Radiation Hazard Analysis for the Harris MCS Earth station Melbourne, Florida

This report analyzes the non-ionizing radiation levels for a 4.8-meter earth station system located at the Harris MCS facility in Melbourne, Florida. 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 sub-reflector 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.

Frequency Range (MHz	Power Density (mW/cm2)
30-300	0.2
300-1500	Frequency (MHz)*(0.8/1200)
1500-100,000	1.0

Table 1. Limits for General Population/Uncontrolled 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 2. Limits for Occupational/Controlled Exposure (MPE)

Parameter	Symbol	Formula	Value	Units
Antenna Diameter	D	Input	4.8	m
Antenna Surface Area	$A_{surface}$	$\pi D^2/4$	18.1	m^2
Sub-reflector Diameter	D_{sr}	Input	.3579	m
Area of Sub-reflector	A_{sr}	$\pi D_{sr}^2/4$	.101	m^2
Frequency	F	Input	14125	MHz
Wavelength	λ	300/F	0.02	m
Transmit Power	P	Input	25	W
Antenna Gain (dBi)	G_{es}	Input	55.2	dBi
Antenna Gain (factor)	G	$10^{Ges/10}$	331131.1	N/A
Pi	π	Constant	3.1415927	N/A
Antenna Efficiency	η	$G\lambda^2/(\pi D)^2$	.65688	N/A

Table 3. Variables used in calculations

1. Far Field Radiation

The distance to the beginning of the far field region (R_{ff}) can be expressed by the equation:

WHERE:

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

$D = 4.8$ Antenna Diameter (meters)

$\lambda = 0.02$ Wavelength

$$R_{ff} = \frac{0.6 \times (4.8)^2}{0.02} = 650.9 \text{ meters}$$

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

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

$G = 331131.1$ Antenna Gain (factor)

$P = 25$ Transmit Power

$$S_{ff} = \frac{(331131.1)*(25)}{4\pi\,(650.9)^2} = 1.55 \text{ W/m}^2 \text{ or } 0.155 \text{ mW/cm}^2$$

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_{nf} = Extent of near-field
D = Antenna diameter
λ = Wavelength

$$R_{nf} = \frac{(4.8)^2}{4 * 0.02} = 271.2 \text{ meters}$$

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

WHERE:

$$S_{nf} = \frac{16\,\eta\,P}{\pi\,D^2}$$

S = Maximum near-field power density
η = Efficiency of aperture (percentage)
P = Power into feed (Watts)
D = Antenna Diameter (meters)

$$S_{nf} = \frac{16 * (.65688) * 25}{3.1415927 * (4.8)^2} = 3.63 \text{ W/m}^2 \text{ or } 0.363 \text{ mW/cm}^2$$

3. Transition Region

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

WHERE:

$$S = \frac{S(nf)\,R(nf)}{R}$$

S = Power Density
S(nf) = Power Density in (near field)
R(nf) = Extent of near field
R = Distance to point of interest

At the beginning of the transition region, i.e. at a distance of 271.2 meters, the power density equals:

$$S = \frac{0.363 \text{ x } 271.2}{271.2} = 0.363 \text{ mW/cm}^2$$

At the beginning of the far-field region, i.e. at a distance of 650.9 meters, the power density equals:

$$S = \frac{0.363 \times 271.2}{650.9} = 0.151 \text{ mW/cm}^2$$

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 calculated by determining the power density at the subreflector surface. This can be determined from the following equation.

WHERE:

$$S_{sr} = \frac{P}{\pi r^2}$$

S = Power density
P = Power into feed
r = radius of subreflector (m)

$$S_{sr} = \frac{25}{3.14 \times .17895^2} = 248.5 \text{ W/m}^2 = 24.9 \text{ mW/ cm}^2$$

5. Region within Antenna

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.

WHERE:

$$S = \frac{P}{\pi r^2}$$

S = Power density
P = Power into feed
r = radius of reflector

$$S = \frac{25}{3.14 \times 2.4^2} = 1.38 \text{ W/m}^2 = 0.138 \text{ mW/ cm}^2$$

6. Between Antenna and Ground

As suggested by OET Bulletin 65, Edition 97-01 (August 1997) the level of RF fields in the off-axis vicinity of the aperture antenna may be estimated by the use of the specification for maximum allowable gain for antenna side-lobes not within the plane of the Geo-stationary orbit, as follows:

$$32- \{25 \log_{10}(\theta)\} \text{ dBi} \quad \textit{for} \quad 1° \leq \theta \leq 48°$$

$$\textit{and:} \quad -10\text{dBi} \quad \textit{for} \quad 48° < \theta \leq 180°$$

Therefore, at the minimum elevation angle of 24˚ a value of -2.5 dBi is utilized for the side-lobe gain at all vicinities to the beginning of the **Far Field** power density where:

$$S_{ff} = \frac{PG}{4 \pi D^2}$$

S = Power density
P = Power into feed
D = Distance from feed to ground
G = Antenna Gain Factor - $10^{-2.5/10}$ = .561

$$S_{ff} = \frac{25 \times 0.561}{4 \times 3.14 \times 2.4^2} = 1.19 \text{ W/m}^2 = 0.194 \text{ mW/ cm}^2$$

7. Summary of calculations

Region	Radiation Level mW/cm^2	Hazard Assessment
Far-Field	0.155 mW/cm^2	Satisfies FCC MPE
Near-Field	0.363 mW/cm^2	Satisfies FCC MPE
Transition Region	0.151 mW/cm^2	Satisfies FCC MPE
Between sub and Main Reflector	24.90 mW/cm^2	See *Note 1*
Reflector Surface	0.138 mW/cm^2	Satisfies FCC MPE
Between antenna and ground	0.194 mW/cm^2	Satisfies FCC MPE

Table 4. Summary of Expected Radiation Levels for Uncontrolled Environment

Region	Radiation Level mW/cm^2	Hazard Assessment
Far-Field	0.155 mW/cm^2	Satisfies FCC MPE
Near-Field	0.363 mW/cm^2	Satisfies FCC MPE
Transition Region	0.151 mW/cm^2	Satisfies FCC MPE
Between sub and Main Reflector	24.90 mW/cm^2	See *Note 1*
Reflector Surface	0.138 mW/cm^2	Satisfies FCC MPE
Between antenna and ground	0.194 mW/cm^2	Satisfies FCC MPE

Table 5. Summary of Expected Radiation Levels for Controlled Environment

Note 1: Region between the subreflector and feed does not meet the MPE. However, the area is inaccessible unless standing in the antenna. If access to subreflector is required, Standard operating procedures require the amplifier be de-enegized and power removed.

8. Conclusion

Based on the prior analysis it is concluded that all levels of radiation within the areas occupied by the public and earth station personnel are below FCC guidelines of 5.0 mW/cm^2. To further minimize the possibility of RF exposure to the public the earth station is secured within a fenced-in area that is security controlled with limited access. Additionally the transmitter will be shut down whenever maintenance personnel are within the secured area.