ANALYSIS OF NON-IONIZING RADIATION
FOR THE GCI C-BAND 2.4M TEMPORAL EARTH STATION ANTENNA AT ST PAUL, ALASKA
Completed 6/08/2021

This report analyzes the non-ionizing radiation levels for the GCI 2.4m C-band hub earth station antenna employed at St Paul, Alaska. The analysis and calculations performed in this report comply with the methods described in the FCC Office of Engineering and Technology Bulletin, No. 65 entitled "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields" - first published in 1985 and revised in 1997 in Edition 97-01. Bulletin No. 65 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 teh 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, below. The General Population/Uncontrolled MPE is a function of the transmit frequency and is for an exposure period of thirty (30) minutes or less. The MPE limits for persons in an Occupational/Controlled environment are shown in Table 2, below. The Occupational/Controlled MPE is a function of the transmit frequency and is for an exposure period of six (6) minutes or less. The purpose of the analysis described in this report is to determine the power flux density levels of the earth station ni the far-field, near-field, transition region, between the subreflector or feed and the main reflector surface, and at the main reflector surface and to compare these levels to the specified MPE limits.

The results of this analysis are summarized in Table 3 on the last page of this analysis.

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)/1500
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)/300
1500-100,000	5.0

The following parameters were used to calculate the various power flux densities for this earth station:

Location:	St Paul	
Latitude:	57.121194	°N
Longitude:	170.282972	°W
Operating Frequency:	6135	MHz
Wavelength (λ)	0.04887	meters
Antenna Diameter (D):	2.40	meters
Antenna Area (A):	4.52	meters^2
Transmit Antenna Gain:	42.2	dBi
Transmit Antenna Gain (G):	16595.9	numeric
Maximum 5° Off Axis Gain:	30.7	dBi
Maximum 5° Off Axis Gain ($G_{5°}$):	1168.0	numeric
Antenna Efficiency (η):	0.697	numeric
Feed Power (P):	200	Watts

1. Antenna/Main Reflector Surface Calculation

The power density in the main reflector region can be estimated by:

		Antenna Diameter	
		2.40	meters
Power Density at Reflector Surface,	$S_{surface}$ =	4P/A	
	$S_{surface}$ =	176.84	W/m^2
	$S_{surface}$ =	**17.68**	**mW/cm^2**

$S_{surface}$ = maximum power density at antenna surface
P = power fed to the antenna
A = physical area of the antenna

2. Near Field Calculations

In the near field region, of the main beam, the power density can reach a maximum before it begins to decrease with distance.
The magnitude of the on axis (main beam) power density varies according to location in the near-field.

The distance to the end of the near field can be determined by the following equation:

		Antenna Diameter	
		2.40	meters
Extent of Near Field,	R_{nf} =	$D^2/4(\lambda)$	
	R_{nf} =	**29.47**	**meters**

R_{nf} = extent of near field
D = maximum dimension of antenna (diameter if circular)
λ = wavelength

The maximum near-field, on-axis, power density is determined by:

		Antenna Diameter	
		2.40	meters
On Axis Near Field Power Density,	S_{nf} =	$16\eta P/\pi D^2$	
	S_{nf} =	123.27	W/m^2
	S_{nf} =	**12.33**	**mW/cm^2**

The maximum near-field, 5° off-axis, power density is determined by:

		Antenna Diameter	
		2.40	meters
Power Density at 5° Off Axis	$S_{nf\,5°}$ =	$(S_{nf}/G)*G_{5°}$	
	$S_{nf\,5°}$ =	**0.8675**	**mW/cm^2**

S_{nf}= maximum near-field power density
$S_{nf\,5°}$ = maximum near-field power density (5° off axis)
η = aperture efficiency
P = power fed to antenna
D = maximum dimension of antenna (diameter if circular)

3. Far Field Calculations

The power density in the far-field region decreases inversely with the square of the distance.

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

		Antenna Diameter	
		2.40	meters
Distance to the Far Field Region,	R_{ff} =	$0.6D^2/\lambda$	
	R_{ff} =	**70.72**	**meters**

R_{ff} = distance to beginning of far field
D = maximum dimension of antenna (diameter if circular)
λ = wavelength

The maximum main beam power density in the far field can be calculated as follows:

		Antenna Diameter	
		2.40	meters
On-Axis Power Density in the Far Field,	S_{ff} =	$(P)(G)/4\pi(R_{ff})^2$	
	S_{ff} =	52.81	W/m^2
	S_{ff} =	**5.28**	**mW/cm^2**

The maximum far-field, 5° off-axis, power density is determined by:

		Antenna Diameter	
		2.40	meters
Power Density at 5° Off Axis	$S_{ff\,5°}$ =	$(S_{ff}/G)*G_{5°}$	
	$S_{ff\,5°}$ =	**0.3716**	**mW/cm^2**

S_{ff}= power density (on axis)
$Sff_{5°}$= power density (5° off axis)
P= power fed to antenna
G= power gain of antenna in the direction of interest relative to an isotropic radiator
R_{ff} = distance to beginning of far field

4. Transition Region Calculations

The transition region is located between the near and far field regions. The power density decreases inversely with distance in the transition region, while 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 in the near field region, as shown above will not exceed:

	Antenna Diameter	
	2.40	meters
S_t=	$(S_{nf}*R_{nf})/R$	
$S_{t\,5°}$ =	$(S_{nf\,5°}*R_{nf})/R$	
S_t=	**12.33**	**mW/cm²**
$S_{t\,5°}$ =	**0.8675**	**mW/cm²**

Table 3

Summary of Expected Radiation Levels

Region	Calculated Maximum Radiation Level (mW/cm²	Distance to Region (m)	Maximum Permissible Exposure (MPE Occupational	General Population
2.4m Earth Station Antenna				
1. Antenna Surface	$S_{surface}$= 17.68		Potential Hazard	Potential Hazard
2. Near Field	S_{nf}= 12.33	29.5	Potential Hazard	Potential Hazard
3. Far Field	S_{ff}= 5.28	70.7	Potential Hazard	Potential Hazard
4. Transition Region	S_t= 12.33		Potential Hazard	Potential Hazard
5. Near Field 5° Off Axis	$S_{nf\,5°}$= 0.8675		Satisfies MPE	Satisfies MPE
6. Far Field 5° Off Axis	$S_{ff\,5°}$= 0.37		Satisfies MPE	Satisfies MPE
7. Transition Region 5° Off Axis	$S_{t\,5°}$ = 0.8675		Satisfies MPE	Satisfies MPE

7. Conclusions

Based on the above analysis, it is concluded that the OET/FCC Radiofrequency Electromagnetic Fields guidelines for Maximum Permissible Exposure (MPE) have been exceeded in any region for the installation and maintenance crews for the antenna surface and the near field. The General Population/Uncontrolled MPE limit is always satisfied at angles 5° off of boresight or greater. As this earth station antenna will never be operated with an elevation angles of less than the minimum specified in 47 C.F.R. Ch. 1 §25.205 (namely 5°), then the MPE associated with the General Population / Uncontrolled limits will always be satisfied. The areas where the MPE limits for the General Population are exceeded (Antenna Surface, the Near Field and the Transition Region) are not accessible to the general population due locked fencing and signage. Only trained RF personnel will have access to the antenna. Finally, the transmitter will be disabled during maintenance activities in these areas to protect personnel from exposure.

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