# Radiation Hazard Analysis

**ThinKom Solutions, Inc.**
**ThinKom Ka2517 Terminal**

## Introduction

This analysis assesses the non-ionizing radiation levels for the ThinKom Ka2517 ("Ka2517") terminal. The calculations performed in this analysis are consistent with the recommendations articulated in the Commission's Office of Engineering and Technology Bulletin, Number 65 ("Bulletin 65"). This analysis demonstrates that the Ka2517 complies with the applicable radiation exposure limits.

Bulletin 65 and Section 1.310 of the Commission's rules specify two separate exposure limits: one for Occupational/Controlled Exposures and one for General Population/Uncontrolled Exposures. The maximum level of non-ionizing radiation to which employees may be exposed under the occupational threshold is limited to a power density level of 5 milliwatts per square centimeter (5 $mW/cm^2$) averaged over any 6-minute period in a controlled environment. The maximum level of non-ionizing radiation to which the General Population may be exposed is limited to a power density level of 1 milliwatt per square centimeter (1 $mW/cm^2$) averaged over any 30-minute period in an uncontrolled environment.

This report analyzes the maximum power density levels in the vicinity of an ES terminal antenna in five regions: (1) the far field, (2) the near field, (3) the transition region between near field and far field, (4) near the main reflector surface, and (5) between the main reflector and the feed. These radiation regions were analyzed using the definitions and formulas in Bulletin 65 for aperture antennas. The results of this analysis are summarized below and identify the potential exposure under nominal operating conditions and worst-case conditions, respectively.

## Input Parameters

The input parameters below are those used to determine the radiation levels for the proposed Ka2517 terminal.

**Ka2517 Earth Station Parameter Chart**

| **Parameter** | **Value** |
|---|---|
| **Antenna Diameter ($D_{maj}$)** | 0.4318 m (17 inches) |
| **Antenna Surface Area ($A_{ref}$)** | 0.1464 $m^2$ (1464.4 $cm^2$) |

| | |
|---|---|
| **Antenna Feed Mouth Area ($A_{feed}$)** | N/A (Internal VICTS Architecture) |
| **Antenna Isotropic Gain ($G$)** | 38.1 dBi (Numerical: 6456.5) |
| **Nominal Antenna Efficiency ($\eta$)** | 36.3% (0.363) |
| **Nominal Frequency ($f$)** | 29.5 GHz |
| **Nominal Wavelength ($\lambda$)** | 0.01017 m (1.017 cm) |
| **Maximum Transmit Power / Carrier ($P_{car}$)** | 40.0 W |
| **Number of Carriers ($N_{car}$)** | 1 |
| **Total Transmit Power ($P_{total}$)** | 40.0 W |
| **W/G & Nominal Ohmic Loss** | 1.92 dB |
| **Total Feed Input Power ($P_{feed}$)** | 25.7 W (25,700 mW) |

# Analysis

**1. At the Antenna Surface.** The maximum power density directly in front of an antenna (e.g., at the antenna surface).

$$S_{ref} = \frac{4 \times P_{feed}}{A_{ref}}$$

$$S_{ref} = \frac{4 \times 25700\ \mathrm{mW}}{1464.4\ \mathrm{cm}^2}$$

**Power Density ($S_{ref}$): 70.20 mW/cm$^2$**

**2. Near Field Region.** The near field region is an elliptical volume co-incident with the boresight of the main beam extending outward from the main reflector.

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

$$R_{nf} = \frac{(43.18\ \mathrm{cm})^2}{4 \times 1.017\ \mathrm{cm}}$$

**Extent of Near Field (*$R_{nf}$*): 458.3 cm = 4.58 m**

$$S_{nf} = \frac{16\eta P_{feed}}{\pi D_{maj}^2}$$

$$S_{nf} = \frac{16 \times 0.363 \times 25700\ \mathrm{mW}}{\pi \times (43.18\ \mathrm{cm})^2}$$

**Near Field Power Density (*$S_{nf}$*): 25.48 mW/cm$^2$**

*Note: OET 65 models assume an ideal uniformly illuminated circular aperture. Calculating* $S_{nf}$ *and* $S_{ref}$ *for a Variable Inclination Continuous Transverse Stub (VICTS) flat-panel array yields highly conservative bounding numbers, as the physical waveguide layout limits spatial peaking compared to a parabolic dish.*

**3. Transition Region.** The transition region is located between the near field region and the far field region. This region has a power density that decreases inversely with increasing distance. Therefore, the power density in the transition region will be less than the power density in the near field for the purpose of evaluating potential exposure.

**Transition Region (*$R_{nf}$* to *$R_{ff}$*): 4.58 m to 11.00 m**

**4. Far Field Region.** That region of the field of an antenna where the angular field distribution is essentially independent of the distance from the antenna.

$$R_{ff} = \frac{0.6 D_{maj}^2}{\lambda}$$

$$R_{ff} = \frac{0.6 \times (43.18\ \mathrm{cm})^2}{1.017\ \mathrm{cm}}$$

**Start of Far Field (*$R_{ff}$*): 1100.0 cm = 11.00 m**

$$S_{ff}\ (\text{at } R_{ff}) = \frac{P_{feed} \times G}{4\pi R_{ff}^2}$$

$$S_{ff} = \frac{25700\ \mathrm{mW} \times 6456.5}{4\pi \times (1100.0\ \mathrm{cm})^2}$$

**Far Field Power Density at $R_{ff}$ ($S_{ff}$): 10.91 mW/cm²**

**Main Beam Safe Distance Calculations:**

Using the far-field free-space path loss formula ($R = \sqrt{\frac{P_{feed}*G}{4\pi S}}$), the distances directly along the main beam axis at which the power density drops to regulatory limits are:

- **Occupational Limit (5 mW/cm²):** $R_{occ}$ = 16.25 meters
- **General Population Limit (1 mW/cm²):** $R_{gen}$ = 36.33 meters

**5. Off-Axis Exposure (Ground / Gate-to-Gate Operations).** The above safe distances assume a person is positioned directly inside the main beam of the antenna. However, per system specification SDS-600-0010, the Ka2517 antenna enforces a **minimum elevation angle of 10°** above the horizon. The main beam can never point downwards or horizontally at the ground.

During "Gate-to-Gate" operation (when the aircraft is on the tarmac and transmitting), a person standing on the ground or tarmac will be significantly off-axis from the main beam. For off-axis calculations, standard engineering practice establishes that at angles >10° outside the main beam, the antenna gain is suppressed by at least 20 dB (a factor of 100).

Applying this off-axis suppression to the far-field calculation, the maximum power density for personnel on the ground at a horizontal distance of just 5 meters (16.4 ft) from the aircraft would be:

$$S_{off-axis}\ (\text{at 5m}) = \frac{P_{feed} \times (G/100)}{4\pi(500\ \mathrm{cm})^2} = \frac{25700\ \mathrm{mW} \times 64.56}{4\pi \times (500\ \mathrm{cm})^2} = 0.52\ \mathrm{mW/cm^2}$$

Because **0.52 mW/cm²** is well below the General Population limit of **1.0 mW/cm²**, **there is no radiation hazard to ground personnel, passengers boarding the aircraft, or tarmac workers during Gate-to-Gate operations.**

**6. Region between the Main Reflector and the Feed.**

The Ka2517 uses ThinKom's proprietary Variable Inclination Continuous Transverse Stub (VICTS) flat-panel architecture. Unlike traditional parabolic reflectors, the RF energy makes a transition from a fully contained internal waveguide structure into continuous transverse stub radiators. There is no external focal mast or exposed feed horn.

# Conclusion and Site Access Restrictions

The analysis above demonstrates that the Ka2517 terminal will exceed the general population and occupational radiation limits directly along the main beam axis out to distances of **36.33 meters** and **16.25 meters**, respectively. Furthermore, the area directly at the antenna's surface classifies as an **FCC Category 3** exposure area (exceeding occupational limits by less than a factor of ten).

However, the Ka2517 is specifically designed as an airborne Earth Station terminal. ThinKom Solutions, Inc. utilizes specific operational measures, geometric isolation, and installation constraints to ensure that no personnel are ever exposed to the main beam hazards:

1. **Geometric Isolation (Gate-to-Gate Safety):** The OAE (Outside Aircraft Equipment) is mounted externally on the top of the aircraft fuselage. Because the system's tracking controller strictly prevents the beam from scanning below a 10° elevation angle, the main beam is always pointed towards the sky. As demonstrated in the off-axis analysis, ground crew and passengers walking around the aircraft at the gate are exposed to less than 0.52 $mW/cm^2$, keeping them entirely safe within Uncontrolled / General Population limits.

2. **System-Level Software Mitigations:** To provide redundant safety for in-flight and ground operations, the system's KANDU controller integrates automated safety interlocks. As defined in the system specifications (SDS-100-0096 and SDS-100-0097), the system enforces Altitude and Ground Speed mute logic, actively disabling RF transmission when the aircraft drops below a set altitude threshold or speed (e.g., < 10,000 ft or < 50 knots) unless authorized Gate-to-Gate networking is explicitly enabled by the operator.

3. **Maintenance Protocols & Signage:** The system incorporates a physical Transmit Standby Keyline and discrete KRFU mute commands, ensuring occupational safety for technicians by easily disabling the high-power amplifier during ground maintenance on the roof of the aircraft. Furthermore, the antenna chassis carries a manufacturer-installed RF warning label, complying with FCC Category 3 awareness requirements for maintenance personnel.

These comprehensive hardware, geometric, and operational restrictions guarantee that the general population and occupational workers do not have access to the hazardous regions of the Ka2517 main beam during active transmission.