Exhibit A-1 - Analysis of Non-Ionizing Radiation for 3.7 Meter Dish Antenna Earth Station

This report analyzes the non-ionizing radiation levels for a 3.7 meter earth station system. The analysis and calculations performed in this report show compliance with the methods described in the FCC Office of Engineering and Technology's General RF Exposure Guidance, 447498 D01 v05r02 and 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, pp 26-30.

The radiation safety limits used in the analysis are in conformance with Title 47 Chapter I, Subchapter A, Part 1, Subpart I, Section 1.1310. Section 1.1310 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 (30) 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 (6) minutes or less.

Frequency Range (MHz)	Power Density (mW/cm^2)
0.3 - 1.34	100
1.34 - 30	$180/(Frequency(MHz))^2$
30-300	0.2
300-1500	Frequency(MHz)/1500
1500-100,000	1

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

Frequency Range (MHz)	Power Density (mW/cm^2)
0.3-3.0	100
3.0-30	900/Frequency(MHz)^2
30-300	1
300-1500	Frequency(MHz)/300
1500-100,000	5

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

Parameter	Symbol	Formula	Value	Units
Ant Largest Diameter	D	Input	3.7	m
Ant Equiv Surface Area	$A_{Surface}$	$\pi(D/2)^2$	10.8	m^2
Ant Surface Pwr Dens	$S_{surface}$	$4P/A_{Surface}$	23.91	W/m
Frequency (band center)*	F	Input	2070	MHz
Wavelength	λ	$300/F\ (MHz)$	0.144	m
Transmit Power (at feed)**	P	Input	64.56	W
Antenna Gain (dBi)	G_{es}	Input (known)	35.67	dBi
Antenna Gain (factor)	G	$10^{(G_{es}/10)}$	3689	n/a
Pi	π	Constant	3.14159	n/a
Antenna Efficiency	η	$(G\lambda^2/(4\pi))/A_{surface}$	0.5421	n/a

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

****Note:*** *The antenna can transmit between 2025 MHz to 2110 MHz, so the center of the frequency band was chosen for the calculations.*

*****Note****: This is the maximum possible power at the antenna feed, however during operation a -3 dB HPA backoff will be implemented.*

1. Near Field Calculations (On-Axis, Parabolic Antenna)

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 surface area as the antenna. Past the boundary of the Near Field region, the power density from the antenna decreases linearly with respect to increasing distance (until the far field is reached).

The distance to the end of the Near Field can be determined from the following equation:

Extent of the Near Field:

$$R_{nf} = D^2/(4\lambda) = 23.76\ \text{m} \quad (1)$$

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

Near Field Power Density :

$$S_{nf} = 16\eta P/\pi D^2 = 13.02\ \text{W/m}^2 = 1.302\ \text{mW/cm}^2 \quad (2)$$

2. Transition Region Calculation (On-Axis, Parabolic Antenna)

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_{tz} can be determined from the following equation:

Transition Region Power Density:

$$S_{tz} = S_{nf}R_{nf}/R_{tz} \quad (3)$$
$$= 13.02\ W/m^2$$
$$= 1.302\ mW/cm^2$$

R_{tz} is calculated at a distance of 23.76 meters from the antenna, which is the worst case; it is the edge of the near-field boundary, R_{nf}.

3. Far Field Calculations (On-Axis, Parabolic Antenna)

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

Distance to the Far Field Region:

$$R_{ff} = 0.60\ (D^2)/\lambda \quad (4)$$
$$R_{ff} = 57.0\ m$$

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

On-Axis (boresight) Power Density in the Far Field:

$$S_{ff} = PG/(4\pi R_{ff}^2) \quad (5)$$
$$= 5.8\ W/m^2$$
$$= 0.58\ mW/cm^2$$

4. Off-Axis Levels at the Far Field Limit and Beyond (Parabolic Antenna)

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 center line and the point of interest. Off-axis power density in the far field can be estimated using the antenna radiation patterns prescribed for the antenna in use. Usually this will correspond to the antenna gain pattern envelope defined by the FCC or the ITU, which takes the form of:

Off-Axis Levels at the Far Field Limit: $G_{off} = 32 - 25\log(\Theta)$ for Θ from 3^0 to 48^0

And -10 dBi for $48^0 < \Theta < 180^0$ (Applicable for commonly used satellite transmit antennas)

$$= 32 - 25\log(3^0)$$

$$= 20 \text{ dBi or } 100 \text{ antenna gain factor}$$

Therefore:

$$PD_{3^0 \text{ off-axis}} = (S_{ff}\, G_{off})/G = 0.015 \text{ mW/cm}^2$$

Considering that satellite antenna beams are aimed skyward and the site's minimum allowed TX elevation is 5^0 without additional site review and concurrence, power density in the off axis far field will usually not be a problem except at low look angles.

5. Summary of Calculations

Calculated Maximum Radiation Power Density Level Density Level - Uncontrolled Environment			
Region	(mW/cm^2)		Hazard Assessment
Far Field (R_{ff} = 57.0 m)	S_{ff}	0.58	Limit 1 mW/cm^2; Satisfies FCC MPE
Near Field (R_{nf} = 23.76 m)	S_{nf}	1.302	Exceeds Uncontrolled
Transition Region ($R_{nf} < R_{tz} < R_{ff}$)	S_{tz}	1.302	Exceeds Uncontrolled
3^0 Off-axis From Main Beam	PD_{3^0}	0.015	Limit 1 mW/cm^2; Satisfies FCC MPE

Table 4. Summary of Expected Radiation Levels for Uncontrolled Environment

Calculated Maximum Radiation Power Density Level Density Level - Controlled Environment			
Region	Level (mW/cm^2)		Hazard Assessment
Far Field (R_{ff} = 57.0 m)	S_{ff}	0.58	Limit 5 mW/cm^2; Satisfies FCC MPE (6 min)
Near Field (R_{nf} = 23.76 m)	S_{nf}	1.302	Limit 5 mW/cm^2; Satisfies FCC MPE (6 min)
Transition Region ($R_{nf} < R_{tz} < R_{ff}$)	S_{tz}	1.302	Limit 5 mW/cm^2; Satisfies FCC MPE (6 min)
3^0 Off-axis From Main Beam	PD_{3^0}	0.015	Limit 5 mW/cm^2; Satisfies FCC MPE (6 min)

Table 5. Summary of Expected Radiation Levels for Controlled Environment

6. Conclusions

Based upon the above analysis, it is concluded that FCC RF Maximum Permissible Exposure (MPE) Guidelines have not been exceeded for an occupational/controlled environment at the station location. However, the MPE for an uncontrolled/public environment is non-compliant (according to the calculations).

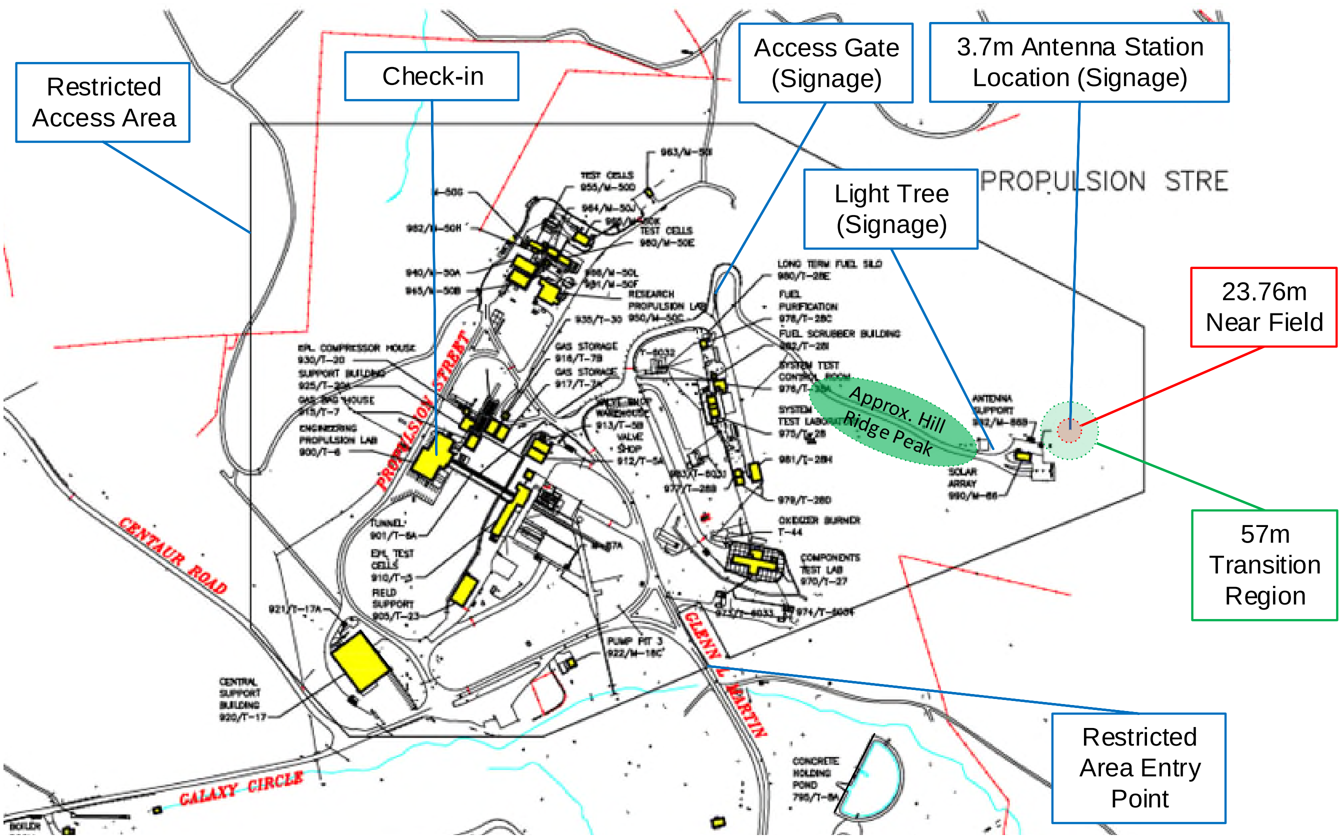
The applicant proposes to comply with the MPE limits of 5.0 mW/cm^2 for occupational/controlled areas until an actual RF survey is performed to measure the actual exposure levels. This also aligns with the existing access posture at the station location, in which access at the proposed location is within not only a controlled environment (Lockheed Martin private property), but also an inner controlled area (restricted access) in where special existing training is required (for hazardous materials) and access is controlled through procedural check in and gated access for authorized personnel only.

It is understood that it is the applicant's responsibility to ensure that the public and operational personnel are not exposed to harmful levels of non-ionizing radiation. In response, the applicant agrees to perform an RF Radiation Survey (after authorization to transmit has been approved) to measure and verify the Non-ionizing Radiation MPE exposure levels, using a calibrated Narda FCC shaped probe and PPE (Nardalert XT) along with certified RF radiation survey personnel. The RF survey will document the surrounding RF exposure levels measured in a report which will be made available to any interested parties upon request. Based on the actual measured values (in conjunction with the calculated values), mitigation steps will be taken to ensure personnel safety which may include (but not limited to) Radiation exposure warning postings, radiation light tree indication, area access training for personnel (at a minimum), limited access (occupational/controlled environment), PPE, etc.

Upon completion of the RF MPE survey, applicable protective measures will be taken to ensure personnel RF safety (as outlined above) compliance for all emitters in at the site location, and training will also be provided, as well as a RF safety zone will be clearly marked with signage at the station location, along with a radiation warning light tree indicator. In addition, contact information for the area will be provided to personnel to determine if the transmitters are active. An antenna power cutoff/lockout tagout will be accessible outside the exposure area for personnel to access in order to ‘safe’ the antenna area before occupation.

Example Of Signage:

Notional Station Location Information:



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.*

Environmental Impacts Assessment:
- Reference Section 1.1307

Location Reference: 39°30'46.8"N, 105°06'54.6"W - Lockheed Martin Space, 12257 South Wadsworth Blvd, Littleton, CO 80127

Response to Section 1.1307:

(a) - No EA impacts have been identified at this station location.
- This location is on Lockheed Martin property, no official wilderness or wildlife protection has been identified.
- No threatened/endangered wildlife or habitat has been identified at this location.
- No heritage/historic buildings or structures, nor religious sites have been identified at this location.
- The location is on top of a mountain in the foothills, no flood plain threat identified.
- Location is native grassland, no excessive land excavation has been identified.