Analysis of Non-Ionizing Radiation for MorganFranklin (West Chicago, IL), Earth Station System

This report analyzes the non-ionizing radiation levels for the earth station system comprised of three antennas; 3.8-meter C-Band (fixed), 2.4-meter Ku-Band (fixed), and a 1.8-meter Ku-Band (fixed). The analysis and calculations performed herein comply with the methods described in the FCC Office of Engineering and Technology (OET) Bulletin #65, Edition 97-01. Radiation safety limits conform to the FCC R&O 96-326. Maximum Permissible Exposure (MPE) limits are specified in these documents.

The MPE limits are defined for General Population/Uncontrolled environment (30 minute maximum exposure) and Occupational/Controlled environment (6 minute maximum exposure). These limits are classified by frequency bands as the human absorption rates vary significantly over frequency. This study will focus on the frequency bands that encompass 5,925 MHz through 6,425MHz and 14,000MHz through 14,500MHz, the frequencies of interest to this earth station system.

The purpose of this study is to determine power flux densities of the earth stations in the near-field, transition, and far-field regions, as well as the immediate areas on and around the reflectors. These levels will be compared to the MPE limits established by the FCC OET Bulletin #65.

MPE Limits

General Population/Uncontrolled environment = 1.0 mW/cm².
Occupational/Controlled environment = 5.0 mW/cm².

Table 1: Formulas & Parameters Used to Calculate Power Flux Densities

Parameter	**Symbol**	**Formula**	**Ant-1**	**Ant-2**	**Ant-3**	**Units**
Antenna Diameter	D	Given	3.8	2.4	1.8	m
Antenna Surface Area	A_{surf}	$\pi D^2 / 4$	11.34	4.52	2.54	m^2
Frequency	F	Given	6175	14250	14250	MHz
Wavelength	λ	300 / F	0.04858	0.02105	0.02105	m
Transmit Power	P	Given	28	4	4	W
Antenna Gain	G_{es}	Given	46.8	49.3	46.0	dBi
Antenna Gain Factor	G	$10^{Ges/10}$	47863.0	85113.8	39810.7	n/a
Antenna Efficiency	η	$G \lambda^2/(\pi^2 D^2$	.793	.664	.552	n/a

At the Antenna Surface

Power flux density at or around the reflector surface

Power at the Reflector $S_{refl} = 4\ P / A_{surf}$ (1)

Ant-1	Ant-2	Ant-3	Units
0.99	0.35	0.63	mW/cm^2

On-Axis Near Field Region Calculation

Power flux density is considered to be at a maximum throughout the entire length of the defined Near Field Region. This region is contained in a cylindrical volume having the same diameter as the antenna reflector.

Extent of the Near Field region $R_{nf} = D^2 / (4\ \lambda)$ (2)

Ant-1	Ant-2	Ant-3	Units
74	68	38	m

Near Field Power Density $S_{nf} = 16.0\ \eta\ P / (\pi\ D^2)$ (3)

Ant-1	Ant-2	Ant-3	Units
7.8	2.3	3.5	W/m^2
0.78	0.23	0.35	mW/cm^2

On-Axis Transition Region Calculation

The Transition region is located between the Near and Far Field regions. The maximum power density in the Transition region will not exceed that calculated in the Near Field region. Safe operating distances are calculated based on the Maximum Permissible Exposure Limits previously listed.

Transition region Power Density $S_t = S_{nf}\ R_{nf} / R$ (4)

Safe Operating Distance (solve for R)

Environment	Ant-1	Ant-2	Ant-3	Units
Uncontrolled	In NF region	In NF region	In NF region	m
Controlled	In NF region	In NF region	In NF region	m

On-Axis Far Field Region Calculation

The on-axis power density in the Far Field region varies inversely with the square of the distance.

Distance to the Far Field region R_{ff} $= 0.60\ D^2 / \lambda$ (5)

Ant-1	Ant-2	Ant-3	Units
178	164	92	m

Far Field region Power Density S_{ff} $= G\ P / (4\ \pi\ Rff^2)$ (6)

Safe Operating Distance (solve for R)

Environment	Ant-1	Ant-2	Ant-3	Units
Uncontrolled	In NF region	In NF region	In NF region	m
Controlled	In NF region	In NF region	In NF region	m

Off-Axis Levels at the Far Field Limit and Beyond

In the far field region, the power is distributed in a pattern of maxima and minima (sidelobes) as a function of the off-axis angle between the antenna centerline and the point of interest. Off-axis power density can be estimated using the antenna patterns prescribed for the particular antenna. The FCC/ITU developed the following calculation which is commonly used for satellite transmit antennas.

Far Field region Power Density G_{off} $= 32 - 25\log(\Theta)$ (7)
For Θ from 1 to 48 degrees; -10 dBi from 48 to 180 degrees

Calculating for 1 degree off axis: S_{off} $= S_{ff}\ G_{off} / G$ (8)

Ant-1	Ant-2	Ant-3	Units
.0002	.00003	.0001	mW/cm^2

Off-Axis Power Densities in the Near Field and Transitional Regions

According to Bulletin 65, for distances at least D meters away from the centerline of the main beam, the power density at that point is at least 20 dB less than the equivalent on-axis power density in the main beam.

Power Density off-axis $S_{nf(oa)} = S_{nf} / 100$ at D off-axis (9)

Ant-1	Ant-2	Ant-3	Units
.0078	.0023	.0035	mW/cm^2

Region Between Feed Horn and Reflector

Transmissions from the feed horn are directed to the reflector surfaces and are confined within a conical shape defined by the feed horn. The energy between the feed horn and the reflector is conceded to be in excess of any limits for permissible exposure. These areas are not accessible to the general public. Operators and technicians will receive training specifying that these are high exposure areas. Procedures will be established that will assure that all transmitters are turned off prior to access into these areas.

Conclusions

Based on the calculations above, it is concluded that the FCC MPE guidelines have been exceeded. The applicant proposes to comply with the MPE limits by one or more of the following methods.

The earth stations are confined within chain link fence. The fenced area entry is limited to approved personnel that have received proper training thus creating a controlled environment. Public safety is thereby ensured for the near and far field regions of the Uncontrolled Environment.

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 met for those regions in close proximity to the main reflectors which could be occupied by operating personnel.