Radiation Hazard Analysis
San Juan (ZSU-CERAP)

This report analyzes the non-ionizing radiation levels for a 4.5-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 exposures 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 the transmit frequency and is for an exposure period of thirty minutes or less. The MPW 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 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/cm2)**
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/cm2)**
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	4.5	m
Antenna Surface Area	$A_{surface}$	$\pi D^2 / 4$	15.90	m^2
Subreflector Diameter	D_{sr}	Input	N/A	cm
Area of Subreflector	A_{sr}	$\pi D_{sr}^2 / 4$	N/A	cm^2
Frequency	F	Input	6000	MHz
Wavelength	λ	300 / F	0.05	m
Transmit Power	P	Input	0.47	W
Antenna Gain (dBi)	G_{es}	Input	42.05	dBi
Antenna Gain (factor)	G	$10^{Ges/10}$	16032.454	N/A
Pi	π	Constant	3.1415927	N/A
Antenna Efficiency	η	$G\lambda^2/(\pi^2 D^2)$	0.2005466	N/A

1. Far Field Radiation

The distance to the beginning of the far field region can be expressed by the equation:

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

R =	Distance to beginning of far field (meters	0.60	m
D =	Antenna Diameter (meters)	4.50	m
λ =	Wavelength	0.05	m

$$R_{ff} = \frac{0.60 \times 4.50 \times 4.50}{0.05} = 243.00 \text{ meters}$$

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

$$S_{ff} = \frac{G\ P}{4\ \pi\ R_{ff}^2}$$

G =	Antenna Gain (factor)	16032.5	
P =	Transmit Power	0.47	W

$$S_{ff} = \frac{16,032.45 \times 0.47}{4 \times 3.1416 \times 243 \times 243} = 0.010155 \text{ W/m}^2 \quad \text{or} \quad 0.00102 \text{ mW/cm}^2$$

2. Near Field Radiation

The extent of the near field can be described by the equation:
WHERE:

R_{nf}	=	$\frac{D^2}{4\lambda}$	R	=	Extent of near-field	meters
			D	=	Antenna diameter	4.5 meters
			λ	=	Wavelength	0.05 meters

$$R_{nf} = \frac{1.2^2}{4 \times 0.0214} = 101.25 \text{ meters}$$

The maximum value of the near field on-axis (main beam) power density is given by the equation:

S_{nf}	=	$\frac{16\,\eta\,P}{\pi D^2}$	S	=	Maximum near-field power density	16	W/m
			η	=	Efficiency of aperture (percentage)	0.200547	%
			P	=	Power into feed (Watts)	0.47	W
			D	=	Antenna Diameter (meters)	4.5	m

$$S_{nf} = \frac{6 \times 0.2005 \times 0.47}{3.1416 \times 4.5 \times 4.5} = 0.0237 \text{ W/m} \quad \text{or} \quad 0.00237 \text{ mW/cm}^2$$

3. Transition Region

On-axis power density will decrease with 40.37 meters distance in the transition region. The power density can be expressed by the equation:

WHERE:

$$S_t = \frac{S_{nf} R_{nf}}{R_{ff}}$$

S =	Power Density		
S_{nf} =	Power Density in (near field)	0.002	mW/cm^2
R_{nf} =	Extent of near field	101.25	m
R_{ff} =	Beginning of far field	243.00	m
R =	Distance to point of interest		

At the beginning of the transition region, i.e. at a distance of 101.25 meters, the power density equals:

$$S_t = \frac{0.002 \times 101.25}{101.25} = 0.00237 \ mW/cm^2$$

At the beginning of the far-field region, i.e. at a distance of 243.00 meters, the power density equals:

$$S_t = \frac{0.002 \times 101.25}{243.00} = 0.00099 \ mW/cm^2$$

4. Region between Main Reflector and Subreflector

Transmissions from the feed assembly are directly 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 calculatee by determining the power density at the subreflector surface. This can be determined from the following equation:

This antenna design does not incorporate a subreflector

5. Main Reflector Region

The maximum power density between the main reflector and the feed is taken as the power density at the main reflector. This can be described from the equation:

$$S_{surface} = \frac{4P}{A_{surface}}$$

P	=	Power into feed	0.47 W
$A_{surface}$	=	Reflector Surface Area	15.90 m^2

$$S_{surface} = \frac{4 \times 0.47}{15.90} = 0.11821\ W/m^2 \quad \text{or} \quad 0.01182\ mW/cm^2$$

6. Between Antenna and Ground

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

$$S_g = \frac{P}{A_{surface}}$$

P =	Power into feed	0.47 W
$A_{surface}$ =	Antenna Surface Area	15.90 m^2

$$S_g = \frac{0.47}{15.90} = 0.02955\ W/m^2 \quad \text{or} \quad 0.00296\ mW/cm^2$$

7. Summary of Calculations

Table 4. Summary of Expected Rdiation Levels for Uncontrolled Environment

Region	Calculated Maximum Radiation Power Density Level (mW/cm2)		Hazard Assessment
1. Far Field (Rff = 243 m)	S_{ff}	0.00102	Satisfies FCC MPE
2. Near Field (Rnf = 101.25 m)	S_{nf}	0.00237	Satisfies FCC MPE
3. Transition Region ($R_{nf} < R_t < R_{ff}$)	S_t	0.00237	Satisfies FCC MPE
4. Between Main Reflector and Subreflector	S_{sr}	N/A	No Subreflector
5. Main Reflector	$S_{surface}$	0.01182	Satisfies FCC MPE
6. Between Main Reflector and Ground	S_g	0.00296	Satisfies FCC MPE

Table5. Summary of Expected Rdiation Levels for Controlled Environment

Region	Calculated Maximum Radiation Power Density Level (mW/cm2)		Hazard Assessment
1. Far Field (Rff = m)	S_{ff}	0.00102	Satisfies FCC MPE
2. Near Field (Rnf = m)	S_{nf}	0.00237	Satisfies FCC MPE
3. Transition Region ($R_{nf} < R_t < R_{ff}$)	S_t	0.00237	Satisfies FCC MPE
4. Between Main Reflector and Subreflector	S_{sr}	N/A	No Subreflector
5. Main Reflector	$S_{surface}$	0.01182	Satisfies FCC MPE
6. Between Main Reflector and Ground	S_g	0.00296	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

Bsed upon the above analysis, it is concluded that harmful levels of radiation will not exist within any region of this earth terminal.