Radiation Hazard Analysis

SoNY Miralite 3.7m

This analysis predicts the radiation levels around a proposed earth station complex, comprised of one or more aperture (reflector) type antennas. 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/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 an 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 Actual Diameter: 3.7 meters 10.8 meters Antenna Surface Area: Antenna Isotropic Gain: 52.6 dBi Number of Identical Adjacent Antennas: 1 Nominal Antenna Efficiency (ε): 60% Nominal Frequency: 14.25 GHz Nominal Wavelength (λ): 0.0211 meters Maximum Transmit Power / Carrier: 45 Watts

Number of Carriers: 1

Total Transmit Power: 45Watts W/G Loss from Transmitter to Feed: 0.0 dB Total Feed Input Power: 45 Watts

Near Field Limit: $R_{nf} = D^2/4\lambda = 162.5$ meters Far Field Limit: $R_{ff} = 0.6 D^2/\lambda = 390$ meters

Transition Region: R_{nf} to R_{ff}

The Radiation Levels will be increased directly by the number of antennas indicated, on the assumption that all antennas may illuminate the same area.

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. In addition to the input parameters above, input cells are provided below for the user to evaluate the power density at specific distances or angles.

1.0 At the Antenna Surface

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

```
PD_{refl} = 4P/A = 1.674 \text{ mW/cm}^2 (1)
Where: P = \text{total power at feed, milliwatts}
A = \text{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. 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\epsilon P)/(\pi D^2) = 1.004 \text{ mW/cm}^2 (2)
from 0 to 162.5 meters
```

Evaluation

Uncontrolled Environment: Complies to FCC Limits Controlled Environment: Complies to FCC 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_t = (PD_{nf})(R_{nf})/R = dependent on R (3)
where: PD_{nf} = near field power density
```

 R_{nf} = near field distance

R = distance to point of interest

For: 162.5 < R < 390 meters

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

Evaluation

Uncontrolled Environment Safe Operating Distance, (meters), R_{safeu}: 163.3 meters Controlled Environment Safe Operating Distance, (meters), R_{safec}: 32.6 meters

4.0 On-Axis Far-Field Region

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

```
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: $R > R_{\rm ff} = 1396$ meters $PD_{\rm ff} = \textbf{0.430}$ mW/cm² at $R_{\rm ff}$

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

5.0 Off-Axis Levels at the FarField 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 - 25log(\Theta) for \Theta 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 - 25log(1) = 32 - 0 dBi = 1585 numeric

PD_{1 deg off-axis} = PD_{ff}x \ 1585/G = 0.0037 \ mW/cm^2 (5)
```

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-axis)} = PD_{nf} / 100 = 0.01004 \text{ mW/cm}^2 \text{ at D off axis (6)}
```

See Note 1 for the calculation of the distance vs. elevation angle required to achieve this rule for a given object height.

7.0 Region Between the Feed Horn and Sub-reflector

Transmissions from the feed horn are directed toward the subreflector surface, and are confined within a conical shape defined by the feed horn. The energy between the feed horn and subreflector is conceded to be in excess of any limits for maximum permissible exposure. This area will not be accessible to the general public. Operators and technicians have received training specifying this area as a high exposure area. Procedures have been established that will assure that all transmitters are rerouted or turned off before access by maintenance personnel to this area is possible.

8.0 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:

$$S = (D/\sin \alpha) + (2h - D - 2)/(2 \tan \alpha)$$
 (7)
Where: $\alpha = \text{minimum elevation angle of antenna}$
 $D = \text{dish diameter in meters}$

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).

 $\begin{array}{ccc} For & D= & 7.0 \ meters \\ & h= & 2 \ meters \end{array}$ Then: $\begin{array}{ccc} \alpha & S \end{array}$

El Angle	Distance to Safe Area					Distance to Safe Area			
6.5	25.2	m							
20	8.5	m							
25	6.9	m							
30	5.9	m							
35	5.2	m							

Suitable fencing or other barrier is installed to prevent casual occupancy of the area in front of the antenna within the limits prescribed above at the lowest elevation angle required.

9.0 Summary of Results

The table below summarizes all calculations:

Summary of All RadHaz Parameters		SONV M:-	alito 2 7~	
•	Λ h.l	Sony Miralite 3.7m Value Units Formula		
Parameter Dish #	Abbr.	Value Miralite	Units	Formula
Antenna Diameter	Df	3.7	meters	
Antenna Centerline	h	2.4	meters	
Antenna Surface Area	Sa	10.8		(π * D²)/ 4
Antenna Suriace Area Antenna Ground Elevation	GE	0.0		(π · D)/ 4
Frequency of Operation	GE f	14.25	GHz	
Wavelength	2	0.0211		c/f
HPA Output Power	P _{HPA}	45.0		671
·				
HPA to Antenna Loss	L _{tx}	0.0	dB	
Transmit Power at Flange	Р	16.5	dBW	10 * Log(P _{HPA}) - L _{tx}
		45.00	watts	
Antenna Gain	G_{es}	52.6	dBi	
		182911.8	n/a	
PI	π	3.1415927	n/a	
Antenna Aperture Efficiency	eff	60%	n/a	$G_{es} / (PI * Df / \lambda)^2$
1. Reflector Surface Region Calculations				
Reflector Surface Power Density	Was	16.74	W/m ²	(16 * P)/(π * D ²)
Inchesion surface rower behalfy	vvas			(10 F)(// D)
0.0.4 (.1)		1.674	mW/cm ²	
2. On-Axis Near Field Calculations				
Extent of Near Field	Rn	162.57	meters	D ² / (4 * λ)
		533.23	feet	
Near Field Power Density	Wn	10.04	W/m ²	(16 * eff * P)/ (π *D ²)
				, ,
		1.004	mW/cm ²	
3. On-Axis Transition Region Calculations				
	D4	400.57		D ² / (4 2)
Extent of Transition Region (min) Extent of Transition Region (min)	Rtr	162.57	meters feet	$D^2 / (4 \times \lambda)$
<u> </u>		533.23		(1 - 2)
Extent of Transition Region (max)	Rtr	390.17		$(0.6 * D^2) /\lambda$
Extent of Transition Region (max)		1279.74	feet	
Worst Case Transition Region Power Density	Wtr	10.04		(16 * eff * P)/ (π * D ²)
		1.004	mW/cm ²	
Uncontrolled Environment Safe Operating Distance	Rsu	163.29	m	=(Wn)*(Rnf)/Rsu
Controlled Environment Safe Operating Distance	Rsc	32.66	m	=(PDnf)*(Rnf)/Rsc
4. On-Axis Far Field Calculations				() ():
	D.f	200.0		(0.C * D ²) /2
Distance to the Far Field Region	Rf	390.2		$(0.6 * D^2) /\lambda$
		1279.74	feet	
On-Axis Power Density in the Far Field	Wf	4.30	W/m ²	(G _{es} * P) / (4 * π * Rf ²)
		0.430	mW/cm ²	
5. Off-Axis Levels at the Far Field Limit and Beyond				
Reflector Surface Power Density	Ws	0.037	W/m ²	(G _{es} * P) / (4 * π * Rf ²)*(Goa/Ges)
Goa/Ges at example angle θ 1 degree	,	0.009		Goa = 32 - 25*log(θ)
Commission of Gogree		0.003	mW/cm ²	02 20 log(0)
6. Off-axis Power Density in the Near Field and Transitional Reg	one C			
Power density 1/100 of Wn for one diameter removed				//40 + # # D \/ / +D \/ / +D \/ / -
ower density 1/100 or will for one diameter removed	Ws	0.1004		((16 * eff * P)/ (π *D²))/100
		0.01004	mW/cm ²	
7. Region Between Antenna and Ground Calculations				
Reflector Surface Power Density	Ws	4.19	W/m ²	(4 * P)/(π * D ²)
·		0.419	mW/cm ²	
8. Safe Distances from Earth Station		,	,	$S = (D/\sin \alpha) + (2h - D - 2)/(2 \tan \alpha)$
α = minimum elevation angle of antenna		16.5	deg	_ (2, 3, 3, 4, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
h = maximum height of object to be cleared, meters		10.0	m ueg	
elevation angle	6.5	25.2	m	
STOTALIOT GINGIN	20		m	
	25	6.9	m	
	30		m	
	35		m	
Note: Maximum FCC power density limits for 6 GHz is 1 mW/cm ² for general popul				ar ar
FCC OE&T Bulletin No. 65. Edition 97-01 August 1997. Appendix A page 67.	auou/uN	l	osure as pe	51
1 00 OLG 1 Dulletin No. 00, Lutiton 31-01 August 1991, Appendix A page 01.				

Note 1:

Mitigation of the radiation level may take several forms. First, check the distance from the antenna to the nearest potentially occupied area that the antenna could be pointed toward, and compare to the distances appearing in Sections 2, 3 & 4. If those distances lie within the potentially hazardous regions, then the most common solution would be to take steps to insure that the antenna(s) are not capable of being pointed at those areas while RF is being transmitted. This may be accomplished by setting the tracking system to not allow the antenna be pointed below certain elevation angles. Other techniques, such as shielding may also be used effectively.

Radiation Hazard Analysis

SoNY Prodelin 3.8m

This analysis predicts the radiation levels around a proposed earth station complex, comprised of one or more aperture (reflector) type antennas. 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/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 an 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 Actual Diameter: 3.8 meters Antenna Surface Area: 11.3 meters Antenna Isotropic Gain: 53.2 dBi Number of Identical Adjacent Antennas: 1 Nominal Antenna Efficiency (ε): 65% Nominal Frequency: 14.25 GHz Nominal Wavelength (λ): 0.0211 meters Maximum Transmit Power / Carrier: 40.0 Watts

Number of Carriers:

Total Transmit Power:

W/G Loss from Transmitter to Feed:

Total Feed Input Power:

40.00 Watts

0.0 dB

40.00 Watts

Near Field Limit: $R_{nf} = D^2/4\lambda = 171.48$ meters Far Field Limit: $R_{ff} = 0.6 \ D^2/\lambda = 411.5$ meters

Transition Region: R_{nf} to R_{ff}

The Radiation Levels will be increased directly by the number of antennas indicated, on the assumption that all antennas may illuminate the same area.

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. In addition to the input parameters above, input cells are provided below for the user to evaluate the power density at specific distances or angles.

1.0 At the Antenna Surface

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

```
PD_{refl} = 4P/A = 1.411 \text{ mW/cm}^2 (1)
Where: P = \text{total power at feed, milliwatts}
A = \text{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. 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\epsilon P)/(\pi D^2) = 0.917 mW/cm<sup>2</sup> (2) from 0 to 171.48 meters
```

Evaluation

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

```
\begin{array}{ll} PD_t = & (PD_{nf})(R_{nf})/R = dependent \ on \ R \ \ (3) \\ where: & PD_{nf} = near \ field \ power \ density \\ R_{nf} = near \ field \ distance \\ R = distance \ to \ point \ of \ interest \end{array}
```

For: 171.48 < R < 411.54 meters

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

Evaluation

Uncontrolled Environment Safe Operating Distance, (meters), R_{safeu}: 157.25 meters Controlled Environment Safe Operating Distance, (meters), R_{safec}: 31.45 meters

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:

```
\begin{split} PD_{ff} &= PG/(4\pi R^2) = \text{dependent on } R \text{ (4)} \\ \text{where: } P = \text{total power at feed} \\ G &= \text{Numeric Antenna gain in the direction of interest relative to isotropic radiator} \\ R &= \text{distance to the point of interest} \\ \text{For: } R > R_{ff} = 411.5 \text{ meters} \\ PD_{ff} &= \textbf{0.393 mW/cm}^2 \text{ at } R_{ff} \end{split}
```

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}: 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_{\rm off} = 32 - 25log(\Theta)
for \Theta 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 - 25log(1) = 32 - 0 dBi = 1585 numeric

PD_{1 deg off-axis} = PD_{ff}x \ 1585/G = 0.0030 \ mW/cm^2 (5)
```

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-axis)} = PD_{nf} / 100 = 0.00917 \text{ mW/cm}^2 \text{ at D off axis (6)}
```

See Note 1 for the calculation of the distance vs. elevation angle required to achieve this rule for a given object height.

7.0 Region Between the Feed Horn and Sub-reflector

Transmissions from the feed horn are directed toward the subreflector surface, and are confined within a conical shape defined by the feed horn. The energy between the feed horn and subreflector is conceded to be in excess of any limits for maximum permissible exposure. This area will not be accessible to the general public. Operators and technicians have received training specifying this area as a high exposure area. Procedures have been established that will assure that all transmitters are rerouted or turned off before access by maintenance personnel to this area is possible.

8.0 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 =
$$(D/\sin \alpha) + (2h - D - 2)/(2 \tan \alpha)$$
 (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 $h = 2$ meters

Then:

 α S

El Angle	Distance to Safe Area			
6.5	25.7	m		
20	8.6	m		
25	7.1	m		
30	6.0	m		
35	5.3	m		

Suitable fencing or other barrier is installed to prevent casual occupancy of the area in front of the antenna within the limits prescribed above at the lowest elevation angle required.

9.0 Summary of Results

The table below summarizes all calculations:

Summary of All RadHaz Parameters		SoNY Prodelin 3.8m		
Parameter	Abbr.	Value	Units	Formula
Dish#		Miralite		
Antenna Diameter	Df	3.8		
Antenna Centerline	h	2.5		
Antenna Surface Area	Sa	11.3	meters ²	$(\pi * D^2)/4$
Antenna Ground Elevation	GE	0.0		
Frequency of Operation	f	14.25		
Navelength	λ	0.0211	meters	c/f
HPA Output Power	P_{HPA}	40.0	watts	
HPA to Antenna Loss	L_{tx}	0.0	dB	
Fransmit Power at Flange	P	16.0	dBW	10 * Log(P _{HPA}) - L _{tx}
		40.00		
Antenna Gain	G _{es}	53.2	dBi	
Internal Carr	es	209010.2	n/a	
P	π	3.1415927	n/a	
	eff	65%		C //DI * Df / 2)2
Antenna Aperture Efficiency	en	03%	n/a	G _{es} / (PI * Df / λ) ²
I. Reflector Surface Region Calculations				
Reflector Surface Power Density	Was	14.11	W/m ²	(16 * P)/(π * D ²)
		1.411	mW/cm ²	
2. On-Axis Near Field Calculations				
Extent of Near Field	Rn	171.48	meters	D ² / (4 * λ)
_ALGHE OF HEART FICIU	IXII			D / (7 //)
I FUR R "		562.44		(40 t # # D) (t = 2)
Near Field Power Density	Wn	9.17	W/m ²	(16 * eff * P)/ (π *D²)
		0.917	mW/cm ²	
3. On-Axis Transition Region Calculations				
Extent of Transition Region (min)	Rtr	171.48	meters	$D^2/(4 \times \lambda)$
Extent of Transition Region (min)		562.44		
Extent of Transition Region (max)	Rtr	411.54	meters	$(0.6 * D^2) / \lambda$
Extent of Transition Region (max)	1 (1)	1349.85		(0.0 12) ///
Norst Case Transition Region Power Density	Wtr	9.17	W/m ²	(16 * eff * P)/ (π * D ²)
Worst Case Transition Region Fower Density	VVU			(10 ell F) (h D)
	- P	0.917	mW/cm ²	(III.) th (D. A./D.
Uncontrolled Environment Safe Operating Distance	Rsu	157.25	m	=(Wn)*(Rnf)/Rsu
Controlled Environment Safe Operating Distance	Rsc	31.45	m	=(PDnf)*(Rnf)/Rsc
4. On-Axis Far Field Calculations				
Distance to the Far Field Region	Rf	411.5	meters	(0.6 * D ²) /λ
		1349.85		(5.5 =),
On-Axis Power Density in the Far Field	Wf	3.93	2	(G _{es} * P) / (4 * π * Rf ²)
on the bolisty in the fair lold	V V I			(Oes 1)/(4 // 101)
		0.393	mW/cm ²	
5. Off-Axis Levels at the Far Field Limit and Beyond				
Reflector Surface Power Density	Ws	0.030	W/m ²	(G _{es} * P) / (4 * π * Rf ²)*(Goa/Ges)
Goa/Ges at example angle θ 1 degree		0.008		Goa = $32 - 25*log(\theta)$
		0.0030	mW/cm ²	
6. Off-axis Power Density in the Near Field and Transitional R	s			
Power density 1/100 of Wn for one diameter removed	Ws	0.0917	W/m ²	((16 * eff * P)/ (π *D²))/100
	.,,	0.00917	mW/cm ²	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,
7 Region Retween Antonna and Ground Calculations		0.00317	IIIVV/CIII	
7. Region Between Antenna and Ground Calculations			2	
Reflector Surface Power Density	Ws	3.53	W/m ²	(4 * P)/(π * D ²)
		0.353	mW/cm ²	
3. Safe Distances from Earth Station				$S = (D/\sin \alpha) + (2h - D - 2)/(2 \tan \alpha)$
α = minimum elevation angle of antenna		16.5	deg	
n = maximum height of object to be cleared, meters		2	m	
elevation angle	16.5	10.3	m	
	20	8.6	m	
	25	7.1	m	
	30	6.0	m	
	35	5.3	m	
2				
Note: Maximum FCC power density limits for 6 GHz is 1 mW/cm ² for general po	pulation/un	controlled ext	osure as pe	er

Note 1:

Mitigation of the radiation level may take several forms. First, check the distance from the antenna to the nearest potentially occupied area that the antenna could be pointed toward, and compare to the distances appearing in Sections 2, 3 & 4. If those distances lie within the potentially hazardous regions, then the most common solution would be to take steps to insure that the antenna(s) are not capable of being pointed at those areas while RF is being transmitted. This may be accomplished by setting the tracking system to not allow the antenna be pointed below certain elevation angles. Other techniques, such as shielding may also be used effectively.

Radiation Hazard Analysis

SoNY S-A 7m

This analysis predicts the radiation levels around a proposed earth station complex, comprised of one or more aperture (reflector) type antennas. 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/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 an 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 Actual Diameter: 7.0 meters Antenna Surface Area: 38.5 meters Antenna Isotropic Gain: 58 dBi Number of Identical Adjacent Antennas: 2 Nominal Antenna Efficiency (ε): 58% Nominal Frequency: 14.25 GHz Nominal Wavelength (λ): 0.0211 meters Maximum Transmit Power / Carrier: 112 Watts

Number of Carriers:

Total Transmit Power:

W/G Loss from Transmitter to Feed:

Total Feed Input Power:

112 Watts

0.0 dB

112 Watts

Near Field Limit: $R_{nf} = D^2/4\lambda = 581$ meters Far Field Limit: $R_{ff} = 0.6 \ D^2/\lambda = 1396$ meters

Transition Region: R_{nf} to R_{ff}

The Radiation Levels will be increased directly by the number of antennas indicated, on the assumption that all antennas may illuminate the same area.

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. In addition to the input parameters above, input cells are provided below for the user to evaluate the power density at specific distances or angles.

1.0 At the Antenna Surface

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

```
PD_{refl} = 4P/A = 1.164 \text{ 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. 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\epsilon P)/(\pi D^2) = 0.675 mW/cm<sup>2</sup> (2) from 0 to 581 meters
```

Evaluation

Uncontrolled Environment: Complies to FCC Limits Controlled Environment: Complies to FCC 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_t = (PD_{nf})(R_{nf})/R = dependent on R (3)
where: PD_{nf} = near field power density
```

 R_{nf} = near field distance

R = distance to point of interest

For: 581 < R < 1396 meters

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

Evaluation

```
Uncontrolled Environment Safe Operating Distance, (meters), R<sub>safeu</sub>: 392 meters Controlled Environment Safe Operating Distance, (meters), R<sub>safec</sub>: 78.5 meters
```

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:

```
\begin{split} PD_{ff} &= PG/(4\pi R^2) = \text{dependent on } R \text{ (4)} \\ \text{where: } P = \text{total power at feed} \\ G &= \text{Numeric Antenna gain in the direction of interest relative to isotropic radiator} \\ R &= \text{distance to the point of interest} \\ \text{For: } R > R_{ff} = 1396 \text{ meters} \\ PD_{ff} &= \textbf{0.289} \text{ mW/cm}^2 \text{ at } R_{ff} \end{split}
```

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

5.0 Off-Axis Levels at the FarField 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 - 25log(\Theta) for \Theta 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 - 25log(1) = 32 - 0 dBi = 1585 numeric

PD_{1 deg off-axis} = PD_{ff}x \ 1585/G = 0.0007 mW/cm^{2} (5)
```

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-axis)} = PD_{nf} / 100 = 0.00675 \text{ mW/cm}^2 \text{ at D off axis (6)}
```

See Note 1 for the calculation of the distance vs. elevation angle required to achieve this rule for a given object height.

7.0 Region Between the Feed Horn and Sub-reflector

Transmissions from the feed horn are directed toward the subreflector surface, and are confined within a conical shape defined by the feed horn. The energy between the feed horn and subreflector is conceded to be in excess of any limits for maximum permissible exposure. This area will not be accessible to the general public. Operators and technicians have received training specifying this area as a high exposure area. Procedures have been established that will assure that all transmitters are rerouted or turned off before access by maintenance personnel to this area is possible.

8.0 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:

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

Where: $\alpha = \text{minimum elevation angle of antenna}$

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
$$D = 7.0$$
 meters $h = 2$ meters

Then:

 α S

El Angle	Distance to Safe Area					Distance to Safe Area			
6.5	39.9	m							
20	13.6	m							
25	11.2	m							
30	9.7	m							
35	8.6	m							

Suitable fencing or other barrier is installed to prevent casual occupancy of the area in front of the antenna within the limits prescribed above at the lowest elevation angle required.

9.0 Summary of Results

The table below summarizes all calculations:

Parameter	Common of All Dodlice Deven		C-NV C A	7	·
Dish of Maralles	Summary of All RadHaz Parameters	A 1- 1			r
Antenna Carenterine Antenna Surface Area Antenna Aperture Efficiency ### ### ### ### ### ### ### ### ### #		Abbr.		Units	Formula
Anterina Genterline h		Df		matara	
Antenens Grante Area Antenens Grante Bewatton Firequency of Operation Firequen					
Antenna Grund Elevation GE		1			(- * D ²)/ 4
1 14.25 GHz		_			(π D)/4
Wavelength A		f			
IRPA DUALP Dever P_HPA	· · · ·	λ			c/f
HPA to Antenna Loss	-	Pupa			
P		T	1		
Antenna Gain Ges		_	1		10 * Log/D) L
Antenna Gain G _{cc} 58.0 dBi	Transmit Power at Flange	P			10 LOg(P _{HPA}) - L _{tx}
Pi	Antonna Cain	-			
1.	Antenna Gain	G _{es}			
Antenna Aperture Efficiency 1. Reflector Surface Region Calculations Was 11.64 W/m² (16 * P)/(π * D² / 2 2. On-Axis Near Field Calculations Extent of Near Field Power Density Near Field Power Density 3. On-Axis Transition Region (min) Extent of Transition Region (max) Work 1 1986.55 feet Settlent of Transition Region (max) Work 2 1986.50 meters (0.6 * D² / 0.4 * X.) Extent of Transition Region (max) Work 2 1986.50 meters (0.6 * D² / 0.4 * X.) Extent of Transition Region (max) Work Case Transition Region (max) Work Case Transition Region (max) Uncontrolled Environment Safe Operating Distance Controlled Environment Safe Operating Distance Rescurrence Rescurrence Rescurrence Controlled Environment Safe Operating Distance Rescurrence Resc	DI .	_			
1. Reflector Surface Region Calculations Was		_			C //DI * Df / 1) ²
Reflector Surface Power Density Was		еп	58%	n/a	G _{es} / (PI " DI / λ)
1.164 mW/cm²	-				
2. On-Axis Near Field Calculations	Reflector Surface Power Density	Was	11.64		(16 * P)/(π * D ²)
Extent of Near Field Rn 581.88 meters D² / (4 * λ)			1.164	mW/cm ²	
1908.55 feet	2. On-Axis Near Field Calculations				
1908.55 feet	Extent of Near Field	Rn	581.88	meters	$D^2/(4*\lambda)$
Near Field Power Density Wn 6.75 W/m² (16 * eff * P) / (π * D²)			1908.55		,
3. On-Axis Transition Region Calculations	Near Field Power Density	Wn	6.75		(16 * eff * P)/ (π *D²)
3. On-Axis Transition Region Calculations Extent of Transition Region (min) Extent of Transition Region (min) Extent of Transition Region (min) Extent of Transition Region (max) Rtr 1396.50 Wurb 4580.52 feet Worst Case Transition Region Power Density Wtr 6.75 Wurb 0.675 0.775 0.775 0.775 0.775 0.775 0.775 0.775 0.775 0.775 0.775 0.775 0.775 0.775	Trodi Flora Fortor Borlony		0.70	**/!!!	(10 611 1); (1. 12)
3. On-Axis Transition Region Calculations Extent of Transition Region (min) Extent of Transition Region (min) Extent of Transition Region (min) Extent of Transition Region (max) Rtr 1396.50 Wurb 4580.52 feet Worst Case Transition Region Power Density Wtr 6.75 Wurb 0.675 0.775 0.775 0.775 0.775 0.775 0.775 0.775 0.775 0.775 0.775 0.775 0.775 0.775			0.675	mW/cm ²	
Extent of Transition Region (min) Extent of Transition Region (min) Extent of Transition Region (min) Extent of Transition Region (max) Worst Case Transition Region Power Density With 6.75 W/m² Uncontrolled Environment Safe Operating Distance Rsu 392.87 m = (Wn)*(Rnf)*/Rsu Controlled Environment Safe Operating Distance Rsc 78.57 m = (PDnf)*(Rnf)*/Rsc 4. On-Axis Far Field Calculations Distance to the Far Field Region Rf 1396.5 meters (0.6 * D²) /λ. Extent of Transition Region (max) Wifh 2.89 W/m² (16 * eff * P)/ (π * D²) meters (0.6 * D²) /λ. Extent of Transition Region (max) (16 * eff * P)/ (π * D²) meters (0.6 * D²) /λ. Extent of Transition Region (max) (16 * eff * P)/ (π * D²) meters (16 * eff * P)/ (π * D²) meters (18 * deg * P) / (4 * π * Rf²) (18 * eff * P)/ (π * D²) meters (18 * eff * P)/ (π * D²) meters (18 * eff * P)/ (π * P²) meters (18 * eff * P)/ (π * P²) meters (18 * eff * P)/ (π * P²) meters (18 * eff * P)/ (π * P²) meters (18 * eff * P)/ (π * P²) meters (18 * eff * P)/ (π * Rnf)/Rsu (18 * eff * P)/ (π * P²) meters (18 * eff * P)/ (π * Rnf)/Rsu (18 * eff	3 On-Axis Transition Region Calculations		0.070	1114470111	
Extent of Transition Region (min)		Dtr	E01 00	matara	$D^2/(4\times 2)$
Extent of Transition Region (max) Extent of Transition Region (max) Extent of Transition Region (max) Worst Case Transition Region Power Density Worst Case Transition Region Power Density Uncontrolled Environment Safe Operating Distance Rsu 392.87 m = (Wn)*(Rnf)/Rsu = (PDnf)*(Rnf)/Rsc Controlled Environment Safe Operating Distance Rsc 78.57 m = (PDnf)*(Rnf)/Rsc 4. On-Axis Far Field Calculations Distance to the Far Field Region Rf 1396.5 meters (0.6 * D²) //. 4580.52 feet On-Axis Power Density in the Far Field Wf 2.89 W/m² (Gee*P) / (4 * π * Rf²) 5. Off-Axis Levels at the Far Field Limit and Beyond Reflector Surface Power Density Ws 0.007 W/m² (Gee*P) / (4 * π * Rf²)*(Goa/Ges) Goa = 32 - 25*log(θ) 6. Off-axis Power Density in the Near Field and Transitional Regions Calculations Power density 1/100 of Wn for one diameter removed Ws 0.067s W/m² ((16 * eff * P y (π * D²))/100 0.0087s Reflector Surface Power Density Ws 0.067s W/m² (4 * P)/(π * D²)/(100 0.0087s Reflector Surface Power Density in the Near Field and Transitional Regions Calculations Reflector Surface Power Density in the Near Field and Transitional Regions Calculations Reflector Surface Power Density in the Near Field and Transitional Regions Calculations Reflector Surface Power Density in the Near Field and Transitional Regions Calculations Reflector Surface Power Density 8. Safe Distances from Earth Station a = minimum elevation angle of antenna h = maximum height of object to be cleared, meters elevation angle 6. 5 39.9 m elevation angle 16.5 deg 17. m 18. Safe Distances from Earth Station 2 m 30 9.7 m 30 9.7 m Note: Maximum FCC power density limits for 6 GHz is 1 mW/cm² for general population/uncontrolled exposure as per	0 \ /	RII			D / (4 x λ)
Extent of Transition Region (max) 4580.52 feet	<u> </u>	D4			(0.C * D ²) (0.
Worst Case Transition Region Power Density Wtr 0.75 0.675 mW/cm² (16 * eff * P)/ (π * D²)		RII			(0.6 ° D) //.
Uncontrolled Environment Safe Operating Distance Rsu 392.87 m = (Wn)*(Rnf)/Rsu	<u> </u>	1			(40 + 55 + 5)(4 + 52)
Uncontrolled Environment Safe Operating Distance Rsu 392.87 m =(Wn)*(Rnf)/Rsu Controlled Environment Safe Operating Distance Rsc 78.57 m =(PDnf)*(Rnf)/Rsc 4. On-Axis Far Field Calculations n 1396.5 meters (0.6 * D²) /λ. Distance to the Far Field Region Rf 1396.5 meters (0.6 * D²) /λ. On-Axis Power Density in the Far Field Wf 2.89 W/m² (G₀s * P) / (4 * π * Rf²) 5. Off-Axis Levels at the Far Field Limit and Beyond ws 0.007 W/m² (G₀s * P) / (4 * π * Rf²)*(Goa/Ges) Goa/Ges at example angle θ 1 degree 0.003 Goa = 32 - 25*log(θ) Goa = 32 - 25*log(θ) 6. Off-axis Power Density in the Near Field and Transitional Regions Calculations ws 0.0675 w/m² ((16 * eff * P)/ (π * D²))/(100 7. Region Between Antenna and Ground Calculations ws 0.995 mW/cm² (4 * P)/(π * D²) 8. Safe Distances from Earth Station s = (D/ sin α) + (2h - D - 2)/(2 tan α) s = (D/ sin α) + (2h - D - 2)/(2 tan α) α = minimum elevation angle of antenna 16.5 39.9 m h = maximum he	Worst Case Transition Region Power Density	Wtr			
Controlled Environment Safe Operating Distance Rsc 78.57 m =(PDnf)*(Rnf)/Rsc					
A. On-Axis Far Field Calculations Rf 1396.5 meters (0.6 * D²) /λ	Uncontrolled Environment Safe Operating Distance	Rsu	392.87	m	
Distance to the Far Field Region Rf 1396.5 meters (0.6 * D²) /λ 4580.52 feet	Controlled Environment Safe Operating Distance	Rsc	78.57	m	=(PDnf)*(Rnf)/Rsc
A 580.52 feet	4. On-Axis Far Field Calculations				
On-Axis Power Density in the Far Field Wf 2.89 W/m² (Ges*P) / (4*π*Rf²)	Distance to the Far Field Region	Rf	1396.5	meters	(0.6 * D ²) /λ
0.289 mW/cm² 1	•		4580.52	feet	,
0.289 mW/cm²	On-Axis Power Density in the Far Field	Wf	2.89	W/m ²	(G _{ee} * P) / (4 * π * Rf ²)
Solf-Axis Levels at the Far Field Limit and Beyond Sefector Surface Power Density Ws 0.007 W/m² (Ges * P) / (4 * π * Rr²)*(Goa/Ges)	•		1		(-63 /- (/
Reflector Surface Power Density Ws 0.007 W/m² (Ges * P) / (4 * π * Rf²)*(Goa/Ges)	5 Off-Axis Levels at the Far Field Limit and Revond		0.200	1111170111	
Goa/Ges at example angle θ 1 degree 0.003 Goa = 32 - 25*log(θ)		101	0.007	\\//m ²	(0 + D) / (4 + + D) (2) + (0 - 1)
0.0007 mW/cm²	·	VVS		VV/III	
Solution Power Density in the Near Field and Transitional Regions Calculations	Goa/Ges at example angle # 1 degree		+	2	Goa = 32 - 25*log(θ)
Power density 1/100 of Wn for one diameter removed Ws 0.0675 W/m² ((16 * eff * P)/ (π *D²))/100 0.00675 mW/cm² (16 * eff * P)/ (π *D²))/100 0.00675 mW/cm² (16 * eff * P)/ (π *D²))/100 0.00675 mW/cm² (4 * P)/(π * D²) (1 * P)/(π * P)/(π * D²) (1 * P)/(π * P)	C. Off avia Dawar Danaity in the Near Field and Transitional Da	, ,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,			
Companies Com			ı	_	
7. Region Between Antenna and Ground Calculations	Power density 1/100 of Wn for one diameter removed	Ws			((16 * eff * P)/ (π *D²))/100
Reflector Surface Power Density Ws 2.91 W/m^2 $(4*P)/(\pi*D^2)$ 8. Safe Distances from Earth Station α = minimum elevation angle of antenna h = maximum height of object to be cleared, meters elevation angle 6.5 39.9 m elevation angle 20 13.6 m 25 11.2 m Note: Maximum FCC power density limits for 6 GHz is 1 mW/cm² for general population/uncontrolled exposure as per			0.00675	mW/cm ²	
0.291 mW/cm²	7. Region Between Antenna and Ground Calculations				
8. Safe Distances from Earth Station S = (D/ sin α) + (2h - D - 2)/(2 tan α) α = minimum elevation angle of antenna 16.5 deg h = maximum height of object to be cleared, meters 2 m elevation angle 6.5 39.9 m 20 13.6 m 25 11.2 m 30 9.7 m Note: Maximum FCC power density limits for 6 GHz is 1 mW/cm² for general population/uncontrolled exposure as per	Reflector Surface Power Density	Ws	2.91	W/m ²	(4 * P)/(π * D ²)
8. Safe Distances from Earth Station S = (D/ sin α) + (2h - D - 2)/(2 tan α) α = minimum elevation angle of antenna 16.5 deg h = maximum height of object to be cleared, meters 2 m elevation angle 6.5 39.9 m 20 13.6 m 25 11.2 m 30 9.7 m Note: Maximum FCC power density limits for 6 GHz is 1 mW/cm² for general population/uncontrolled exposure as per			0.291	mW/cm ²	
Calcar = minimum elevation angle of antenna 16.5 deg	8. Safe Distances from Earth Station				
h = maximum height of object to be cleared, meters			16.5	dea	(, (
elevation angle 6.5 39.9 m	h = maximum height of object to be cleared, meters		2		
20 13.6 m 25 11.2 m 30 9.7 m 35 8.6 m Note: Maximum FCC power density limits for 6 GHz is 1 mW/cm² for general population/uncontrolled exposure as per	elevation angle	6.5	39.9		
25					_
35 8.6 m Note: Maximum FCC power density limits for 6 GHz is 1 mW/cm² for general population/uncontrolled exposure as per		25	11.2	m	
Note: Maximum FCC power density limits for 6 GHz is 1 mW/cm ² for general population/uncontrolled exposure as per				m	
FCC OE&T Bulletin No. 65, Edition 97-01 August 1997, Appendix A page 67.		ulation/un	controlled exp	osure as p	er
	FCC OE&T Bulletin No. 65, Edition 97-01 August 1997, Appendix A page 67.				

Note 1:

Mitigation of the radiation level may take several forms. First, check the distance from the antenna to the nearest potentially occupied area that the antenna could be pointed toward, and compare to the distances appearing in Sections 2, 3 & 4. If those distances lie within the potentially hazardous regions, then the most common solution would be to take steps to insure that the antenna(s) are not capable of being pointed at those areas while RF is being transmitted. This may be accomplished by setting the tracking system to not allow the antenna be pointed below certain elevation angles. Other techniques, such as shielding may also be used effectively.