**Analysis of Non-Ionizing Radiation for Thales ESAA Antenna**

This report analyzes the non-ionizing radiation levels for a 0.365 m effective aperture earth station antenna (0.623m x 0.168m aperture). The analysis and calculations performed in this report are in compliance with the methods described in the FCC Office of Engineering and Technology Bulletin No. 65. 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.

The applicable exposure limit for the General Population / Uncontrolled environment at this frequency of operation is 1 mW/cm². The applicable exposure limit for the Occupational / Controlled environment at this frequency of operation is 5 mW/cm².

**Definition of terms**

The terms are used in the formulas here are defined as follows:

$S_{surface}$ = 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 = distance to point of interest

| | |
|---|---|
| Pa = 16 W | power amplifier maximum output in Watts |
| Lfs = 5.4 dB | losses between amplifier and antenna input in dB<br>(Includes 1 dB radome loss) |
| P = 4.57 W | power input to the antenna in Watts<br>(16 W / 10^(5.44 dB / 10)) |
| A = 0.1046 $m^2$ | physical area of the aperture antenna (0.623x0.168 m²) |
| G = 7762 (38.9 dBi) | power gain relative to an isotropic radiator |
| Dmaj = 0.623 m | Aperture antenna major axis |
| Dmin = 0.168 m | Aperture antenna minor axis |
| F = 29,500 | frequency in MHz |
| λ = 0.0102 m | wavelength in meters (300/$F_{MHz}$) |
| η = 0.61 | aperture efficiency |

**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:

Ssurface = (4 * P) / A, Note, P is 1 dB higher under the radome

= (4 * 5.76)/0.104 $m^2$

= 220.19 $W/m^2$

= 22.019 $mW/cm^2$

**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 decrease with distance. The extent of the near field can be described by the following equation (**D** and λ in same units):

Rnf = $Dmaj^2 / (4 * \lambda)$

= $0.623^2 / (4 * 0.0102)$

= 9.54 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:

Snf = $(16 * \eta * P) / (\pi * Dmaj^2)$

= $(16 * 0.61 * 4.57) / (\pi * 0.623^2)$

= 36.61 $W/m^2$

= 3.66 $mW/cm^2$

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

Rff = $(0.6 * Dmaj^2) / \lambda$

= $(0.6 * 0.623^2) / 0.0102$

= 22.9 m

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

$S_{ff} = (P * G) / (4 * \pi * R_{ff}^2)$

$= (4.57 * 7762) / (4 * \pi * 22.9^2)$

$= 5.38\ W/m^2$

$= 0.538\ mW/cm^2$

**Transition Region.** Power density in the transition region decreases inversely with distance from the antenna, while power density in the far field (Fraunhofer region) of the antenna decreases 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:

$S_t = (S_{nf} * R_{nf}) / R$

$= (3.66\ mW/cm^2 * 9.54\ m) / R$

$= 3.66\ mW/cm^2$ where R is the start of the transition region (9.54m)

**Summary of expected radiation levels for an Uncontrolled environment**

| Region | Maximum Power Density | Hazard Assessment |
|---|---|---|
| Far field ($R_{ff}$) = 22.9 m | 0.538 mW/cm$^2$ | Satisfies FCC MPE |
| Near field ($R_{nf}$) = 9.54 m | 3.66 mW/cm$^2$ | Potential Hazard |
| Transition region ($R_t$) ($R_t$) = $R_{nf} < R_t < R_{ff}$ | 3.66 mW/cm$^2$ | Potential Hazard |
| Main Reflector Surface (Ssurface) | 22.02 mW/cm$^2$ | Potential Hazard |

Note, power density level in the area between the feed and the reflector surface is greater than the reflector surface and is assumed to be a potential hazard.

**Summary of expected radiation levels for a Controlled environment**

| Region | Maximum Power Density | Hazard Assessment |
|---|---|---|
| Far field (Rff) = 22.9 m | 0.538 mW/cm2 | Satisfies FCC MPE |
| Near field (Rnf) = 9.54 m | 3.66 mW/cm2 | Satisfies FCC MPE |
| Transition region (Rt) | 3.66 mW/cm2 | Satisfies FCC MPE |
| (Rt) = Rnf < Rt < Rff | | |
| Main Reflector Surface (Ssurface) | 22.02 mW/cm2 | Potential Hazard |

**Conclusions**

The satellite terminal will be protected from uncontrolled access while in operation. There will also be proper emission warning signs placed and all operating personnel will be aware of the human exposure levels at and around the terminal. 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 workers.