3.8m RADIATION HAZARD STUDY

1.0 Introduction

NewCom International ("NewCom") intends to deploy a transmit/receive 3.8m antenna at its flagship teleport in Miami, Florida. This fixed satellite antenna has 53.2 dBi gain, and will be equipped with a 20 Watt transceiver. Maximum output from the transceiver will be limited to 20 Watt and EIRP will not exceed 65.96 dBW.

2.0 Antenna Analysis Method

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 milliwatt per square centimeter (5 mW/cm2) 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/cm2) averaged over any 30 minute period in a uncontrolled environment. These calculations demonstrate that the radiation levels associated with NewCom's short-term testing are within acceptable limits when compared to the levels established for Maximum Permissible Exposure ("MPE") defined in Bulletin 65, Appendix A for Occupational/Controlled Limits and General Population/Uncontrolled Limits.

3.1 3.8m Antenna Specifications

The proposed antenna is a Prodelin 1383 Series transmit/receive antenna equipped with a 20 Watt transceiver. The parameters for this antenna are shown in the table below.

Antenna Actual Diameter	**3.80 meters**
Antenna Surface Area	**11.34 sq. meters**
Antenna Isotropic Gain	**53.2 dBi**
Number of Identical Adjacent Antennas*	**0**
Nominal Antenna Efficiency (η)	**65 %**
Nominal Frequency	**14250 MHz**
Nominal Wavelength (λ)	**0.0211 meters**
Maximum Transmit Power / Carrier	**20 Watts**
Number of Carriers	**1**
Total Transmit Power	**20 Watts**
W/G Loss from Transmitter to Feed	**0.25 dB**
Total Feed Input Power	**18.88 Watts**
Near Field Limit	$R_{nf} = D^2/4\lambda = 171.1$ **meters**
Far Field Limit	$R_{ff} = 0.6\, D^2/\lambda = 410.6$ **meters**
Transition Region	R_{nf} **to** R_{ff}

Note that the worst-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.

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.

3.2 Main Reflector Region

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

PD_{refl} = 4P/A = 0.666 mW/cm² (1)

Where: P = total power at feed, milliwatts

A = Total area of reflector, sq. cm

In the normal range of transmit powers for this satellite antenna, the power densities at or around the reflector surface are expected not to exceed safe levels. Even though, precautionary measures will be taken during the individual installations of the antenna to ensure that this area will be inaccessible to the general public. Operators and technicians have received training specifying this area as a high exposure area. Furthermore, procedures have been established that ensure all transmitters are turned off before access to this area by maintenance personnel is possible.

3.3 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 power density within the on-axis near field region can be calculated from the expression:

$PD_{nf} = (16\ \eta\ P)/(\pi\ D^2)$ = 0.433 mW/cm² (2)

from 0 to 171.1 meters

Evaluation

Uncontrolled Environment:	**Complies to FCC Limits ***
Controlled Environment:	**Complies to FCC Limits ***

* Power Density Limit for Controlled and Uncontrolled Environment is met in the Near Field Region.

3.4 On-Axis Transition Field 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:

We use the equation below (3) to determine the safe on-axis distances required for the two occupancy conditions:

PD_t =	**$(PD_{nf})(R_{nf})/R$ = dependent on R (3)** **= 0.433 mW/cm² at R = 171.1 m**
where:	**PD_{nf} = near field power density**
	R_{nf} = near field distance
	R = distance to point of interest
For:	**171.1 < R < 410.6 meters**

Evaluation

Uncontrolled Environment Safe Operating Distance,(meters), R_{safeu}:	**171.1 m ****
Controlled Environment Safe Operating Distance,(meters), R_{safec}:	**171.1 m ****

** Power Density Limit for Controlled and Uncontrolled Environments is met in the Transition Field Region.

3.5 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:

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

PD_{ff} =	**$PG/(4\pi R^2)$ = dependent on R (4)**
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} = 410.6 meters**
	PD_{ff} = 0.186 mW/cm² at R_{ff}

Evaluation

Uncontrolled Environment Safe Operating Distance,(meters), R_{safeu}:	**410.6 m**

Controlled Environment Safe Operating Distance,(meters), R_{safec}: **410.6 m**

3.6 Off-Axis Far-Field Region

In the far field region 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:

$G_{off} = 32 - 25\log(\Theta)$ (5)
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 one (1) degree off axis At the far-field limit, we can calculate the power density as:

$G_{off} = 32 - 25\log(1) = 32 - 0$ dBi = 1585 numeric

Evaluation
$PD_{1\ deg\ off\text{-}axis} = PD_{ff} x\ 1585/G = 0.00141$ mW/cm²

3.7 Off-Axis Power Density in the Near-Field and Transitional Region

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 3.8 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:

$PD_{nf(off\text{-}axis)} = PD_{nf} /100 = 0.00433$ mW/cm² at D off axis (6)

Evaluation of Safe Occupancy Area in Front of Antenna

The safe 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 above (6). Assuming a flat terrain in front of the antenna, the relationship is:

$S = (D/\sin\alpha) + (2h - D - 2)/(2\tan\alpha)$ (7)

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 (7), the radiation hazard will be below safe levels for all but the most powerful stations (> 4 kilowatts RF at the feed).

For	**D =**	**3.8 meters**
	h =	**1 meter**

Then:

α	S
10	**11.1 meters**
15	**7.6 meters**
20	**5.9 meters**
25	**4.9 meters**
30	**4.3 meters**
35	**3.9 meters**
45	**3.5 meters**

4.0 Expected Radiation Levels

Region / Antenna	Antenna Surface Area (mW/cm^2)	Near Field Dist. (m) (mW/cm2)	Far Field Dist. (m) (mW/cm2)	Transition (Midpoint) Dist. (m) (mW/cm2)
3.8 m / 18.88 W BUC		171.1	410.6	290.8
	0.666	0.433	0.186	0.255

5.0 Conclusions

Based on the above analysis, it is concluded that harmful levels of radiation will not exist in regions normally occupied by the public or the antenna's operating personnel. It is still recommended that all personnel be trained in RF safety when working around or maintaining this type of antenna. Furthermore, it will be stressed that transmitters always be turned off during maintenance in accordance with standard operating procedures.