Attachment C

Radiation Hazard Analysis for Kacific Terminals

I. Introduction

This analysis demonstrates compliance with applicable radiation limits for of Kacific Broadband Satellites International Limited's ("Kacific") fixed customer earth station terminals (the "Kacific Terminals").[1] The calculations performed in this analysis comply with the methods described in Federal Communications Commission Office of Engineering & Technology Bulletin, Number 65 (Edition 97-01) ("OET Bulletin 65") and demonstrate compliance with the Maximum Permissible Exposure ("MPE") limits set forth in Section 1.1310 of the Commission's rules.

II. Kacific Terminal Description and Operating Parameters

The Kacific Terminals fulfill the criteria for the Commission's rules. Section 1.1310 of the Commission's rules and OET Bulletin 65 specify radiation limits for two different scenarios: (i) occupational/controlled exposures and (ii) general population/uncontrolled exposures:

i. The limits for occupational/controlled exposure apply when persons are exposed as a consequence of their employment, provided those persons are fully aware of the potential for exposure and can exercise control over their exposure;
ii. General population/uncontrolled exposure limits apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or cannot exercise control over their exposure.

The Kacific Terminals will be deployed in a variety of commercial and industrial applications. As such, the analysis below reflects the more restrictive general population/uncontrolled MPE limits to demonstrate compliance in all potential deployment environments and scenarios. The MPE limit applicable to frequencies between 1.5-100 GHz is a power density equal to 1 milliwatt per centimeter squared averaged over a thirty-minute period. The applicable MPE limits for general population/uncontrolled exposure for Kacific Terminals are shown in Table 1.

Table 1: MPE limits for general population/uncontrolled exposure for Kacific Terminals.

Frequency Range (GHz)	Power Density (S) (mW/cm^2)	Averaging Time (minutes)
1.5 -100 GHz	1	30

[1] *See* 47 C.F.R. 25.115(p) (requiring licensees to ensure compliance with radiofrequency exposure limits).

III. Analysis

The exposure power densities are derived from equation (3) in OET Bulletin 65 which predicts RF field strength and power density levels around a radiating antenna and is used to make a "worst case" prediction:

$$S = \frac{P\ x\ G}{4\pi\ x\ R^2}$$

where: S = power density; P = power input to the antenna; G = power gain of the antenna in the direction of interest relative to an isotropic radiator; R = distance to center of radiation of the antenna. This general equation is accurate in the far-field of the antenna but will over-predict the power density in the near-field.

The relevant parameters for each of the Kacific Terminals to be used in the calculations to predict the RF field strength and power density levels in the near-field and far-field are given in Table 2.

Table 2: Parameters for Determining Power Density Levels for Kacific Terminals.

Earth Station Make/Model	Antenna Diameter (major axis) (m)	Antenna Diameter (minor axis) (m)	Frequency (GHz)	Antenna Gain (dBi)	Antenna Gain	Max Power into Antenna (W)
Newtec ANT2010	0.75	0.75	29.65	45.5	3.55E+04	3.0
JONSA E74	0.77	0.75	29.65	45.5	3.55E+04	3.0
Newtec ANT2025	1.00	1	29.65	48.0	6.31E+04	3.0
JONSA E0971V	1.00	0.97	29.65	47.1	5.13E+04	3.0
Newtec ANT2035	1.28	1.2	29.65	49.6	9.12E+04	3.0
Global Skyware #12159	1.20	1.2	29.65	49.2	8.32E+04	3.0
JONSA E1201V22-5	1.22	1.184	29.65	48.6	7.24E+04	3.0
General Dynamics 3180	1.80	1.8	29.65	52.3	1.70E+05	3.9
Newstar NS-SECK-180	1.80	1.8	29.65	52.8	1.91E+05	3.5
Newstar NS-SECK-240	2.40	2.4	29.65	55.1	3.24E+05	2.0
Newstar NS-SECK-450	4.50	4.5	29.65	60.6	1.15E+06	0.6

This analysis will first address the maximum power density levels in the near-field and far-field for the on-axis case (i.e., in the mainbeam of the antenna). The extent of the near-field can be described by the following equation:

$$R_{nf} = \frac{D^2}{4\lambda}$$

where R_{nf} = extent (length) of the near-field; D = antenna diameter; λ = wavelength = speed of light/frequency.

The magnitude of the on-axis 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:

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

where S_{nf} = maximum near-field power density; η= aperture efficiency; P = power fed to the antenna; D = antenna diameter.

For the purposes of evaluating RF exposure, the distance to the beginning of the far-field region can be approximated by the following equation:

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

where R_{ff} = distance to beginning of far-field; D = antenna diameter; λ = wavelength. The power density in the far-field region can be estimated by the general equation given earlier in this section:

$$S = \frac{P\ x\ G}{4\pi\ x\ R^2}$$

Based upon the input parameters and the above equations, the maximum on-axis power density levels for the various Kacific Terminals in the near-field and far-field are given in Table 3.

Table 3: On-axis Power Density Levels for Kacific Terminals in the Near-Field and Far-Field

Earth Station Make/Model	**Length of Near Field (m)**	**On-Axis Power Density (Near-Field) (mW/cm^2)**	**Beginning of Far Field (m)**	**On-Axis Power Density (Far-Field) (mW/cm^2)**
Newtec ANT2010	13.9	1.777	33.4	0.761
JONSA E74	14.3	1.673	34.4	0.717
Newtec ANT2025	24.7	1.000	59.3	0.428
JONSA E0971V	23.9	0.867	57.4	0.372
Newtec ANT2035	38.0	0.613	91.1	0.262
Global Skyware #12159	35.6	0.636	85.4	0.272
JONSA E1201V22-5	35.7	0.549	85.7	0.235
General Dynamics 3180	80.1	0.333	192.1	0.143
Newstar NS-SECK-180	80.1	0.336	192.1	0.144
Newstar NS-SECK-240	142.3	0.103	341.6	0.044
Newstar NS-SECK-450	500.3	0.009	1200.8	0.004

The on-axis power densities calculated above represent the maximum exposure levels that the system can produce. The off-axis power densities will be considerably less.

Generally, these antennas would be mounted on rooftops or on high poles to ensure that the pointing is above the tree line. For the Kacific Terminals, the minimum elevation angle from the service areas in the Commonwealth of the Northern Mariana Islands and American Samoa will be approximately 40°, resulting in a minimum off-axis angle toward the horizon of 40°.

In the far-field region, power is distributed in a series of maxima and minima as a function of the off-axis angle. In OET Bulletin 65, it is stated that for practical estimation of RF fields in the off-axis vicinity of aperture antennas, use of the antenna radiation pattern envelope can be useful. For the Kacific terminals, the gain of the antenna will lie below the envelope defined by:

$$G(\theta) = 32 - 25log_{10}(\theta) \text{ for } 1° \leq \theta \leq 48°$$

In OET Bulletin 65, it is stated that for off-axis calculations in the near-field it can be assumed that, if the point of interest is at least one antenna diameter removed from the center of the main beam, the power density at that point would be at least a factor of 100 (20 dB) less than the value calculated for the equivalent distance in the main beam.

Taking into account the above regarding off-axis gains and the power density equations, the off-axis power density levels for the various Kacific Terminals in the near-field and far-field are re-calculated and are given in Table 4. For the far-field calculations, a conservative off-axis angle of 10° was used for this analysis.

Table 4: Off-axis Power Density Levels for Kacific Terminals in the Near-Field and Far-Field

Earth Station Make/Model	**Length of Near Field (m)**	**Off-Axis Power Density (Near-Field) (mW/cm^2)**	**Beginning of Far Field (m)**	**Off-Axis Power Density (Far-Field) (mW/cm^2)**
Newtec ANT2010	13.9	0.0178	33.4	0.0010754
JONSA E74	14.3	0.0167	34.4	0.0010123
Newtec ANT2025	24.7	0.0100	59.3	0.0003403
JONSA E0971V	23.9	0.0087	57.4	0.0003631
Newtec ANT2035	38.0	0.0061	91.1	0.0001442
Global Skyware #12159	35.6	0.0064	85.4	0.0001641
JONSA E1201V22-5	35.7	0.0055	85.7	0.0001628
General Dynamics 3180	80.1	0.0033	192.1	0.0000421
Newstar NS-SECK-180	80.1	0.0034	192.1	0.0000378
Newstar NS-SECK-240	142.3	0.0010	341.6	0.0000068
Newstar NS-SECK-450	500.3	0.0001	1200.8	0.0000002

In addition to the off-axis considerations, the Kacific Terminals will not be transmitting for 100% of the time. For a typical TDMA system, the duty cycle would be a maximum of 20% over the averaging time of 30 minutes, thereby reducing the exposure levels in Table 4 even further.

Based upon the considerations and calculations above, all Kacific Terminals will operate with a maximum power density levels over the applicable averaging time that do not exceed the MPE limit of 1.0 mW/cm^2 averaged over a thirty-minute period and are therefore not radiation hazards.

IV. Conclusion

As demonstrated in the analysis above, operation of the Kacific Terminals will not result in exposure levels exceeding the applicable radiation hazard limits.