Analysis of Non-Ionizing Radiation for a ViaSat, model 3420 Parabolic Antenna Earth Station

This report analyzes the non-ionizing radiation levels for a ViaSat, model 3420 parabolic antenna earth station.

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.

The applicable exposure limit for the General Population / Uncontrolled environment, i.e., areas that people may enter freely, at an operational frequency of 2070 MHz is 1 mW/cm^2 average power density over a 6 minute period.

The applicable exposure limit for the Occupational / Controlled environment, i.e., areas that only authorized / trained personnel have access to, at an operational frequency of 2070 MHz is 1 mW/cm^2 average power density over a 30 minute period.

The antenna will not be operated in an uncontrolled environment so only the controlled environment values are summarized.

Summary of expected radiation levels for a Controlled environment

Region	Maximum Power Density	Hazard Assessment
Far field $\left(R_{ff}\right)=221.7\ m$	$S_{ff}=0.032\ \frac{mW}{cm^2}$	Satisfies FCC MPE
Transition region $\left(R_t\right)=92.4\ m$	$S_t=0.075\ \frac{mW}{cm^2}$	Satisfies FCC MPE
Near field $\left(R_{nf}\right)=92.4\ m$	$S_{nf}=0.075\ \frac{mW}{cm^2}$	Satisfies FCC MPE
Main Reflector Surface $\left(S_{surface}\right)$	$S_{Surface}=0.151\ \frac{mW}{cm^2}$	Satisfies FCC MPE

Conclusions

The proposed earth station system will be located in an environment with controlled access and will be serviced by trained personnel. Only trained personnel will operate the transmitting system during testing. No access to the reflector/feed area will be permitted when the transmitter is turned on. Based on the above analysis it is concluded that no hazard exists for the public.

OET 65 Radiation Hazard Analysis

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
P = power fed to the antenna
A = physical area of the aperture antenna
G = power gain in the direction of interest relative to an isotropic radiator
D = maximum dimension of antenna (diameter if circular)
λ = wavelength
η = aperture efficiency, typically 0.65 to 0.75

Formulas

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:

$$f_{S\_Surface}(P, A) := \frac{4\ P}{A}$$

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):

$$f_{R\_nf}(D, \lambda) := \frac{D^2}{4\ \lambda}$$

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:

$$f_{S\_nf}(P, D, \eta) := \frac{16\ \eta \cdot P}{\pi \cdot D^2}$$

Aperture efficiency can be estimated, or a reasonable approximation for circular apertures can be obtained from the ratio of the effective aperture area to the physical area as follows:

$$f_\eta(G, D, \lambda) := \frac{\left(\frac{G \cdot \lambda^2}{4 \cdot \pi}\right)}{\left(\frac{\pi \cdot D^2}{4}\right)}$$

If the antenna gain is not known, it can be calculated from the following equation using the actual or estimated value for aperture efficiency:

$$f_G(A, \lambda, \eta) := \frac{4 \cdot \pi \cdot \eta \cdot A}{\lambda^2}$$

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. For purposes of evaluating RF exposure, the distance to the beginning of the far-field region (farthest extent of the transition region) can be approximated by the following equation:

$$f_{R\_ff}(D, \lambda) := \frac{0.6 \cdot D^2}{\lambda}$$

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:

$$f_{S\_t}(S_{nf}, R_{nf}, R) := \frac{S_{nf} \cdot R_{nf}}{R}$$

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 power density in the far-field region of the radiation pattern can be estimated by the general equation discussed earlier:

$$f_{S\_ff}(P, G, R) := \frac{P \cdot G}{4 \cdot \pi \cdot R^2}$$

Results for 24 ft. Diameter Antenna

The relevant values will be calculated for a 24 ft. antenna operating at 2.070 GHz using 121.62 mW nominal power.

Constants

$c := 299792458 \ \frac{m}{s}$

Variables

$D := 24 \ ft$

$L_{fs} := 10^{\left(\frac{0 \ dB}{10}\right)}$

$L_{fs} = 1$

$F := 2.07 \ GHz$

$\eta := 0.5$

$P_a := 15848.93 \ mW$

Definitions

$\lambda := \frac{c}{F}$

$A := \pi \cdot \frac{D^2}{4}$

$P := \frac{P_a}{L_{fs}}$

$G := f_G(A, \lambda, \eta)$

$G_{dB} := 10 \cdot \log(G) \ dB$

$S_{Surface} := f_{S\_Surface}(P, A)$

$R_{nf} := f_{R\_nf}(D, \lambda)$

$S_{nf} := f_{S\_nf}(P, D, \eta)$

$R_t := R_{nf}$

$S_t := f_{S\_t}(S_{nf}, R_{nf}, R_t)$

$R_{ff} := f_{R\_ff}(D, \lambda)$

$R_f := R_{ff}$

$S_{ff} := f_{S\_ff}(P, G, R_f)$

Calculations

$\lambda = (1.448 \cdot 10^{-1}) \ m$

$A = 42.028 \ m^2$

$P = 15848.93 \ mW$

$G = 1.259 \cdot 10^4$

$G_{dB} = 41 \ dBi$

$S_{Surface} = 1508.404 \ \frac{mW}{m^2}$

$R_{nf} = 92.4 \ m$

$R_{nf} = 303.1 \ ft$

$S_{nf} = 754.202 \ \frac{mW}{m^2}$

$R_t = 92.4 \ m$

$R_t = 303.1 \ ft$

$S_t = 754.202 \ \frac{mW}{m^2}$

$R_{ff} = 221.7 \ m$

$R_{ff} = 727.3 \ ft$

$S_{ff} = 323.076 \ \frac{mW}{m^2}$