mW/cm^2)**
30-300	1
300-1500	Frequency(MHz)*(4.0/1200)
1500-100,000	5