

ITC Global

Modification of ESV Blanket License

Technical Appendix

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I. Intellian V240M Radiation Hazard Analysis

Ku-band Radiation Hazard Study

Intellian v240M (Ku-band)

This study analyzes the non-ionizing radiation levels for the Intellian v240M antenna while operating in the Ku-band. This report is developed in accordance with the prediction methods contained in OET Bulletin No. 65, Evaluating Compliance with FCC Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields, Edition 97-01.

Bulletin No. 65 specifies that there are two separate tiers of exposure limits that are depending on the area of exposure and/or the status of the individuals who are subject to the exposure -- the General Population/ Uncontrolled Environment and the Controlled Environment, where the general population cannot access.

The maximum level of non-ionizing radiation to which individuals may be exposed is limited to a power density level of 5 milliwatts per square centimeter (5 mW/cm^2) averaged over any 6 minute period in a controlled environment, and the maximum level of non-ionizing radiation to which the general public is exposed is limited to a power density level of 1 milliwatt per square centimeter (1 mW/cm^2) averaged over any 30 minute period in a uncontrolled environment.

In the normal range of transmit powers for satellite antennas, the power densities at or around the antenna surface are expected to exceed safe levels. The purpose of this study is to determine the power flux density levels for the earth station under study as compared with the MPE limits. This comparison is done in each of the following regions:

1. Far-field region
2. Near-field region
3. Transition region
4. The region between the feed and the antenna surface
5. The main reflector region
6. The region between the antenna edge and the ground

Input Parameters

The following input parameters were used in the calculations:

<u>Parameters:</u>	<u>Value</u>	<u>Unit</u>	<u>Symbol</u>
<i>Antenna Diameter</i>	2.4	m	<i>D</i>
<i>Antenna Transmit Gain</i>	49	dBi	<i>G</i>
<i>Transmit Frequency</i>	14125	MHz	<i>f</i>
<i>Antenna Feed Flange diameter</i>	15	cm	<i>d</i>
<i>Power Input to the Antenna</i>	222	W	<i>P</i>

Calculated Parameters:

The following values were calculated using the above input parameters and the corresponding formulas:

<u>Parameter</u>	<u>Value</u>	<u>Unit</u>	<u>Symbol</u>	<u>Formula</u>
<i>Antenna Surface Area</i>	4.524	m ²	<i>A</i>	$\pi D^2/4$
<i>Area of Antenna Flange</i>	176.715	cm ²	<i>a</i>	$\pi d^2/4$
<i>Antenna Efficiency</i>	0.63		η	$G\lambda^2/(\pi^2 D^2)$
<i>Gain Factor</i>	79432.82		<i>g</i>	$10^{G/10}$
<i>Wavelength</i>	0.0212	m	λ	$300/f$

Behavior of EM Fields as a Function of Distance

The behavior of the characteristics of EM fields varies depending on the distance from the radiating antenna. These characteristics are analyzed in three primary regions: the near-field region, the far-field region and the transition region. Of interest also are the region between the antenna main reflector and the subreflector, the region of the main reflector area and the region between the main reflector and ground.

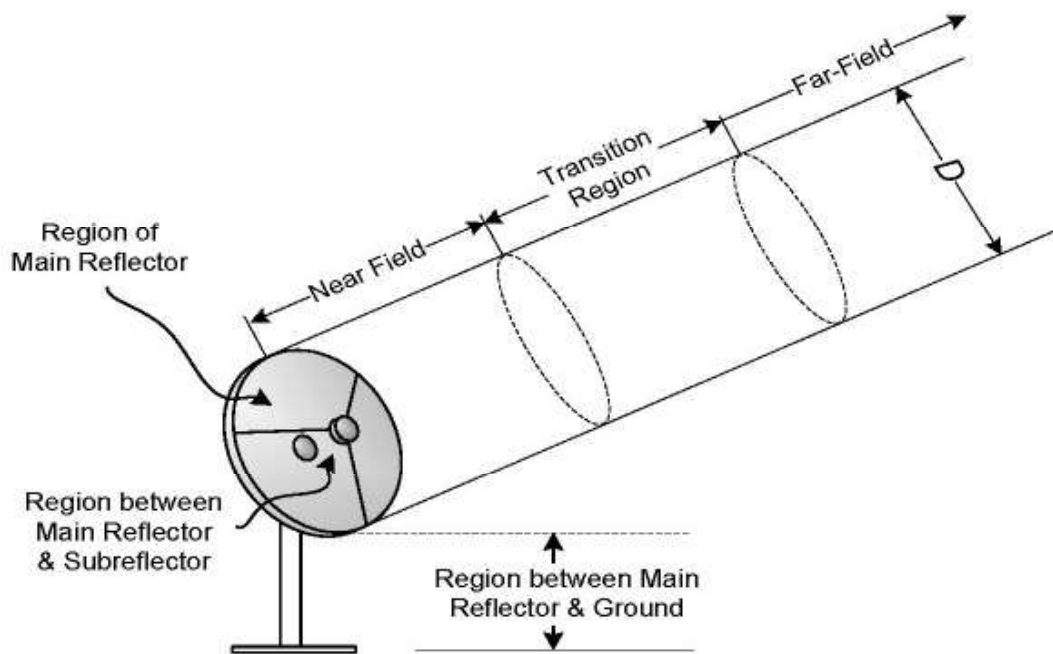


Figure 1. EM Fields as a Function of Distance

For parabolic aperture antennas with circular cross sections, such as the antenna under study, the near-field, farfield and transition region distances are calculated as follows:

<u>Parameter</u>	<u>Value</u>	<u>Unit</u>	<u>Formula</u>
<i>Near-Field Distance</i>	67.8	m	$R_{nf} = D^2/(4\lambda)$
<i>Distance to Far-Field</i>	162.72	m	$R_{ff} = 0.60D^2/(\lambda)$
<i>Distance of Transition Region</i>	67.8	m	$R_t = R_{nf}$

The distance in the transition region is between the near and far fields. Thus, $R_{nf} \leq R_t \leq R_{ff}$. However, the power density in the transition region will not exceed the power density in the near-field. Therefore, for purposes of the present analysis, the distance of the transition region can equate the distance to the near-field.

Power Flux Density Calculations

The power flux density is considered to be at a maximum through the entire length of the near-field. This region is contained within a cylindrical volume with a diameter, D , equal to the diameter of the antenna. In the transition region and the far-field, the power density decreases inversely with the square of the distance. The following equations are used to calculate power density in these regions.

<u>Parameter</u>	<u>Value</u>	<u>Unit</u>	<u>Symbol</u>	<u>Formula</u>
<i>Power Density in the Near-Field</i>	12.354	mW/cm ²	S_{nf}	$16.0 \eta P / (\pi D^2)$
<i>Power Density in the Far-Field</i>	5.292	mW/cm ²	S_{ff}	$GP / (4\pi R_{ff}^2)$
<i>Power Density in the Transition Region</i>	12.354	mW/cm ²	S_t	$S_{nf} R_{nf} / (R_t)$

The region between the main reflector and the subreflector is confined within a conical shape defined by the feed assembly. The most common feed assemblies are waveguide flanges. This energy is determined as follows:

<u>Parameter</u>	<u>Value</u>	<u>Unit</u>	<u>Symbol</u>	<u>Formula</u>
<i>Power Density at the Feed Flange</i>	5017.6	mW/cm ²	S_{fa}	$4P / a$

The power density in the main reflector is determined similarly to the power density at the feed flange; except that the area of the reflector is used.

<u>Parameter</u>	<u>Value</u>	<u>Unit</u>	<u>Symbol</u>	<u>Formula</u>
<i>Power Density at Main Reflector</i>	19.6	mW/cm ²	$S_{surface}$	$4P / A$

The power density between the reflector and ground, assuming uniform illumination of the reflector surface, is calculated as follows:

<u>Parameter</u>	<u>Value</u>	<u>Unit</u>	<u>Symbol</u>	<u>Formula</u>
<i>Power Density b/w Reflector and Ground</i>	4.9	mW/cm ²	S_g	P / A

The below table summarizes the calculated power flux density values for each region. In a controlled environment, the only regions that exceed FCC limitations are shown below. These regions are only accessible by trained technicians who, as a matter of procedure, turn off transmit power before performing any work in these areas.

<u>Power Density</u>	<u>Value</u>	<u>Unit</u>	<u>Controlled Environment</u>
<i>Far Field Calculation</i>	5.292	mW/cm ²	Exceeds Limits
<i>Near Field Calculation</i>	12.354	mW/cm ²	Exceeds Limits
<i>Transition Region</i>	12.354	mW/cm ²	Exceeds Limits
<i>Region b/w feed iris and reflector</i>	5017.6	mW/cm ²	Exceeds Limits
<i>Main Reflector Region</i>	19.6	mW/cm ²	Exceeds Limits
<i>Region b/w Main Reflector & Ground</i>	4.9	mW/cm ²	Satisfies FCC MPE

The maximum input power assumed in this study (222 W) is much higher than the actual operational input power of the antenna, which is 62.6 W. Based on these worst-case scenario calculations, the applicant will comply with the Maximum Permissible Exposure (MPE) limits of 1 mW/cm² for the Uncontrolled areas and the MPE limits of 5 mW/cm² for the Controlled areas by restricting access to the antenna and posting warning signs. Access to the antenna will be restricted to the public. Only personnel with knowledge of the radiation hazards associated with the antennas at this facility will have access to those regions that exceed the MPE levels. The antenna transmitter will be turned off during maintenance in order to comply with the MPE limit of 5 mW/cm² for Controlled Areas. In conclusion, the antenna, under the proper mitigation procedures, meets the guidelines specified in 47 C.F.R. § 1.1310.

Analysis of Non-Ionizing Radiation for Intellian V240MT 2.4-Meter Earth Station System (Ku-Band)

This report analyzes the non-ionizing radiation levels for a 2.4-meter earth station system. The analysis and calculations performed in this report comply with the methods described in the FCC Office of Engineering and Technology Bulletin, No. 65 first published in 1985 and 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. Bulletin No. 65 and the FCC R&O specifies that there are two separate tiers of exposure limits that are dependent on the situation in which the exposure takes place and/or the status of the individuals who are subject to the exposure. The Maximum Permissible Exposure (MPE) limits for persons in a General Population/Uncontrolled environment are shown in Table 1. The General Population/Uncontrolled MPE is a function of transmit frequency and is for an exposure period of thirty minutes or less. The MPE limits for persons in an Occupational/Controlled environment are shown in Table 2. The Occupational MPE is a function of transmit frequency and is for an exposure period of six minutes or less. The purpose of the analysis described in this report is to determine the power flux density levels of the earth station in the far-field, near-field, transition region, between the subreflector or feed and main reflector surface, at the main reflector surface, and between the antenna edge and the ground and to compare these levels to the specified MPEs.

Table 1. Limits for General Population/Uncontrolled Exposure (MPE)

Frequency Range (MHz)	Power Density (mW/cm ²)
30-300	0.2
300-1500	Frequency (MHz)*(0.8/1200)
1500-100,000	1.0

Table 2. Limits for Occupational/Controlled Exposure (MPE)

Frequency Range (MHz)	Power Density (mW/cm ²)
30-300	1.0
300-1500	Frequency (MHz)*(4.0/1200)
1500-100,000	5.0

Table 3. Formulas and Parameters Used for Determining Power Flux Densities

Parameter	Symbol	Formula	Value	Units
Antenna Diameter	D	Input	2.40	m
Antenna Surface Area	A _{surface}	$\pi D^2/4$	4.524	m ²
Subreflector Diameter	D _{sr}	Input	15.00	cm
Area of Subreflector	A _{sr}	$\pi D_{sr}^2/4$	176.715	cm ²
Frequency	F	Input	14,125	MHz
Wavelength	λ	300 / F	0.021239	m
Transmit Power	P	Input	77.6	W
Antenna Gain (dBi)	G _{es}	Input	47.4	dBi
Antenna Gain (factor)	G	10 ^{^(Ges/10)}	54,954.087	n/a
Pi	π	Constant	3.1415927	n/a
Antenna Efficiency	η	$G\lambda^2/(\pi^2 D^2)$	0.44	n/a

1. Far Field Distance Calculation

The distance to the beginning of the far field can be determined from the following equation:

$$\begin{aligned} \text{Distance to the Far Field Region, } R_{ff} &= 0.60 D^2 / \lambda & (1) \\ &= 162.720 \text{ m} \end{aligned}$$

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

$$\begin{aligned} \text{On-Axis Power Density in the Far Field, } S_{ff} &= G P / (4 \pi R_{ff}^2) & (2) \\ &= 12.817 \text{ W/m}^2 \\ &= 1.282 \text{ mW/cm}^2 \end{aligned}$$

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 can be determined from the following equation:

$$\begin{aligned} \text{Extent of the Near Field, } R_{nf} &= D^2 / (4 \lambda) & (3) \\ &= 67.80 \text{ m} \end{aligned}$$

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

$$\begin{aligned} \text{Near Field Power Density, } S_{nf} &= 16.0 \eta P / (\pi D^2) & (4) \\ &= 29.919 \text{ W/m}^2 \\ &= 2.992 \text{ mW/cm}^2 \end{aligned}$$

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 maximum power density in the Transition region will not exceed that calculated for the Near 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 can be determined from the following equation:

$$\begin{aligned} \text{Transition Region Power Density, } S_t &= S_{nf} R_{nf} / R_t & (5) \\ &= 2.992 \text{ mW/cm}^2 \text{ when } R_t = R_{nf} \end{aligned}$$

4. Region between the Main Reflector and the Subreflector

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

$$\begin{aligned} \text{Power Density at the Subreflector, } S_{sr} &= 4000 P / A_{sr} & (6) \\ &= 1756.505 \text{ mW/cm}^2 \end{aligned}$$

5. Main Reflector Region

The power density in the main reflector is determined in the same manner as the power density at the subreflector. The area is now the area of the main reflector aperture and can be determined from the following equation:

$$\begin{aligned} \text{Power Density at the Main Reflector Surface } S_{\text{surface}} &= 4 P / A_{\text{surface}} (7) \\ &= 68.613 \text{ W/m}^2 \\ &= 6.681 \text{ mW/cm}^2 \end{aligned}$$

6. Region between the Main Reflector and the Ground

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

$$\begin{aligned} \text{Power Density between Reflector and Ground, } S_g &= P / A_{\text{surface}} & (8) \\ &= 17.153 \text{ W/m}^2 \\ &= 1.715 \text{ mW/cm}^2 \end{aligned}$$

7. Summary of Calculations

**Table 4. Summary of Expected Radiation Levels for Uncontrolled Environment
Calculated Maximum
Radiation Power Density Level (mW/cm²)**

Region	Distance	Value	Unit	Power Density Symbol	Value	Unit	Hazard Assessment
1. Far Field	R _{ff}	162.7	m	S _{ff}	1.282	mW/m ²	Exceeds Limits
2. Near Field	R _{nf}	67.8	m	S _{nf}	2.992	mW/m ²	Exceeds Limits
3. Transition Region	R _{nf} < R _t < R _{ff}			S _t	2.992	mW/m ²	Exceeds Limits
4. Between Main Reflector and Subreflector				S _{sr}	1756.505	mW/m ²	Exceeds Limits
5. Main Reflector				S _{surface}	6.861	mW/m ²	Exceeds Limits
6. Between Main Reflector and Ground				S _g	1.715	mW/m ²	Exceeds Limits

Table 5. Summary of Expected Radiation Levels for Controlled Environment
Calculated Maximum
Radiation Power Density Level (mW/cm²)

Region	Distance	Value	Unit	Power Density Symbol	Value	Unit	Hazard Assessment
1. Far Field	R _{ff}	162.7	m	S _{ff}	1.282	mW/m ²	Satisfies FCC MPE
2. Near Field	R _{nf}	67.8	m	S _{nf}	2.992	mW/m ²	Satisfies FCC MPE
3. Transition Region	R _{nf} < R _t < R _{ff}			S _t	2.992	mW/m ²	Satisfies FCC MPE
4. Between Main Reflector and Subreflector				S _{sr}	1756.505	mW/m ²	Exceeds Limits
5. Main Reflector				S _{surface}	6.861	mW/m ²	Exceeds Limits
6. Between Main Reflector and Ground				S _g	1.715	mW/m ²	Satisfies FCC MPE

It is the applicant's responsibility to ensure that the public and operational personnel are not exposed to harmful levels of radiation.

8. Conclusions

Based on the above analysis it is concluded that the FCC RF Guidelines have been exceeded in the specified region(s) of Tables 4 and 5 and have been met in the specified regions under the Controlled Environment as indicated in Table 5. The applicant will comply with the Maximum Permissible Exposure (MPE) limits of 1 mW/cm² for the Uncontrolled areas and the MPE limits of 5 mW/cm² for the Controlled areas by restricting access to the antenna and posting warning signs. Access to the antenna will be restricted to the public. Only personnel with knowledge of the radiation hazards associated with the antennas at this facility will have access to those regions that exceed the MPE levels. The antenna transmitter will be turned off during maintenance in order to comply with the MPE limit of 5 mW/cm² for Controlled Areas. In conclusion, the antenna, under the proper mitigation procedures, meets the guidelines specified in 47 C.F.R. § 1.1310.

Analysis of Non-Ionizing Radiation for a 1.05-Meter Earth Station System

This report analyzes the non-ionizing radiation levels for a 1.0-meter earth station system. The analysis and calculations performed in this report comply with the methods described in the FCC Office of Engineering and Technology Bulletin, No. 65 first published in 1985 and 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. Bulletin No. 65 and the FCC R&O specifies that there are two separate tiers of exposure limits that are dependant on the situation in which the exposure takes place and/or the status of the individuals who are subject to the exposure. The Maximum Permissible Exposure (MPE) limits for persons in a General Population/Uncontrolled environment are shown in Table 1. The General Population/Uncontrolled MPE is a function of transmit frequency and is for an exposure period of thirty minutes or less. The MPE limits for persons in an Occupational/Controlled environment are shown in Table 2. The Occupational MPE is a function of transmit frequency and is for an exposure period of six minutes or less. The purpose of the analysis described in this report is to determine the power flux density levels of the earth station in the far-field, near-field, transition region, between the subreflector or feed and main reflector surface, at the main reflector surface, and between the antenna edge and the ground and to compare these levels to the specified MPEs.

Table 1. Limits for General Population/Uncontrolled Exposure (MPE)

Frequency Range (MHz)	Power Density (mW/cm ²)
30-300	0.2
300-1500	Frequency (MHz)*(0.8/1200)
1500-100,000	1.0

Table 2. Limits for Occupational/Controlled Exposure (MPE)

Frequency Range (MHz)	Power Density (mW/cm ²)
30-300	1.0
300-1500	Frequency (MHz)*(4.0/1200)
1500-100,000	5.0

Table 3. Formulas and Parameters Used for Determining Power Flux Densities

Parameter	Symbol	Formula	Value	Units
Antenna Diameter	D	Input	1.05	m
Antenna Surface Area	A _{surface}	$\pi D^2 / 4$	0.87	m ²
Feed Flange Diameter	D _{fa}	Input	0.2	cm
Area of Feed Flange	A _{fa}	$\pi D_{fa}^2 / 4$	0.03	cm ²
Frequency	F	Input	14250	MHz
Wavelength	λ	300 / F	0.021053	m
Transmit Power	P	Input	25.00	W
Antenna Gain (dBi)	G _{es}	Input	41.6	dBi
Antenna Gain (factor)	G	10 ^{Ges/10}	14454.4	n/a
Pi	π	Constant	3.1415927	n/a
Antenna Efficiency	η	$G\lambda^2 / (\pi^2 D^2)$	0.59	n/a

1. Far Field Distance Calculation

The distance to the beginning of the far field can be determined from the following equation:

$$\begin{aligned} \text{Distance to the Far Field Region} \quad R_{ff} &= 0.60 D^2 / \lambda \\ &= 31.4 \text{ m} \end{aligned} \quad (1)$$

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

$$\begin{aligned} \text{On-Axis Power Density in the Far Field} \quad S_{ff} &= G P / (4 \pi R_{ff}^2) \\ &= 29.126 \text{ W/m}^2 \\ &= 2.913 \text{ mW/cm}^2 \end{aligned} \quad (2)$$

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 can be determined from the following equation:

$$\begin{aligned} \text{Extent of the Near Field} \quad R_{nf} &= D^2 / (4 \lambda) \\ &= 13.1 \text{ m} \end{aligned} \quad (3)$$

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

$$\begin{aligned} \text{Near Field Power Density} \quad S_{nf} &= 16.0 \eta P / (\pi D^2) \\ &= 67.993 \text{ W/m}^2 \\ &= 6.799 \text{ mW/cm}^2 \end{aligned} \quad (4)$$

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 maximum power density in the Transition region will not exceed that calculated for the Near 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 can be determined from the following equation:

$$\begin{aligned} \text{Transition Region Power Density} \quad S_t &= S_{nf} R_{nf} / R_t \\ &= 6.799 \text{ mW/cm}^2 \end{aligned} \quad (5)$$

4. Region between the Feed Assembly and the Antenna Reflector

Transmissions from the feed assembly are directed toward the antenna reflector surface, and are confined within a conical shape defined by the type of feed assembly. The most common feed assemblies are waveguide flanges, horns or subreflectors. The energy between the feed assembly and reflector surface can be calculated by determining the power density at the feed assembly surface. This can be determined from the following equation:

$$\begin{aligned} \text{Power Density at the Feed Flange} \quad S_{fa} &= 4000 P / A_{fa} & (6) \\ &= 3183098.815 \text{ mW/cm}^2 \end{aligned}$$

5. Main Reflector Region

The power density in the main reflector is determined in the same manner as the power density at the feed assembly. The area is now the area of the reflector aperture and can be determined from the following equation:

$$\begin{aligned} \text{Power Density at the Reflector Surface} \quad S_{\text{surface}} &= 4 P / A_{\text{surface}} & (7) \\ &= 115.487 \text{ W/m}^2 \\ &= 11.549 \text{ mW/cm}^2 \end{aligned}$$

6. Region between the Reflector and the Ground

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

$$\begin{aligned} \text{Power Density between Reflector and Ground} \quad S_g &= P / A_{\text{surface}} & (8) \\ &= 28.872 \text{ W/m}^2 \\ &= 2.887 \text{ mW/cm}^2 \end{aligned}$$

7. Summary of Calculations

Table 4. Summary of Expected Radiation levels for Uncontrolled Environment

Region	Calculated Maximum Radiation Power Density Level (mW/cm²)		Hazard Assessment
1. Far Field ($R_{ff} = 31.4$ m)	S_{ff}	2.913	Potential Hazard
2. Near Field ($R_{nf} = 13.1$ m)	S_{nf}	6.799	Potential Hazard
3. Transition Region ($R_{nf} < R_t < R_{ff}$)	S_t	6.799	Potential Hazard
4. Between Feed Assembly and Antenna Reflector	S_{fa}	3183098.815	Potential Hazard
5. Main Reflector	$S_{surface}$	11.549	Potential Hazard
6. Between Reflector and Ground	S_g	2.887	Potential Hazard

Table 5. Summary of Expected Radiation levels for Controlled Environment

Region	Calculated Maximum Radiation Power Density Level (mW/cm²)		Hazard Assessment
1. Far Field ($R_{ff} = 31.4$ m)	S_{ff}	2.913	Satisfies FCC MPE
2. Near Field ($R_{nf} = 13.1$ m)	S_{nf}	6.799	Potential Hazard
3. Transition Region ($R_{nf} < R_t < R_{ff}$)	S_t	6.799	Potential Hazard
4. Between Feed Assembly and Antenna Reflector	S_{fa}	3183098.815	Potential Hazard
5. Main Reflector	$S_{surface}$	11.549	Potential Hazard
6. Between Reflector and Ground	S_g	2.887	Satisfies FCC MPE

It is the applicant's responsibility to ensure that the public and operational personnel are not exposed to harmful levels of radiation.

8. Conclusions

Based on the above analysis it is concluded that the FCC MPE guidelines have been exceeded (or met) in the regions of Table 4 and 5. The applicant proposes to comply with the MPE limits by one or more of the following methods.

The earth station will be mounted aboard a ship, and it is recommended that the lower edge of the antenna should be at least 2 meters above the deck. If this is not the case, additional procedures will be instituted to insure the safety of the Public in the vicinity of the antenna.

The applicant will ensure that the main beam of the antenna will be pointed at least one diameter away from any buildings, or other obstacles in those areas that exceed the MPE levels. Since one diameter removed from the center of the main beam the levels are down at least 20 dB, or by a factor of 100, public safety will be ensured.

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 may be working, or otherwise present on the ship, and in or near, the main beam of the antenna.

Finally, occupational exposure will be limited, and the transmitter will be turned off during 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, and subreflector, which could be occupied by operating personnel.

The applicant agrees to abide by the conditions specified in Condition 5208 provided below:

Condition 5208 - 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 worker.

Analysis of Non-Ionizing Radiation for a 1.5-Meter Earth Station System

This report analyzes the non-ionizing radiation levels for a 1.5-meter earth station system. The analysis and calculations performed in this report comply with the methods described in the FCC Office of Engineering and Technology Bulletin, No. 65 first published in 1985 and 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. Bulletin No. 65 and the FCC R&O specifies that there are two separate tiers of exposure limits that are dependant on the situation in which the exposure takes place and/or the status of the individuals who are subject to the exposure. The Maximum Permissible Exposure (MPE) limits for persons in a General Population/Uncontrolled environment are shown in Table 1. The General Population/Uncontrolled MPE is a function of transmit frequency and is for an exposure period of thirty minutes or less. The MPE limits for persons in an Occupational/Controlled environment are shown in Table 2. The Occupational MPE is a function of transmit frequency and is for an exposure period of six minutes or less. The purpose of the analysis described in this report is to determine the power flux density levels of the earth station in the far-field, near-field, transition region, between the subreflector or feed and main reflector surface, at the main reflector surface, and between the antenna edge and the ground and to compare these levels to the specified MPEs.

Table 1. Limits for General Population/Uncontrolled Exposure (MPE)

Frequency Range (MHz)	Power Density (mW/cm ²)
30-300	0.2
300-1500	Frequency (MHz)*(0.8/1200)
1500-100,000	1.0

Table 2. Limits for Occupational/Controlled Exposure (MPE)

Frequency Range (MHz)	Power Density (mW/cm ²)
30-300	1.0
300-1500	Frequency (MHz)*(4.0/1200)
1500-100,000	5.0

Table 3. Formulas and Parameters Used for Determining Power Flux Densities

Parameter	Symbol	Formula	Value	Units
Antenna Diameter	D	Input	1.5	m
Antenna Surface Area	A _{surface}	$\pi D^2 / 4$	1.77	m ²
Feed Flange Diameter	D _{fa}	Input	0.7	cm
Area of Feed Flange	A _{fa}	$\pi D_{fa}^2 / 4$	0.38	cm ²
Frequency	F	Input	14250	MHz
Wavelength	λ	$300 / F$	0.021053	m
Transmit Power	P	Input	151.40	W
Antenna Gain (dBi)	G _{es}	Input	45.1	dBi
Antenna Gain (factor)	G	$10^{G_{es}/10}$	32359.4	n/a
Pi	π	Constant	3.1415927	n/a
Antenna Efficiency	η	$G\lambda^2 / (\pi^2 D^2)$	0.65	n/a

1. Far Field Distance Calculation

The distance to the beginning of the far field can be determined from the following equation:

$$\begin{aligned} \text{Distance to the Far Field Region} \quad R_{ff} &= 0.60 D^2 / \lambda \\ &= 64.1 \text{ m} \end{aligned} \quad (1)$$

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

$$\begin{aligned} \text{On-Axis Power Density in the Far Field} \quad S_{ff} &= G P / (4 \pi R_{ff}^2) \\ &= 94.812 \text{ W/m}^2 \\ &= 9.481 \text{ mW/cm}^2 \end{aligned} \quad (2)$$

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 can be determined from the following equation:

$$\begin{aligned} \text{Extent of the Near Field} \quad R_{nf} &= D^2 / (4 \lambda) \\ &= 26.7 \text{ m} \end{aligned} \quad (3)$$

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

$$\begin{aligned} \text{Near Field Power Density} \quad S_{nf} &= 16.0 \eta P / (\pi D^2) \\ &= 221.332 \text{ W/m}^2 \\ &= 22.133 \text{ mW/cm}^2 \end{aligned} \quad (4)$$

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 maximum power density in the Transition region will not exceed that calculated for the Near 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 can be determined from the following equation:

$$\begin{aligned} \text{Transition Region Power Density} \quad S_t &= S_{nf} R_{nf} / R_t \\ &= 22.133 \text{ mW/cm}^2 \end{aligned} \quad (5)$$

4. Region between the Feed Assembly and the Antenna Reflector

Transmissions from the feed assembly are directed toward the antenna reflector surface, and are confined within a conical shape defined by the type of feed assembly. The most common feed assemblies are waveguide flanges, horns or subreflectors. The energy between the feed assembly and reflector surface can be calculated by determining the power density at the feed assembly surface. This can be determined from the following equation:

$$\begin{aligned} \text{Power Density at the Feed Flange} \quad S_{fa} &= 4000 P / A_{fa} & (6) \\ &= 1573620.116 \text{ mW/cm}^2 \end{aligned}$$

5. Main Reflector Region

The power density in the main reflector is determined in the same manner as the power density at the feed assembly. The area is now the area of the reflector aperture and can be determined from the following equation:

$$\begin{aligned} \text{Power Density at the Reflector Surface} \quad S_{\text{surface}} &= 4 P / A_{\text{surface}} & (7) \\ &= 342.699 \text{ W/m}^2 \\ &= 34.270 \text{ mW/cm}^2 \end{aligned}$$

6. Region between the Reflector and the Ground

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

$$\begin{aligned} \text{Power Density between Reflector and Ground} \quad S_g &= P / A_{\text{surface}} & (8) \\ &= 85.675 \text{ W/m}^2 \\ &= 8.567 \text{ mW/cm}^2 \end{aligned}$$

7. Summary of Calculations

Table 4. Summary of Expected Radiation levels for Uncontrolled Environment

Region	Calculated Maximum Radiation Power Density Level (mW/cm ²)		Hazard Assessment
1. Far Field ($R_{ff} = 64.1$ m)	S_{ff}	9.481	Potential Hazard
2. Near Field ($R_{nf} = 26.7$ m)	S_{nf}	22.133	Potential Hazard
3. Transition Region ($R_{nf} < R_t < R_{ff}$)	S_t	22.133	Potential Hazard
4. Between Feed Assembly and Antenna Reflector	S_{fa}	1573620.116	Potential Hazard
5. Main Reflector	$S_{surface}$	34.270	Potential Hazard
6. Between Reflector and Ground	S_g	8.567	Potential Hazard

Table 5. Summary of Expected Radiation levels for Controlled Environment

Region	Calculated Maximum Radiation Power Density Level (mW/cm ²)		Hazard Assessment
1. Far Field ($R_{ff} = 64.1$ m)	S_{ff}	9.481	Potential Hazard
2. Near Field ($R_{nf} = 26.7$ m)	S_{nf}	22.133	Potential Hazard
3. Transition Region ($R_{nf} < R_t < R_{ff}$)	S_t	22.133	Potential Hazard
4. Between Feed Assembly and Antenna Reflector	S_{fa}	1573620.116	Potential Hazard
5. Main Reflector	$S_{surface}$	34.270	Potential Hazard
6. Between Reflector and Ground	S_g	8.567	Potential Hazard

It is the applicant's responsibility to ensure that the public and operational personnel are not exposed to harmful levels of radiation.

8. Conclusions

Based on the above analysis it is concluded that the FCC MPE guidelines have been exceeded (or met) in the regions of Table 4 and 5. The applicant proposes to comply with the MPE limits by one or more of the following methods.

The earth station will be mounted aboard a ship, and it is recommended that the lower edge of the antenna should be at least 2 meters above the deck. If this is not the case, additional procedures will be instituted to insure the safety of the Public in the vicinity of the antenna.

The applicant will ensure that the main beam of the antenna will be pointed at least one diameter away from any buildings, or other obstacles in those areas that exceed the MPE levels. Since one diameter removed from the center of the main beam the levels are down at least 20 dB, or by a factor of 100, public safety will be ensured.

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 may be working, or otherwise present on the ship, and in or near, the main beam of the antenna.

Finally, occupational exposure will be limited, and the transmitter will be turned off during 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, and subreflector, which could be occupied by operating personnel.

The applicant agrees to abide by the conditions specified in Condition 5208 provided below:

Condition 5208 - 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 worker.