<u>Exhibit A – Radiation Hazard Study</u>

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Revision: -

Subject: Radiation Hazard Analysis of the MNLA VA-91-KA 9.1M Antenna

1. Introduction

This analysis has been prepared to determine the radiation hazard levels for the VA-91-KA 9.1M antenna. This analysis is not intended to certify that a safety hazard does or does not exist. It is the responsibility of the organization operating the antenna to evaluate the results of this analysis, along with other sources of data, and determine if a safety hazard exists.

2. Applicable Safety Standards

The safety standards for electromagnetic field exposure vary between different countries and organizations, and there is not a single worldwide standard currently in effect. Some of the standards that ViaSat is familiar with are listed in Table 1.

TABLE 1 - ELECTROMAGNETIC FIELD EXPOSURE STANDARDS

Standard Number	Standard Title	Issuing Organization	Power Density Limit	
			Controlled Environments	Uncontrolled Environments
ANSI/IEEE C95.1-1991	IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz	Institute of Electrical and Electronics Engineers	10.0 mW/cm^2 15-300 GHz	10.0 mW/cm^2 15-300 GHz
OET Bulletin 65 Edition 97-01	Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields	Federal Communications Commission	5.0 mW/cm^2 1.5-100 GHz	1.0 mW/cm^2 1.5-100 GHz

The standards listed above set exposure limits in terms of the mean squared electric (E^2) and magnetic (M^2) field strengths (V^2/m^2) and/or in terms of the equivalent plane-wave free-space power density (mW/cm^2), as a function of frequency. The power density values given are those that apply to the transmit frequency band of the VA-91-KA antenna, 28.1 – 30.0 GHz.

3. Antenna Description

The antenna being considered in this analysis utilizes a high efficiency 9.14-meter diameter axi-symmetric dual-reflector design. Some of the antenna dimensions are shown in Figure 1.

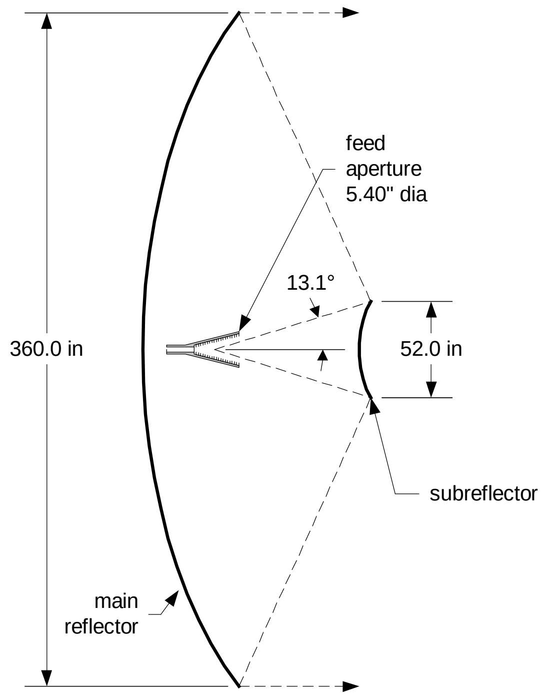

FIGURE 1 - ANTENNA GEOMETRY

The antenna is capable of transmitting over the 28.1 to 30.0 GHz frequency band. This analysis will be performed at the mid-band frequency of 29 GHz.

The antenna is equipped with three high power amplifiers (HPA); each capable of producing a maximum output power of 250 watts. The HPAs are arranged in a 3 for 2 configuration with only 2 operational at any time for a total transmit power of 500 watts.

The power delivered to the antenna is determined by subtracting the transmission line losses from the HPA output power. The losses between the HPA output and the antenna feed horn are approximately 1.73 dB. This results in 335.7 watts maximum being radiated by the antenna feed.

4. Analysis

4.1 General

The power flux densities in the spatial areas surrounding the antenna can be estimated from the geometry of the antenna system and by the use of computer programs capable of computing the near- and far-field radiation patterns of the antenna. The spatial areas around the antenna will be divided into specific regions and an appropriate analysis method will be used for each region. The following regions will be considered:

- Region between the subreflector and main reflector
- Region directly in front of the reflector aperture (parallel beam region)
- Nearfield region
- Far-field region

These regions are illustrated in Figure 2. For a large antenna of aperture diameter D, most of the energy in the far-field region, beginning at a distance $R=2D^2/\lambda$, occurs within a conical volume having a half-angle of λ/D radians. Close to the antenna, the energy is mostly confined to a cylindrical volume of diameter D. This energy is substantially parallel over the first part of the Nearfield region, diverging into a cone of half-angle λ/D at a transition range

$R_0 = D^2/2\lambda$. The transition from one region to the next is gradual, and the dimensions shown indicate the traditional boundaries. Within the region between the subreflector and main reflector, the energy radiated by the feed is enclosed in a conical shaped volume extending from the feed aperture to the subreflector, and from the subreflector to the main reflector.

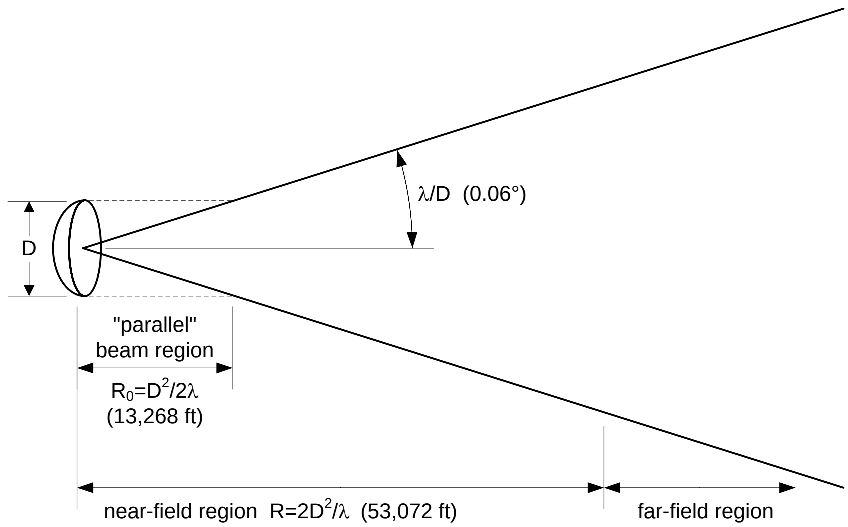

FIGURE 2 - FIELD REGIONS

4.2 Main Reflector – Subreflector Region

The energy radiated from the feed horn is confined to a conically shaped region that extends from the feed aperture to the surface of the subreflector. The energy reflects from the surface of the subreflector and is directed back towards the main reflector surface. The feed horn is designed such that the energy level at the edge of the subreflector is less than the level at the center of the subreflector. As a first approximation, the energy distribution can be assumed to be uniform over the conical region's cross-section and the power density can be expressed as:

$$W = \frac{P}{A}$$

where A = cross sectional area of the conical region in square centimeters

P = radiated power in milliwatts.

At the feed aperture we have a power density of:

$$A_f = \pi(R_f)^2 = \pi(6.86\,\text{cm})^2 = 147.76\,\text{cm}^2$$

$$P = 335.7\text{ W} = 3.357 \times 10^5\text{ mW}$$

$$W_f = 2271.9\,\text{mW/cm}^2$$

At the subreflector we have a power density of:

$$A_s = \pi(R_s)^2 = \pi(66.0\,\text{cm})^2 = 13{,}701.4\,\text{cm}^2$$
$$P = 335.7\ \text{W} = 3.357 \times 10^5\ \text{mW}$$
$$W_s = 24.5\,\text{mW/cm}^2$$

Assuming that total reflection occurs at the subreflector, the power density over the reflector aperture is:

$$A_m = \pi(R_m)^2 = \pi(457.2\,\text{cm})^2 = 656{,}692.9\,\text{cm}^2$$
$$P = 335.7\ \text{W} = 3.357 \times 10^5\ \text{mW}$$
$$W_m = 0.511\,\text{mW/cm}^2$$

Throughout most of the region between the subreflector and the main reflector, the actual power density that exists at a particular point is the combination of direct radiation and reflected radiation. For example, over most of the reflector aperture a person would be exposed to direct energy from the subreflector scattered field and to energy reflected from the main reflector. As a result, the electric field in some regions could be twice as strong, resulting in a power density four times as strong (power is proportional to voltage squared). As a conservative estimate, the power densities computed above are multiplied by four, resulting in the following power density values:

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Feed Aperture	W_f x 4 = 9088.0 mW/cm^2
Subreflector Surface	W_s x 4 = 98.0 mW/cm^2
Main Reflector Surface	W_m x 4 = 2.04 mW/cm^2

4.3 On-Axis Power Density

The radiated power in the region directly in front of the antenna reflector is primarily confined to a cylindrical volume having the same diameter as the reflector and extending out to a distance of approximately $R_0=D^2/2\lambda$. In this region, the power density varies as both a function of distance along the antenna axis and of distance away from the antenna axis. Figure 3 shows the on-axis power density vs. distance for a circular aperture with a 6 dB edge taper, computed using the expression derived by Mumford [3]. Also shown in Figure 3 are approximate formulas by Mumford that can be used to estimate the maximum power density.

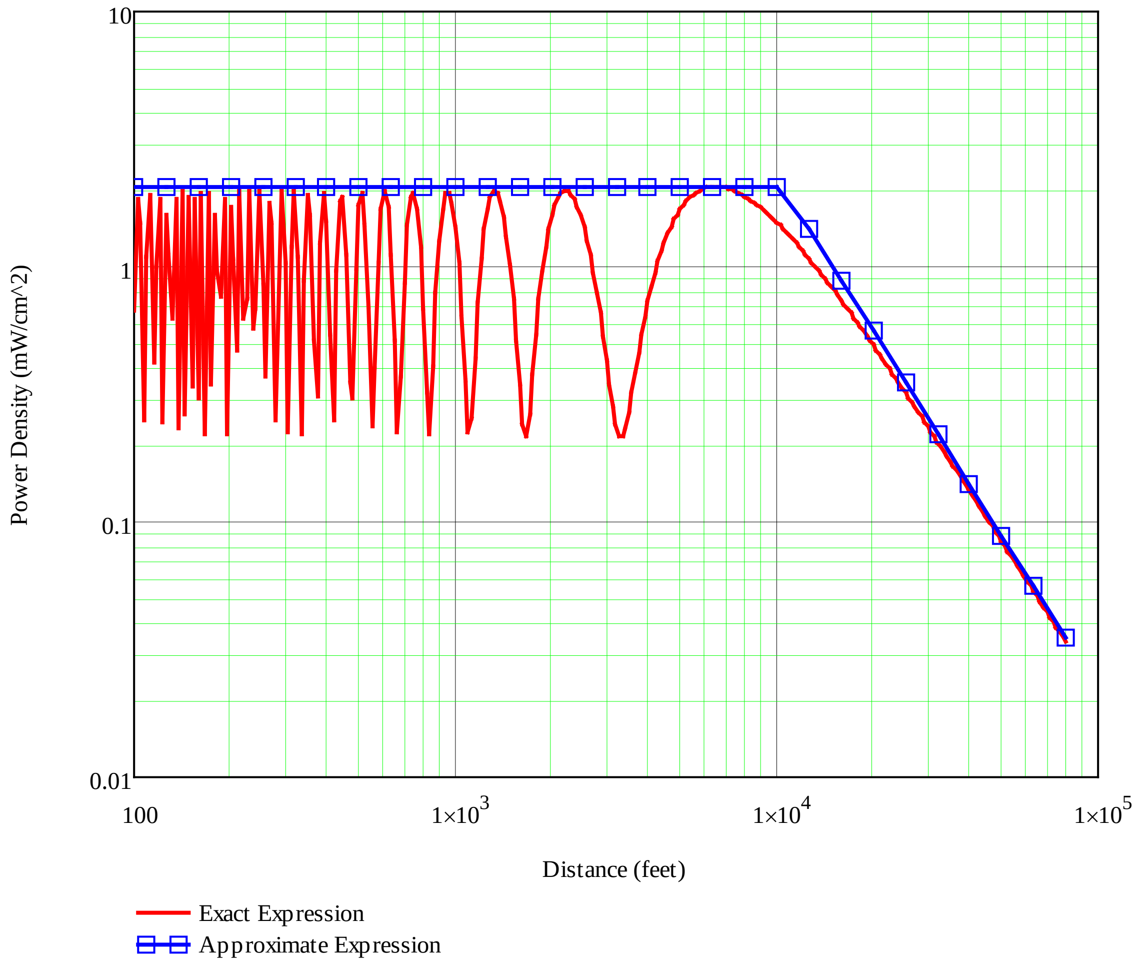

FIGURE 3 - ON-AXIS POWER DENSITY VS. DISTANCE FOR A CIRCULAR APERTURE WITH A 6 DB PARABOLIC ON PEDESTAL APERTURE TAPER

The simple expression for the maximum on-axis power density in the near-field region is:

$$W_{nf} = \frac{4P}{A_m} \text{ mW/cm}^2$$

where P is the transmit power and A_m is the reflector aperture area. For the VA-91-KA antenna, this is:

$$A_m = \pi(R_m)^2 = \pi(457.2\text{ cm})^2 = 656{,}692.9\text{ cm}^2$$

$$P = 335.7\text{ W} = 3.357 \times 10^5\text{ mW}$$

$$W_{nf} = 2.045\text{ mW/cm}^2$$

The simple expression for the maximum on-axis power density in the far-field region is:

$$W_{ff} = \frac{A_m P}{\lambda^2 r^2} \text{ mW/cm}^2$$

where λ is the wavelength and r is the distance from the aperture.

Table 4-1 shows the on-axis distance required to reach various power density levels. These distances are measured along the boresite axis of the antenna in the direction of the satellite.

TABLE 4-1: ON-AXIS DISTANCE VS POWER DENSITY

Power Density (W_{ff}) mW/cm^2	Distance (meters)	Distance (feet)
2.045	≤ 3,176	≤ 10,420
1.0	4,542	14,901
0.5	6,423	21,073
0.1	14,363	47,122

4.4 Off-Axis Power Density

In order to determine the variation of power density off of the antenna axis, more sophisticated antenna analysis methods must be used. One such tool is the GRASP8 computer code, which permits the near- and far-field patterns of dual-shaped reflector antennas, such as the VA-91-KA antenna, to be analyzed. Previous analyses of similar antennas shows that the power density is relatively constant over the angular region corresponding to the cylindrical projection of the main reflector aperture, and that the power drops off rapidly outside the main reflector boundaries. The magnitude of the power density corresponds to the on-axis power density levels predicted by the approximate expression in the previous sections. Because the on-axis power density for the VA-91-KA antenna is well below the 10.0 mW/cm^2 power density limit of the IEEE C95.1 standard, it is not necessary to compute the off-axis power density levels.

5. Summary of Results

The results of the analyses are summarized in Table 2.

TABLE 2 - SUMMARY OF RESULTS

Region	Power Density mW/cm^2	Comparison to Safety Standard: IEEE C95.1 10 mW/cm^2	Comparison to Safety Standard: FCC OET Bulletin 65 (uncontrolled areas) 1 mW/cm^2
Feed Aperture	9,087.6	Exceeded	Exceeded
Subreflector Surface	98.0	Exceeded	Exceeded
Main Reflector Surface	2.04	Acceptable	Exceeded
Aperture Plane	2.04	Acceptable	Exceeded
Near-field at a Radius of 10,000 feet	2.04	Acceptable	Exceeded
Far-field (beam peak)	See Figure 3	Acceptable	Acceptable

These results indicate that the only region where the referenced safety standards are exceeded is the following:

- The conical shaped region between the feed and subreflector and directly on boresight with the aperture out to approximately 15,000 ft (4572m). Personnel hazards in this area may be avoided by disabling the transmitter whenever anyone attempts to access the area between the feed and subreflector and whenever the antenna is pointed toward an inhabited location.

6. References

1. IEEE Std. C95. 1-1991, IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz
2. Federal Communications Commission, Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields, OET Bulletin 65, Revision 97-01, Appendix A, August 1997.
3. Mumford, W.W., "Some Technical Aspects of Microwave Radiation Hazards", Proc. IRE, vol. 49, pp. 427-447, February 1961.