Radiation Hazard Analysis

SR2000 and SR3000

This analysis predicts the radiation levels around a proposed earth station complex, comprised of a single panel type antenna. This report is developed in accordance with the prediction methods contained in OET Bulletin No. 65, Evaluating Compliance with FCC Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields, Edition 97-01, pp 26-30. The maximum level of non-ionizing radiation to which employees may be exposed 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 and the maximum level of non-ionizing radiation to which the general public is 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 a uncontrolled environment. Note that the worse-case radiation hazards exist along the beam axis. Under normal circumstances, it is highly unlikely that the antenna axis will be aligned with any occupied area since that would represent a blockage to the desired signals, thus rendering the link unusable.

Earth Station Technical Parameter Table

Antenna Aperture Size	0.59 m x 0.08m
Antenna Effective Diameter	0.245 meters
Antenna Surface Area	0.047 sq. meters
Antenna Isotropic Gain	27.5 dBi
Number of Identical Adjacent Antennas	1
Nominal Antenna Efficiency (ε)	42%
Nominal Frequency	14.25 GHz
Nominal Wavelength (λ)	0.0211 meters
Maximum Transmit Power / Carrier	40.0 Watts
Number of Carriers	1
Total Transmit Power	40.0 Watts
W/G Loss from Transmitter to Feed	1.5 dB
Total Feed Input Power	28.32 Watts
Radome Losses	0.5 dB
Effective RF Power at radome	25.24 Watts
Near Field Limit	$R_{nf} = D^2/4\lambda = 0.714$ meters
Far Field Limit	$R_{ff} = 0.6\ D^2/\lambda = 1.71$ meters
Transition Region	R_{nf} to R_{ff} = 0.714 meters to 1.71 meters

In the following sections, the power density in the above regions, as well as other critically important areas will be calculated and evaluated. The calculations are done in the order discussed in OET Bulletin 65.

1.0 At the Antenna Surface

The power density at the reflector surface can be calculated from the expression:

$PD_{as} = 4P/A =$ **240.29** mW/cm^2 (1)

Where: P = total power at feed, milliwatts
A = Total area of reflector, sq. cm

In the normal range of transmit powers for satellite antennas, the power densities at or around the reflector surface is expected to exceed safe levels. This area will not be accessible to the general public.

This antenna will incorporate a radome which has 0.5 dB of loss. The worst case power density at the surface of the radome is shown below:

$PD_{radome}=4P_{rad}/A$ = **214.16** mW/cm² (2)
Where: Prad = total power at feed less radome losses, milliwatts
A = Total area of reflector, sq. cm (this would represent worst case)

Operators and technicians should receive training specifying this area as a high exposure area. Procedures must be established that will assure that all transmitters are rerouted or turned off before access by maintenance personnel to this area is possible.

2.0 On-Axis Near Field Region

The geometrical limits of the radiated power in the near field approximate a cylindrical volume with a diameter equal to that of the antenna. In the near field, the power density is neither uniform nor does its value vary uniformly with distance from the antenna. For the purpose of considering radiation hazard it is assumed that the on-axis flux density is at its maximum value throughout the length of this region. The length of this region, i.e., the distance from the antenna to the end of the near field, is computed as Rnf above.

The maximum power density in the near field is given by:

$PD_{nf} = (16\varepsilon P)/(\pi D^2)$ = **90.10** mW/cm² (3)
from 0 to 0.713 meters

Evaluation
Uncontrolled Environment: **Does Not Meet Controlled Limits**
Controlled Environment: **Does Not Meet Uncontrolled Limits**

3.0 On-Axis Transition Region

The transition region is located between the near and far field regions. As stated in Bulletin 65, the power density begins to vary inversely with distance in the transition region. The maximum power density in the transition region will not exceed that calculated for the near field region, and the transition region begins at that value. The maximum value for a given distance within the transition region may be computed for the point of interest according to:

PD_{tr} = $(PD_{nf})(R_{nf})/R$ = dependent on R (4)
where: PD_{nf} = near field power density
R_{nf} = near field distance
R = distance to point of interest
PD_{tr} = **90.10** mW/cm²
For: $0.713 < R < 1.71$ meters

We use Eq (4) to determine the safe on-axis distances required for the two occupancy conditions:

Evaluation

Uncontrolled Environment Safe Operating Distance, (meters), R_{safeu}: 64.2
Controlled Environment Safe Operating Distance, (meters), R_{safec}: 12.8

4.0 On-Axis Far-Field Region

The on- axis power density in the far field region (PD_{ff}) varies inversely with the square of the distance as follows:

PD_{ff} = $PG/(4\pi R^2)$ = dependent on R (5)
where: P = total power at feed
G = Numeric Antenna gain in the direction of interest relative to isotropic radiator
R = distance to the point of interest
For: $R > R_{ff}$ = 1.71 meters
PD_{ff} = **38.60** mW/cm² at R_{ff}

We use Eq (5) to determine the safe on-axis distances required for the two occupancy conditions:

Evaluation

Uncontrolled Environment Safe Operating Distance,(meters), R_{safeu} : See Section 3
Controlled Environment Safe Operating Distance,(meters), R_{safec} : See Section 3

5.0 Off-Axis Levels at the Far Field Limit and Beyond

In the far field region, the power is distributed in a pattern of maxima and minima (sidelobes) as a function of the off-axis angle between the antenna center line and the point of interest. Off-axis power density in the far field can be estimated using the antenna radiation patterns prescribed for the antenna in use. Usually this will correspond to the antenna gain pattern envelope defined by the FCC or the ITU, which takes the form of:

$G_{off} = 32 - 25\log(\Theta)$
for Θ from 1 to 48 degrees; -10 dBi from 48 to 180 degrees
(Applicable for commonly used satellite transmit antennas)

Considering that satellite antenna beams are aimed skyward, power density in the far field will usually not be a problem except at low look angles. In these cases, the off axis gain reduction may be used to further reduce the power density levels.

For example: At two (2) degrees off axis At the far-field limit, we can calculate the power density as:

$G_{off} = 32 - 25\log(2) = 32 – 7.52$ dBi = 280.2 numeric

$PD_{2\ deg\ off\text{-}axis} = PD_{ff} \times 280.2/G$ = **19.23** mW/cm² **(6)**

6.0 Off-Axis power density in the Near Field and Transitional Regions

According to Bulletin 65, off-axis calculations in the near field may be performed as follows: assuming that the point of interest is at least one antenna diameter removed from the center of the main beam, the power density at that point is at least a factor of 100 (20 dB) less than the value calculated for the equivalent on-axis power density in the main beam. Therefore, for regions at least D meters away from the center line of the dish, whether behind, below, or in front under of the antenna's main beam, the power density exposure is at least 20 dB below the main beam level as follows:

$PD_{nf(off\text{-}axis)} = PD_{nf} /100 =$ **0.901** mW/cm^2 at D off axis (7)

See Section 7 for the calculation of the distance vs. elevation angle required to achieve this rule for a given object height.

7.0 Evaluation of Safe Occupancy Area in Front of Antenna

The distance (S) from a vertical axis passing through the dish center to a safe off axis location in front of the antenna can be determined based on the dish diameter rule (Item 6.0). Assuming a flat terrain in front of the antenna, the relationship is:

$S = (D/ \sin \alpha) + (2h - D - 2)/(2 \tan \alpha)$ (8)

Where: α = minimum elevation angle of antenna
D = dish diameter in meters
h = maximum height of object to be cleared, meters

For distances equal or greater than determined by equation (8), the radiation hazard will be below safe levels for all but the most powerful stations (> 4 kilowatts RF at the feed).

For	α =	20 degrees, minimum elevation angle of antenna
	h =	2.0 meters, delta between antenna and object >1 m
Then:		
	α	S
	10	0.7 meters
	15	0.5 meters
	20	0.4 meters
	25	0.3 meters
	30	0.3 meters

8.0 Summary of Results

The earth station site will be protected from uncontrolled access by virtue of the fact that it will be mounted on the roof of a vehicle. 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 earth station. The applicant agrees to abide by the conditions specified in Condition 18 provided below:

> *(18) - The Raysat Antenna Systems LLC shall take all reasonable and customary measures to ensure that the MET does not create potential for harmful non-ionizing radiation to persons who may be in the vicinty of the MET when it is in operation. At a minimum, permanent warning label(s) shall be affixed to the MET warning of the radiation hazard and including a diagram showing the regions around the MET where the radiation levels could exceed 1.0mW/cm2. The operator of the MET shall be responsible for assuring that individuals do not stray into the region around the MET where there is a potential for exceeding the maximum permissible exposure limits required by Section 1.1310 of the Commission's rules 47 C.F.R § 1.1310. This shall be accomplished by means of signs, caution tape, verbal warnings, placement of the MET so as to minimize access to the hazardous region and/or any other appropriate means*

The table below summarizes all of the above calculations.

Parameter	Abbr.		Units	Formula
Antenna Effective Diameter	Df	0.245	meters	
Antenna Centerline	h	2	meters	
Antenna Surface Area	Sa	0.047	$meter^2$	$(\pi * Df^2)/4$
Antenna Ground Elevation	GE	2	meters	
Frequency of Operation	f	14.25	GHz	
Wavelength	λ	0.0211	meters	
HPA Output Power	P_{HPA}	40	watts	
HPA to Antenna Loss	L_{Tx}	1.5	dB	
Radome Loss	L_{Rad}	0.5	dB	
Transmit Power at Flange	P	28.32	watts	$P/10Log^{-1}(L_{Tx}/10)$
Effective Power after Radome		25.24	watts	$P/10Log^{-1}$(Radome Loss/10)
Antenna Gain	G_{es}	27.5	dBi	does not include radome loss
Antenna Aperature Efficiency	η	42%	n/a	
1. Reflector Surface Region Calculations				
Antenna Surface Power Density	Pdas	2402.9	W/m^2	$(16 * P)/(\pi * D^2)$
		240.29	mW/cm^2	
Power at Radome Surface	Pdrad	2141.6	W/m^2	$(16 * P)/(\pi * D^2)$
(outside radome)		214.16	mW/cm^2	**Does not meet controlled limits** **Does not meet uncontrolled limits**
2. On Axis Near Field Calculations				
Extent of Near Field	Rn	0.713	meters	$D^2 / (4 * \lambda)$
		2.338	feet	
Near Field Power Density	PDnf	901.0	w/m^2	$(16 * \eta * P)/(\pi * D^2)$
		90.10	mW/cm^2	**Does not meet controlled limits** **Does not meet uncontrolled limits**
3. On Axis Transition Region Calculations				
Extent of Transition Region (min)	R_{Tr}	0.713	meters	$D^2 / (4 * \lambda)$
Extent of Transition Region (min)		2.338	feet	
Extent of Transition Region (max)	R_{Tr}	1.711	meters	$0.6 * D^2 / \lambda$
Extent of Transition Region (max)		5.612	feet	
Worst Case Transition Region Power Density	PD_{tr}	901.0	w/m^2	
		90.10	mW/cm^2	**Does not meet controlled limits** **Does not meet uncontrolled limits**
Uncontrolled enviorment safe operating distance	Rsu	64.2	meters	$(PD_{nf})/R_{nf})/Rsu$
Controlled enviorment safe operating distance	Rsc	12.8	meters	$(PD_{nf})/R_{nf})/Rsc$
4. On Axis Far Field Calculations				
Distance to Far Field Region	Rf	1.71	meters	$0.6 * D^2 / \lambda$
		5.61	feet	
On Axis Power Density in the Far Field	PD_{ff}	386.0	W/m^2	$(G_{es} * P) / (4 * \pi * Rf^2)$
		38.60	mW/cm^2	**Does not meet controlled limits** **Does not meet uncontrolled limits**
5. Off-axis Power Density in the Far Field Limit and Beyond				
Antenna Surface Power Density	PDs	192.3	W/m^2	$(G_{es} * P) / (4 * \pi * Rf^2) * (Goa/Ges)$
Goa/Ges at a sample angle of θ=2 degrees		0.498		Goa = 32 - 25*log(θ)
		19.23	mW/cm^2	
6. Off Axis Power Density in the Near Field and Transitional Region Calculations				
Power Density of Wn/100 for 1 diameter	PDs	9.01	W/m^2	$[(16 * \eta * P)/(\pi * D^2)] / 100$
removed		0.901	mW/cm^2	**Meets controlled limits** **Meets Uncontrolled limits**
7.0 Off-axis Safe Distances from Earth Station				
minimum elevation angle of antenna	α	10	degree	
hieght of object to be cleared	h	2	meter	
Groun elevation delta antenna-obstacle elevation ang	**GD**	**S**		
	10	0.7	meter	S=(D/sinα) + (2h - D- 2) / (2tanα)
	15	0.5	meter	
	20	0.4	meter	
	25	0.3	meter	
	30	0.3	meter	

Note: Maximum FCC power density limits for 6GHz is 1mW/cm2 for general population exposure as per FCC OS&T

StealthRay™ 2000

TechSpec

2-way low-profile in-motion satellite antenna compatible with any external standard Ku band BUC (up to 50W)

Physical	Outdoor unit size	115 L x 90 W x 15 H cm (45 x 35 x 6 in)
	Outdoor unit weight	28 kg (62 lb)
	Indoor unit size	18 L x 23 W x 7 H cm (7 x 9 x 3 in)
	Indoor unit weight	1.3 kg (2.8 lb)
		(The radome is included in all measurements and dimensions)
Electrical	Frequency band	
	Receive	High band 11.7 - 12.75 GHz Low band 10.95 - 11.7 GHz (Factory option)
	Transmit	14.0 - 14.5 GHz
	Polarization	Linear (auto polarization control)
	Gain	
	Receive	30 dBi
	Transmit	27 dBi
	Antenna G/T	8 dB/°K at 30° elevation or 9 dB/°K at 45° elevation
	Uplink EIRP	41.7 dBW (with external 40 Watt BUC)
	Cross polarization	> 25dB
	IF input (Tx)	950 - 1450 MHz
	IF output (Rx)	950 - 2150 MHz
	Ku band input	14 - 14.5 GHz, 50W max.
	Power supply	10 - 30 VDC
	Continuous power consumption	55 W (ant. only, excluding BUC)
Antenna Performance	Elevation look angle range	Automatically adjusted, 25° - 80°
	Azimuth angle range	Automatically adjusted, 360° continuous
	Tracking rate	60°/sec
	Polarization angle range	Automatically adjusted, -180º to +180º
	Initial satellite acquisition & lock	< 60 sec, fully automated with integrated GPS
	Satellite re-acquisition	< 10 sec (when LoS blocage is < 2 minutes)
	Azimuth tracking accuracy	0.5°@ 60°/s, 360°/s^2
	Elevation tracking accuracy	1.0°@ 45°/s, 180°/s^2
Electrical Interfaces	Tx input	N (50Ω)
	Rx output	TNC (50Ω)
Environmental	Temperature range	-25º to +70ºC (-13º to +158ºF)
	Relative humidity	Up to 95%
	Ground speed	Up to 350 Km/h (220 mi/h)

Specifications subject to change without notice

About RAS

Established in 2006, Raysat Antenna Systems (RAS) is a world leader in providing low-profile, in-motion, two-way satellite antennas for land mobile applications of COTM (Comms on-the-move). RAS products are used extensively for mobile emergency communications, homeland security, governmental organizations, DSNG, private security, asset tracking, research & exploration, and general mobile satellite data communications. RAS products operate in both Ku and Ka bands. RAS is a wholly owned subsidiary of Gilat Satellite Networks (NASDAQ: GILT).

RaySat Antenna Systems
Satcom on-the-move

RAS, LTD. 21 Yegia Kapayim Street, Kiryat Arye, Petach Tikva, Israel 49130 T: +972-3-9707800; F: +972-3-9707801
To Contact RAS International Sales & Marketing Team email sales-RAS@raysat.com | www.raysat.com