Exhibit B
Analysis of Non-Ionizing Radiation

1. Introduction

This report analyzes the non-ionizing radiation levels for directional and hemispherical antennas at 1.66 GHz.

The FCC's Office of Engineering Technology's Bulletin No. 65 specifies that there are two separate tiers of exposure limits that are dependent upon the situation in which the exposure takes place and/or the status of the individuals who are subject to the exposure. The two tiers are General Population / Uncontrolled environment, and an Occupational / Controlled environment. Because the antennas will not be installed in General Population / Uncontrolled environments, only Occupational / Controlled environments are analyzed in this report.

As described in the definitional section of this document, this report considers the maximum power density levels in the vicinity of an ES antenna in several regions: (1) the far field, (2) the near field, (3) the transition region between near field and far field, and (4) the surface of the radiating aperture. These radiation regions were analyzed using the definitions and formulas in Bulletin 65 for aperture antennas. The results of this analysis are summarized at the end of this document.

2. Analysis of Occupational/Controlled Environment

The applicable exposure limit for the General Population / Uncontrolled environment, i.e., areas that people may enter freely, at this frequency of operation is 1 mW/cm^2 average power density over a 30-minute period.

The applicable exposure limit for the Occupational / Controlled environment, i.e., areas that only authorized / trained personnel have access to, at this frequency of operation is 5 mW/cm^2 average power density over a 6-minute period.

The tables below summarize the expected radiation level in the main beam of the antennas for an Occupational / Controlled environment at the frequencies of operation.

Table 2.1: Summary of expected radiation levels for a directional antenna at 1.66 GHz for a Controlled Environment

Region	Maximum Power Density	Hazard Assessment
Far field (R_{ff}) =0.25 m	0.79 mW/cm^2	Satisfies FCC MPE
Near field (R_{nf}) = 0.1 m	2.07 mW/cm^2	Satisfies FCC MPE
Transition region (R_t) (Rt) = R_{nf} < R_t < R_{ff}	21.7/R_t mW/cm^2	Satisfies FCC MPE
Main Reflector Surface ($S_{surface}$)	1.35 mW/cm^2	Satisfies FCC MPE

Table 2.2: Summary of expected radiation levels for a hemispherical antenna at 1.66 GHz for a Controlled Environment

Region	Maximum Power Density	Hazard Assessment
Far field (R_{ff}) =0.008 m	67.4 mW/cm^2	Does not satisfy FCC MPE
Near field (R_{nf}) = 0.004 m	52.12 mW/cm^2	Does not satisfy FCC MPE
Transition region (R_t) (Rt) = R_{nf} < R_t < R_{ff}	18.8/R_t mW/cm^2	Does not satisfy FCC MPE
Main Reflector Surface ($S_{surface}$)	39.16 mW/cm^2	Does not satisfy FCC MPE

3. Analysis

The analysis and calculations that follow in this report are performed in compliance with the methods described in the OET Bulletin No. 65.

4. Conclusion

Antennas are mounted such that and no persons will be permitted within the minimum distance during any transmission. Any maintenance on the antenna system will be performed under controlled environment conditions by trained personnel. In the case of the general public, no access is available near the antenna and any blockage of the antenna resulting in loss of signal from the satellite point of communication initiates the termination of any transmission. The minimum safe distance to meet the exposure limits for the smaller hemispherical antennas is shown in the table below. Since these antennas are installed for IoT service and not on any personal device, no person will be within the minimum safe distance while the antenna is transmitting

	Hemispherical (5dBi)	MPE Limit
General Population	7.1 cm	1 mW/cm^2 Averaged over 30 min
Occupational	3.2 cm	5 mW/cm^2 Averaged over 6 min

Based on the above analysis, it is concluded that no hazard exists for the public.

5. Calculations

In the following section, the power density in the above regions, as well as other critically important areas will be calculated and evaluated using the parameters for the antennas at 1.66 GHz.

Definition of terms

The terms used in the analysis are defined below. Values for the calculations are provided for the worst case of each type of antenna, directional and hemispherical.

S_{surf}	=	maximum power density at the antenna surface	
S_{nf}	=	maximum near-field power density	
S_t	=	power density in the transition region	
S_{ff}	=	power density (on axis)	
R_{nf}	=	extent of near-field	
R_{ff}	=	distance to the beginning of the far-field	
R_t	=	distance to point of interest	
P	=	200 mW	power fed to the antenna in milliwatts
A	=	0.059 m^2; 0.002m^2	physical area of the aperture antenna
G	=	15 dBi; 5 dBi	antenna gain relative to an isotropic radiator
D	=	0.275 m; 0.051 m	diameter of antenna in meters
F	=	1.66 GHz	frequency in GHz
λ	=	0.181 m	wavelength in meters
η	=	0.65; 0.75	aperture efficiency
D_C	=	1	duty cycle

Antenna Surface. The maximum power density directly in front of an antenna (e.g., at the antenna surface) can be approximated by the following equation:

Directional Antenna	Hemispherical Antenna
$S_{surface}$ =(D_C * 4 * P) / A **=(1 * 4 * 0.2 W) / 0.059 m^2** **=1.36 mW/cm^2**	$S_{surface}$ =(D_C * 4 * P) / A =(1 * 4 * 0.2 W) / 0.059 m^2 =39.2 mW/cm^2

Near Field Region. In the near-field or Fresnel region, of the main beam, the power density can reach a maximum before it begins to decreased with distance. The extent of the near field can be described by the following equation (**D** and λ in same units):

Directional Antenna	Hemispherical Antenna
R_{nf} =D^2 / (4 * λ) **=$(0.275)^2$ / (4 * 0.181 m)** **=0.1 m**	R_{nf} =D^2 / (4 * λ) =$(0.051)^2$ / (4 * 0.181 m) =0.004 m

The magnitude of the on-axis (main beam) power density varies according to location in the near field. However, the maximum value of the near-field, on-axis, power density can be expressed by the following equation:

Directional Antenna	Hemispherical Antenna
S_{nf} =(DC * 16 * P) / (η * π * D^2) **=(1* 16 * 0.2 W) / (0.5* π * (0.275 m)^2)** **=2.1 mW/cm^2**	S_{nf} =(DC * 16 * P) / (η * π * D^2) =(1* 16 * 0.2 W) / (0.5* π * (0.051 m)^2) =52.2 mW/cm^2

Transition Region. Power density in the transition region decreased inversely with distance from the antenna, while power density in the far field (Fraunhofer region) of the antenna decreased inversely with the square of the distance. The transition region will then be the region extending from R_{nf} to R_{ff}. If the location of interest falls within this transition region, the on-axis power density can be determined from the following equation:

Directional Antenna	Hemispherical Antenna
S_t =(DC * S_{nf}* R_{nf}) / R_t **=(0.5 * 0.027 mW/cm^2 * 0.1 m) / R (cm)** **=(21.7 mW/cm) / R_t (cm)**	S_t =(DC * S_{nf}* R_{nf}) / R_t =(0.5 * 0.78 mW/cm^2 * 0.004 m) / R (cm) =(18.8 mW/cm) / R_t (cm)

where R_t is the location of interest in centimeters

Far-Field Region. The power density in the far-field or Fraunhofer region of the antenna pattern decreased inversely as the square of the distance. The distance to the start of the far field can be calculated by the following equation:

Directional Antenna	Hemispherical Antenna
R_{ff} =(0.6 * D^2) / λ **=(0.6 * (0.275 m)^2) / 0.181 m** **=0.25 m**	R_{ff} =(0.6 * D^2) / λ =(0.6 * (0.051 m)^2) / 0.181 m =0.009 m

The power density at the start of the far-field region of the radiation pattern can be estimated by the equation:

Directional Antenna	Hemispherical Antenna
S_{ff} = (DC * P * G) / (4 * π * R_{ff}^2) **= (0.5 * 0.2 W * 31.62) / (4 * π * (0.25 m)^2)** **= 0.79 mW/cm^2**	S_{ff} = (DC * P * G) / (4 * π * R_{ff}^2) = (0.5 * 0.2 W * 3.16) / (4 * π * (0.01 m)^2) = 67.4 mW/cm^2

Minimum Distance. The minimum distance required for each antenna and MPE limit was computed using the power density in the far-field formula and the results are shown in the table below:

	Hemispherical (5dBi)	MPE Limit
General Population	7.1 cm	1 mW/cm^2 Averaged over 30 min
Occupational	3.2 cm	5 mW/cm^2 Averaged over 6 min