# EXHIBIT FOR SEA TEL RADIATION HAZARD REPORTS

INCLUDES RADIATION HAZARD REPORTS FOR :

SEA TEL Model 9797 ANTENNA WITH 8 WATT BUC

SEA TEL Model 9797 ANTENNA WITH 16 WATT BUC

SEA TEL Model 9797 ANTENNA WITH 40 WATT BUC

SEA TEL Model USAT-30 and 3011 WITH 8 WATT BUC

1

9797 with 8watt BUC



# Analysis of Non-Ionizing Radiation for a 2.4-Meter Earth Station System

This report analyzes the non-ionizing radiation levels for a 2.4-meter earth station system. The analysis and calculations performed in this report comply with the methods described in the FCC Office of Engineering and Technology Bulletin, No. 65 first published in 1985 and revised in 1997 in Edition 97-01. The radiation safety limits used in the analysis are in conformance with the FCC R&O 96-326. Bulletin No. 65 and the FCC R&O specifies that there are two separate tiers of exposure limits that are dependant on the situation in which the exposure takes place and/or the status of the individuals who are subject to the exposure. The Maximum Permissible Exposure (MPE) limits for persons in a General Population/Uncontrolled environment are shown in Table 1. The General Population/Uncontrolled MPE is a function of transmit frequency and is for an exposure period of thirty minutes or less. The MPE limits for persons in an Occupational/Controlled environment are shown in Table 2. The Occupational MPE is a function of transmit frequency and is for an exposure period of six minutes or less. The purpose of the analysis described in this report is to determine the power flux density levels of the earth station in the far-field, near-field, transition region, between the subreflector or feed and main reflector surface, at the main reflector surface, and between the antenna edge and the ground and to compare these levels to the specified MPEs.

Table 1. Limits for General Population/Uncontrolled Exposure (MPE)

| Frequency Range (MHz) | Power Density (mW/cm$^2$) |
|---|---|
| 30-300 | 0.2 |
| 300-1500 | Frequency (MHz)*(0.8/1200) |
| 1500-100,000 | 1.0 |

Table 2. Limits for Occupational/Controlled Exposure (MPE)

| Frequency Range (MHz) | Power Density (mW/cm$^2$) |
|---|---|
| 30-300 | 1.0 |
| 300-1500 | Frequency (MHz)*(4.0/1200) |
| 1500-100,000 | 5.0 |

Table 3. Formulas and Parameters Used for Determining Power Flux Densities

| Parameter | Symbol | Formula | Value | Units |
|---|---|---|---|---|
| Antenna Diameter | D | Input | 2.4 | m |
| Antenna Surface Area | $A_{surface}$ | $\pi D^2 / 4$ | 4.52 | m$^2$ |
| Feed Flange Diameter | $D_{fa}$ | Input | 19.0 | cm |
| Area of Feed Flange | $A_{fa}$ | $\pi D_{fa}{}^2/4$ | 283.53 | cm$^2$ |
| Frequency | F | Input | 14250 | MHz |
| Wavelength | $\lambda$ | 300 / F | 0.021053 | m |
| Transmit Power | P | Input | 6.73 | W |
| Antenna Gain (dBi) | $G_{es}$ | Input | 48.4 | dBi |
| Antenna Gain (factor) | G | $10^{Ges/10}$ | 69183.1 | n/a |
| Pi | $\pi$ | Constant | 3.1415927 | n/a |
| Antenna Efficiency | $\eta$ | $G\lambda^2/(\pi^2 D^2)$ | 0.54 | n/a |

## 1. Far Field Distance Calculation

The distance to the beginning of the far field can be determined from the following equation:

Distance to the Far Field Region $R_{ff} = 0.60\ D^2 / \lambda$ (1)
$= 164.2$ m

The maximum main beam power density in the far field can be determined from the following equation:

On-Axis Power Density in the Far Field $S_{ff} = G\ P / (4\ \pi\ R_{ff}^2)$ (2)
$= 1.375$ W/m$^2$
$= 0.137$ mW/cm$^2$

## 2. Near Field Calculation

Power flux density is considered to be at a maximum value throughout the entire length of the defined Near Field region. The region is contained within a cylindrical volume having the same diameter as the antenna. Past the boundary of the Near Field region, the power density from the antenna decreases linearly with respect to increasing distance.

The distance to the end of the Near Field can be determined from the following equation:

Extent of the Near Field $R_{nf} = D^2 / (4\ \lambda)$ (3)
$= 68.4$ m

The maximum power density in the Near Field can be determined from the following equation:

Near Field Power Density $S_{nf} = 16.0\ \eta\ P / (\pi\ D^2)$ (4)
$= 3.210$ W/m$^2$
$= 0.321$ mW/cm$^2$

## 3. Transition Region Calculation

The Transition region is located between the Near and Far Field regions. The power density begins to decrease linearly with increasing distance in the Transition region. While the power density decreases inversely with distance in the Transition region, the power density decreases inversely with the square of the distance in the Far Field region. The maximum power density in the Transition region will not exceed that calculated for the Near Field region. The power density calculated in Section 1 is the highest power density the antenna can produce in any of the regions away from the antenna. The power density at a distance $R_t$ can be determined from the following equation:

Transition Region Power Density $S_t = S_{nf}\ R_{nf} / R_t$ (5)
$= 0.321$ mW/cm$^2$

## 4. Region between the Feed Assembly and the Antenna Reflector

Transmissions from the feed assembly are directed toward the antenna reflector surface, and are confined within a conical shape defined by the type of feed assembly. The most common feed assemblies are waveguide flanges, horns or subreflectors. The energy between the feed assembly and reflector surface can be calculated by determining the power density at the feed assembly surface. This can be determined from the following equation:

Power Density at the Feed Flange $S_{fa} = 4000\ P / A_{fa}$ (6)
$= 94.946\ mW/cm^2$

## 5. Main Reflector Region

The power density in the main reflector is determined in the same manner as the power density at the feed assembly. The area is now the area of the reflector aperture and can be determined from the following equation:

Power Density at the Reflector Surface $S_{surface} = 4\ P / A_{surface}$ (7)
$= 5.951\ W/m^2$
$= 0.595\ mW/cm^2$

## 6. Region between the Reflector and the Ground

Assuming uniform illumination of the reflector surface, the power density between the antenna and the ground can be determined from the following equation:

Power Density between Reflector and Ground $S_g = P / A_{surface}$ (8)
$= 1.488\ W/m^2$
$= 0.149\ mW/cm^2$

## 7. Summary of Calculations

Table 4. Summary of Expected Radiation levels for Uncontrolled Environment

| Region | Calculated Maximum Radiation Power Density Level (mW/cm²) | | Hazard Assessment |
|---|---|---|---|
| 1. Far Field ($R_{ff}$ = 164.2 m) | $S_{ff}$ | 0.137 | Satisfies FCC MPE |
| 2. Near Field ($R_{nf}$ = 68.4 m) | $S_{nf}$ | 0.321 | Satisfies FCC MPE |
| 3. Transition Region ($R_{nf} < R_t < R_{ff}$) | $S_t$ | 0.321 | Satisfies FCC MPE |
| 4. Between Feed Assembly and Antenna Reflector | $S_{fa}$ | 94.946 | Potential Hazard |
| 5. Main Reflector | $S_{surface}$ | 0.595 | Satisfies FCC MPE |
| 6. Between Reflector and Ground | $S_g$ | 0.149 | Satisfies FCC MPE |

Table 5. Summary of Expected Radiation levels for Controlled Environment

| Region | Calculated Maximum Radiation Power Density Level (mW/cm²) | | Hazard Assessment |
|---|---|---|---|
| 1. Far Field ($R_{ff}$ = 164.2 m) | $S_{ff}$ | 0.137 | Satisfies FCC MPE |
| 2. Near Field ($R_{nf}$ = 68.4 m) | $S_{nf}$ | 0.321 | Satisfies FCC MPE |
| 3. Transition Region ($R_{nf} < R_t < R_{ff}$) | $S_t$ | 0.321 | Satisfies FCC MPE |
| 4. Between Feed Assembly and Antenna Reflector | $S_{fa}$ | 94.946 | Potential Hazard |
| 5. Main Reflector | $S_{surface}$ | 0.595 | Satisfies FCC MPE |
| 6. Between Reflector and Ground | $S_g$ | 0.149 | Satisfies FCC MPE |

It is the applicant's responsibility to ensure that the public and operational personnel are not exposed to harmful levels of radiation.

## 8. 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 earth station's operating personnel. The transmitter will be turned off during antenna maintenance so that the FCC MPE of 5.0 mW/cm2 will be complied with for those regions with close proximity to the reflector that exceed acceptable levels.

The applicant agrees to abide by the conditions specified in Condition 5208 provided below:

*Condition 5208 - The licensee shall take all necessary measures to ensure that the antenna does not create potential exposure of humans to radiofrequency radiation in excess of the FCC exposure limits defined in 47 CFR 1.1307(b) and 1.1310 wherever such exposures might occur. Measures must be taken to ensure compliance with limits for both occupational/controlled exposure and for general population/uncontrolled exposure, as defined in these rule sections. Compliance can be accomplished in most cases by appropriate restrictions such as fencing. Requirements for restrictions can be determined by predictions based on calculations, modeling or by field measurements. The FCC's OET Bulletin 65 (available on-line at www.fcc.gov/oet/rfsafety) provides information on predicting exposure levels and on methods for ensuring compliance, including the use of warning and alerting signs and protective equipment for worker.*

9797 with 16 watt BUC



# Analysis of Non-Ionizing Radiation for a 2.4-Meter Earth Station System

This report analyzes the non-ionizing radiation levels for a 2.4-meter earth station system. The analysis and calculations performed in this report comply with the methods described in the FCC Office of Engineering and Technology Bulletin, No. 65 first published in 1985 and revised in 1997 in Edition 97-01. The radiation safety limits used in the analysis are in conformance with the FCC R&O 96-326. Bulletin No. 65 and the FCC R&O specifies that there are two separate tiers of exposure limits that are dependant on the situation in which the exposure takes place and/or the status of the individuals who are subject to the exposure. The Maximum Permissible Exposure (MPE) limits for persons in a General Population/Uncontrolled environment are shown in Table 1. The General Population/Uncontrolled MPE is a function of transmit frequency and is for an exposure period of thirty minutes or less. The MPE limits for persons in an Occupational/Controlled environment are shown in Table 2. The Occupational MPE is a function of transmit frequency and is for an exposure period of six minutes or less. The purpose of the analysis described in this report is to determine the power flux density levels of the earth station in the far-field, near-field, transition region, between the subreflector or feed and main reflector surface, at the main reflector surface, and between the antenna edge and the ground and to compare these levels to the specified MPEs.

Table 1. Limits for General Population/Uncontrolled Exposure (MPE)

| Frequency Range (MHz) | Power Density ($mW/cm^2$) |
|---|---|
| 30-300 | 0.2 |
| 300-1500 | Frequency (MHz)*(0.8/1200) |
| 1500-100,000 | 1.0 |

Table 2. Limits for Occupational/Controlled Exposure (MPE)

| Frequency Range (MHz) | Power Density ($mW/cm^2$) |
|---|---|
| 30-300 | 1.0 |
| 300-1500 | Frequency (MHz)*(4.0/1200) |
| 1500-100,000 | 5.0 |

Table 3. Formulas and Parameters Used for Determining Power Flux Densities

| Parameter | Symbol | Formula | Value | Units |
|---|---|---|---|---|
| Antenna Diameter | $D$ | Input | 2.4 | m |
| Antenna Surface Area | $A_{surface}$ | $\pi D^2 / 4$ | 4.52 | $m^2$ |
| Feed Flange Diameter | $D_{fa}$ | Input | 19.0 | cm |
| Area of Feed Flange | $A_{fa}$ | $\pi D_{fa}{}^2/4$ | 283.53 | $cm^2$ |
| Frequency | $F$ | Input | 14250 | MHz |
| Wavelength | $\lambda$ | $300 / F$ | 0.021053 | m |
| Transmit Power | $P$ | Input | 13.46 | W |
| Antenna Gain (dBi) | $G_{es}$ | Input | 48.4 | dBi |
| Antenna Gain (factor) | $G$ | $10^{Ges/10}$ | 69183.1 | n/a |
| Pi | $\pi$ | Constant | 3.1415927 | n/a |
| Antenna Efficiency | $\eta$ | $G\lambda^2/(\pi^2 D^2)$ | 0.54 | n/a |

## 1. Far Field Distance Calculation

The distance to the beginning of the far field can be determined from the following equation:

Distance to the Far Field Region $R_{ff} = 0.60\ D^2 / \lambda$ (1)
$= 164.2$ m

The maximum main beam power density in the far field can be determined from the following equation:

On-Axis Power Density in the Far Field $S_{ff} = G\ P / (4\ \pi\ R_{ff}^2)$ (2)
$= 2.750\ W/m^2$
$= 0.275\ mW/cm^2$

## 2. Near Field Calculation

Power flux density is considered to be at a maximum value throughout the entire length of the defined Near Field region. The region is contained within a cylindrical volume having the same diameter as the antenna. Past the boundary of the Near Field region, the power density from the antenna decreases linearly with respect to increasing distance.

The distance to the end of the Near Field can be determined from the following equation:

Extent of the Near Field $R_{nf} = D^2 / (4\ \lambda)$ (3)
$= 68.4$ m

The maximum power density in the Near Field can be determined from the following equation:

Near Field Power Density $S_{nf} = 16.0\ \eta\ P / (\pi\ D^2)$ (4)
$= 6.419\ W/m^2$
$= 0.642\ mW/cm^2$

## 3. Transition Region Calculation

The Transition region is located between the Near and Far Field regions. The power density begins to decrease linearly with increasing distance in the Transition region. While the power density decreases inversely with distance in the Transition region, the power density decreases inversely with the square of the distance in the Far Field region. The maximum power density in the Transition region will not exceed that calculated for the Near Field region. The power density calculated in Section 1 is the highest power density the antenna can produce in any of the regions away from the antenna. The power density at a distance $R_t$ can be determined from the following equation:

Transition Region Power Density $S_t = S_{nf}\ R_{nf} / R_t$ (5)
$= 0.642\ mW/cm^2$

## 4. Region between the Feed Assembly and the Antenna Reflector

Transmissions from the feed assembly are directed toward the antenna reflector surface, and are confined within a conical shape defined by the type of feed assembly. The most common feed assemblies are waveguide flanges, horns or subreflectors. The energy between the feed assembly and reflector surface can be calculated by determining the power density at the feed assembly surface. This can be determined from the following equation:

Power Density at the Feed Flange $S_{fa} = 4000\ P / A_{fa}$ (6)
$= 189.893\ mW/cm^2$

## 5. Main Reflector Region

The power density in the main reflector is determined in the same manner as the power density at the feed assembly. The area is now the area of the reflector aperture and can be determined from the following equation:

Power Density at the Reflector Surface $S_{surface} = 4\ P / A_{surface}$ (7)
$= 11.901\ W/m^2$
$= 1.190\ mW/cm^2$

## 6. Region between the Reflector and the Ground

Assuming uniform illumination of the reflector surface, the power density between the antenna and the ground can be determined from the following equation:

Power Density between Reflector and Ground $S_g = P / A_{surface}$ (8)
$= 2.975\ W/m^2$
$= 0.298\ mW/cm^2$

## 7. Summary of Calculations

Table 4. Summary of Expected Radiation levels for Uncontrolled Environment

| Region | Calculated Maximum Radiation Power Density Level ($mW/cm^2$) | | Hazard Assessment |
|---|---|---|---|
| 1. Far Field ($R_{ff}$ = 164.2 m) | $S_{ff}$ | 0.275 | Satisfies FCC MPE |
| 2. Near Field ($R_{nf}$ = 68.4 m) | $S_{nf}$ | 0.642 | Satisfies FCC MPE |
| 3. Transition Region ($R_{nf}$ < $R_t$ < $R_{ff}$) | $S_t$ | 0.642 | Satisfies FCC MPE |
| 4. Between Feed Assembly and Antenna Reflector | $S_{fa}$ | 189.893 | Potential Hazard |
| 5. Main Reflector | $S_{surface}$ | 1.190 | Potential Hazard |
| 6. Between Reflector and Ground | $S_g$ | 0.298 | Satisfies FCC MPE |

Table 5. Summary of Expected Radiation levels for Controlled Environment

| Region | Calculated Maximum Radiation Power Density Level ($mW/cm^2$) | | Hazard Assessment |
|---|---|---|---|
| 1. Far Field ($R_{ff}$ = 164.2 m) | $S_{ff}$ | 0.275 | Satisfies FCC MPE |
| 2. Near Field ($R_{nf}$ = 68.4 m) | $S_{nf}$ | 0.642 | Satisfies FCC MPE |
| 3. Transition Region ($R_{nf}$ < $R_t$ < $R_{ff}$) | $S_t$ | 0.642 | Satisfies FCC MPE |
| 4. Between Feed Assembly and Antenna Reflector | $S_{fa}$ | 189.893 | Potential Hazard |
| 5. Main Reflector | $S_{surface}$ | 1.190 | Satisfies FCC MPE |
| 6. Between Reflector and Ground | $S_g$ | 0.298 | Satisfies FCC MPE |

It is the applicant's responsibility to ensure that the public and operational personnel are not exposed to harmful levels of radiation.

## 8. Conclusions

Based upon the above analysis, it is concluded that harmful levels of radiation may exist in those regions noted for the Uncontrolled (Table 4) environment.

The earth station will marked with the standard radiation hazard warnings, as well as the area in the vicinity of the earth station, to inform those in the general population, who may be working, or otherwise present on the roof, deck, and in or near, the main beam of the antenna.

Finally, occupational exposure will be limited, and the transmitter will be turned off during periods of maintenance, so that the MPE standard of 5.0 mw/cm**2 will be complied with for those regions in close proximity to the main reflector, and subreflector, which could be occupied by operating personnel.

The applicant agrees to abide by the conditions specified in Condition 5208 provided below:

> *Condition 5208 - The licensee shall take all necessary measures to ensure that the antenna does not create potential exposure of humans to radiofrequency radiation in excess of the FCC exposure limits defined in 47 CFR 1.1307(b) and 1.1310 wherever such exposures might occur. Measures must be taken to ensure compliance with limits for both occupational/controlled exposure and for general population/uncontrolled exposure, as defined in these rule sections. Compliance can be accomplished in most cases by appropriate restrictions such as fencing. Requirements for restrictions can be determined by predictions based on calculations, modeling or by field measurements. The FCC's OET Bulletin 65 (available on-line at www.fcc.gov/oet/rfsafety) provides information on predicting exposure levels and on methods for ensuring compliance, including the use of warning and alerting signs and protective equipment for worker.*

9797 with 40 watt BUC



# Analysis of Non-Ionizing Radiation for a 2.4-Meter Earth Station System

This report analyzes the non-ionizing radiation levels for a 2.4-meter earth station system. The analysis and calculations performed in this report comply with the methods described in the FCC Office of Engineering and Technology Bulletin, No. 65 first published in 1985 and revised in 1997 in Edition 97-01. The radiation safety limits used in the analysis are in conformance with the FCC R&O 96-326. Bulletin No. 65 and the FCC R&O specifies that there are two separate tiers of exposure limits that are dependant on the situation in which the exposure takes place and/or the status of the individuals who are subject to the exposure. The Maximum Permissible Exposure (MPE) limits for persons in a General Population/Uncontrolled environment are shown in Table 1. The General Population/Uncontrolled MPE is a function of transmit frequency and is for an exposure period of thirty minutes or less. The MPE limits for persons in an Occupational/Controlled environment are shown in Table 2. The Occupational MPE is a function of transmit frequency and is for an exposure period of six minutes or less. The purpose of the analysis described in this report is to determine the power flux density levels of the earth station in the far-field, near-field, transition region, between the subreflector or feed and main reflector surface, at the main reflector surface, and between the antenna edge and the ground and to compare these levels to the specified MPEs.

Table 1. Limits for General Population/Uncontrolled Exposure (MPE)

| Frequency Range (MHz) | Power Density ($mW/cm^2$) |
|---|---|
| 30-300 | 0.2 |
| 300-1500 | Frequency (MHz)*(0.8/1200) |
| 1500-100,000 | 1.0 |

Table 2. Limits for Occupational/Controlled Exposure (MPE)

| Frequency Range (MHz) | Power Density ($mW/cm^2$) |
|---|---|
| 30-300 | 1.0 |
| 300-1500 | Frequency (MHz)*(4.0/1200) |
| 1500-100,000 | 5.0 |

Table 3. Formulas and Parameters Used for Determining Power Flux Densities

| Parameter | Symbol | Formula | Value | Units |
|---|---|---|---|---|
| Antenna Diameter | $D$ | Input | 2.4 | m |
| Antenna Surface Area | $A_{surface}$ | $\pi D^2 / 4$ | 4.52 | $m^2$ |
| Feed Flange Diameter | $D_{fa}$ | Input | 19.0 | cm |
| Area of Feed Flange | $A_{fa}$ | $\pi D_{fa}^2/4$ | 283.53 | $cm^2$ |
| Frequency | $F$ | Input | 14250 | MHz |
| Wavelength | $\lambda$ | $300 / F$ | 0.021053 | m |
| Transmit Power | $P$ | Input | 33.66 | W |
| Antenna Gain (dBi) | $G_{es}$ | Input | 48.4 | dBi |
| Antenna Gain (factor) | $G$ | $10^{Ges/10}$ | 69183.1 | n/a |
| Pi | $\pi$ | Constant | 3.1415927 | n/a |
| Antenna Efficiency | $\eta$ | $G\lambda^2/(\pi^2 D^2)$ | 0.54 | n/a |

## 1. Far Field Distance Calculation

The distance to the beginning of the far field can be determined from the following equation:

Distance to the Far Field Region $R_{ff} = 0.60\ D^2 / \lambda$ (1)
$= 164.2$ m

The maximum main beam power density in the far field can be determined from the following equation:

On-Axis Power Density in the Far Field $S_{ff} = G\ P / (4\ \pi\ R_{ff}^2)$ (2)
$= 6.877$ W/m²
$= 0.688$ mW/cm²

## 2. Near Field Calculation

Power flux density is considered to be at a maximum value throughout the entire length of the defined Near Field region. The region is contained within a cylindrical volume having the same diameter as the antenna. Past the boundary of the Near Field region, the power density from the antenna decreases linearly with respect to increasing distance.

The distance to the end of the Near Field can be determined from the following equation:

Extent of the Near Field $R_{nf} = D^2 / (4\ \lambda)$ (3)
$= 68.4$ m

The maximum power density in the Near Field can be determined from the following equation:

Near Field Power Density $S_{nf} = 16.0\ \eta\ P / (\pi\ D^2)$ (4)
$= 16.053$ W/m²
$= 1.605$ mW/cm²

## 3. Transition Region Calculation

The Transition region is located between the Near and Far Field regions. The power density begins to decrease linearly with increasing distance in the Transition region. While the power density decreases inversely with distance in the Transition region, the power density decreases inversely with the square of the distance in the Far Field region. The maximum power density in the Transition region will not exceed that calculated for the Near Field region. The power density calculated in Section 1 is the highest power density the antenna can produce in any of the regions away from the antenna. The power density at a distance $R_t$ can be determined from the following equation:

Transition Region Power Density $S_t = S_{nf}\ R_{nf} / R_t$ (5)
$= 1.605$ mW/cm²

## 4. Region between the Feed Assembly and the Antenna Reflector

Transmissions from the feed assembly are directed toward the antenna reflector surface, and are confined within a conical shape defined by the type of feed assembly. The most common feed assemblies are waveguide flanges, horns or subreflectors. The energy between the feed assembly and reflector surface can be calculated by determining the power density at the feed assembly surface. This can be determined from the following equation:

Power Density at the Feed Flange $S_{fa} = 4000\ P / A_{fa}$ (6)
$= 474.872\ mW/cm^2$

## 5. Main Reflector Region

The power density in the main reflector is determined in the same manner as the power density at the feed assembly. The area is now the area of the reflector aperture and can be determined from the following equation:

Power Density at the Reflector Surface $S_{surface} = 4\ P / A_{surface}$ (7)
$= 29.762\ W/m^2$
$= 2.976\ mW/cm^2$

## 6. Region between the Reflector and the Ground

Assuming uniform illumination of the reflector surface, the power density between the antenna and the ground can be determined from the following equation:

Power Density between Reflector and Ground $S_g = P / A_{surface}$ (8)
$= 7.440\ W/m^2$
$= 0.744\ mW/cm^2$

## 7. Summary of Calculations

Table 4. Summary of Expected Radiation levels for Uncontrolled Environment

| Region | Calculated Maximum Radiation Power Density Level ($mW/cm^2$) | | Hazard Assessment |
|---|---|---|---|
| 1. Far Field ($R_{ff}$ = 164.2 m) | $S_{ff}$ | 0.688 | Satisfies FCC MPE |
| 2. Near Field ($R_{nf}$ = 68.4 m) | $S_{nf}$ | 1.605 | Potential Hazard |
| 3. Transition Region ($R_{nf} < R_t < R_{ff}$) | $S_t$ | 1.605 | Potential Hazard |
| 4. Between Feed Assembly and Antenna Reflector | $S_{fa}$ | 474.872 | Potential Hazard |
| 5. Main Reflector | $S_{surface}$ | 2.976 | Potential Hazard |
| 6. Between Reflector and Ground | $S_g$ | 0.744 | Satisfies FCC MPE |

Table 5. Summary of Expected Radiation levels for Controlled Environment

| Region | Calculated Maximum Radiation Power Density Level ($mW/cm^2$) | | Hazard Assessment |
|---|---|---|---|
| 1. Far Field ($R_{ff}$ = 164.2 m) | $S_{ff}$ | 0.688 | Satisfies FCC MPE |
| 2. Near Field ($R_{nf}$ = 68.4 m) | $S_{nf}$ | 1.605 | Satisfies FCC MPE |
| 3. Transition Region ($R_{nf} < R_t < R_{ff}$) | $S_t$ | 1.605 | Satisfies FCC MPE |
| 4. Between Feed Assembly and Antenna Reflector | $S_{fa}$ | 474.872 | Potential Hazard |
| 5. Main Reflector | $S_{surface}$ | 2.976 | Satisfies FCC MPE |
| 6. Between Reflector and Ground | $S_g$ | 0.744 | Satisfies FCC MPE |

It is the applicant's responsibility to ensure that the public and operational personnel are not exposed to harmful levels of radiation.

## 8. Conclusions

Based upon the above analysis, it is concluded that FCC RF Guidelines have been exceeded in the specified region(s) of the Uncontrolled (Table 4) environment. The applicant proposes to comply with the Maximum Permissible Exposure (MPE) limits of 1.0 mW/cm**2 for the Uncontrolled Areas, and the MPE limits of 5.0 mW/cm**2 for the Controlled Areas.

The earth station will be mounted aboard a ship, and the lower edge of the antenna will be at least 4 meters above the deck. Public access to the earth station will be restricted.

The applicant will ensure that the main beam of the antenna will be pointed at least one diameter away from any building, or other obstacles in those areas that exceed the MPE levels. Since one diameter removed from the center of the main beam the levels are down at least 20 dB, or by a factor of 100, these potential hazards do not exist for either the public, or for earth station personnel.

Finally, the earth station's operating personnel will not have access to areas that exceed the MPE levels, while the earth station is in operation. The transmitter will be turned off during periods of maintenance, so that the MPE standard of 5.0 mw/cm**2 will be complied with for those regions in close proximity to the main reflector, which could be occupied by operating personnel.

The applicant agrees to abide by the conditions specified in Condition 5208 provided below:

> *Condition 5208 - The licensee shall take all necessary measures to ensure that the antenna does not create potential exposure of humans to radiofrequency radiation in excess of the FCC exposure limits defined in 47 CFR 1.1307(b) and 1.1310 wherever such exposures might occur. Measures must be taken to ensure compliance with limits for both occupational/controlled exposure and for general population/uncontrolled exposure, as defined in these rule sections. Compliance can be accomplished in most cases by appropriate restrictions such as fencing. Requirements for restrictions can be determined by predictions based on calculations, modeling or by field measurements. The FCC's OET Bulletin 65 (available on-line at www.fcc.gov/oet/rfsafety) provides information on predicting exposure levels and on methods for ensuring compliance, including the use of warning and alerting signs and protective equipment for worker.*

USAT-30 with 8 watt BUC and 3011



# Analysis of Non-Ionizing Radiation for a 0.75-Meter Earth Station System

This report analyzes the non-ionizing radiation levels for a 0.8-meter earth station system. The analysis and calculations performed in this report comply with the methods described in the FCC Office of Engineering and Technology Bulletin, No. 65 first published in 1985 and revised in 1997 in Edition 97-01. The radiation safety limits used in the analysis are in conformance with the FCC R&O 96-326. Bulletin No. 65 and the FCC R&O specifies that there are two separate tiers of exposure limits that are dependant on the situation in which the exposure takes place and/or the status of the individuals who are subject to the exposure. The Maximum Permissible Exposure (MPE) limits for persons in a General Population/Uncontrolled environment are shown in Table 1. The General Population/Uncontrolled MPE is a function of transmit frequency and is for an exposure period of thirty minutes or less. The MPE limits for persons in an Occupational/Controlled environment are shown in Table 2. The Occupational MPE is a function of transmit frequency and is for an exposure period of six minutes or less. The purpose of the analysis described in this report is to determine the power flux density levels of the earth station in the far-field, near-field, transition region, between the subreflector or feed and main reflector surface, at the main reflector surface, and between the antenna edge and the ground and to compare these levels to the specified MPEs.

Table 1. Limits for General Population/Uncontrolled Exposure (MPE)

| Frequency Range (MHz) | Power Density ($mW/cm^2$) |
|---|---|
| 30-300 | 0.2 |
| 300-1500 | Frequency (MHz)*(0.8/1200) |
| 1500-100,000 | 1.0 |

Table 2. Limits for Occupational/Controlled Exposure (MPE)

| Frequency Range (MHz) | Power Density ($mW/cm^2$) |
|---|---|
| 30-300 | 1.0 |
| 300-1500 | Frequency (MHz)*(4.0/1200) |
| 1500-100,000 | 5.0 |

Table 3. Formulas and Parameters Used for Determining Power Flux Densities

| Parameter | Symbol | Formula | Value | Units |
|---|---|---|---|---|
| Antenna Diameter | D | Input | 0.8 | m |
| Antenna Surface Area | $A_{surface}$ | $\pi D^2 / 4$ | 0.44 | $m^2$ |
| Feed Flange Diameter | $D_{fa}$ | Input | 6.0 | cm |
| Area of Feed Flange | $A_{fa}$ | $\pi D_{fa}{}^2/4$ | 28.27 | $cm^2$ |
| Frequency | F | Input | 14250 | MHz |
| Wavelength | $\lambda$ | 300 / F | 0.021053 | m |
| Transmit Power | P | Input | 6.70 | W |
| Antenna Gain (dBi) | $G_{es}$ | Input | 39.0 | dBi |
| Antenna Gain (factor) | G | $10^{Ges/10}$ | 7943.3 | n/a |
| Pi | $\pi$ | Constant | 3.1415927 | n/a |
| Antenna Efficiency | $\eta$ | $G\lambda^2/(\pi^2D^2)$ | 0.63 | n/a |

## 1. Far Field Distance Calculation

The distance to the beginning of the far field can be determined from the following equation:

Distance to the Far Field Region $R_{ff} = 0.60\ D^2 / \lambda$ (1)
$= 16.0$ m

The maximum main beam power density in the far field can be determined from the following equation:

On-Axis Power Density in the Far Field $S_{ff} = G\ P / (4\ \pi\ R_{ff}^2)$ (2)
$= 16.479$ W/m$^2$
$= 1.648$ mW/cm$^2$

## 2. Near Field Calculation

Power flux density is considered to be at a maximum value throughout the entire length of the defined Near Field region. The region is contained within a cylindrical volume having the same diameter as the antenna. Past the boundary of the Near Field region, the power density from the antenna decreases linearly with respect to increasing distance.

The distance to the end of the Near Field can be determined from the following equation:

Extent of the Near Field $R_{nf} = D^2 / (4\ \lambda)$ (3)
$= 6.7$ m

The maximum power density in the Near Field can be determined from the following equation:

Near Field Power Density $S_{nf} = 16.0\ \eta\ P / (\pi\ D^2)$ (4)
$= 38.469$ W/m$^2$
$= 3.847$ mW/cm$^2$

## 3. Transition Region Calculation

The Transition region is located between the Near and Far Field regions. The power density begins to decrease linearly with increasing distance in the Transition region. While the power density decreases inversely with distance in the Transition region, the power density decreases inversely with the square of the distance in the Far Field region. The maximum power density in the Transition region will not exceed that calculated for the Near Field region. The power density calculated in Section 1 is the highest power density the antenna can produce in any of the regions away from the antenna. The power density at a distance $R_t$ can be determined from the following equation:

Transition Region Power Density $S_t = S_{nf}\ R_{nf} / R_t$ (5)
$= 3.847$ mW/cm$^2$

## 4. Region between the Feed Assembly and the Antenna Reflector

Transmissions from the feed assembly are directed toward the antenna reflector surface, and are confined within a conical shape defined by the type of feed assembly. The most common feed assemblies are waveguide flanges, horns or subreflectors. The energy between the feed assembly and reflector surface can be calculated by determining the power density at the feed assembly surface. This can be determined from the following equation:

Power Density at the Feed Flange $S_{fa} = 4000\ P / A_{fa}$ (6)
$= 947.856\ mW/cm^2$

## 5. Main Reflector Region

The power density in the main reflector is determined in the same manner as the power density at the feed assembly. The area is now the area of the reflector aperture and can be determined from the following equation:

Power Density at the Reflector Surface $S_{surface} = 4\ P / A_{surface}$ (7)
$= 60.663\ W/m^2$
$= 6.066\ mW/cm^2$

## 6. Region between the Reflector and the Ground

Assuming uniform illumination of the reflector surface, the power density between the antenna and the ground can be determined from the following equation:

Power Density between Reflector and Ground $S_g = P / A_{surface}$ (8)
$= 15.166\ W/m^2$
$= 1.517\ mW/cm^2$

# 7. Summary of Calculations

Table 4. Summary of Expected Radiation levels for Uncontrolled Environment

| Region | Calculated Maximum Radiation Power Density Level ($mW/cm^2$) | | Hazard Assessment |
|---|---|---|---|
| 1. Far Field ($R_{ff}$ = 16.0 m) | $S_{ff}$ | 1.648 | Potential Hazard |
| 2. Near Field ($R_{nf}$ = 6.7 m) | $S_{nf}$ | 3.847 | Potential Hazard |
| 3. Transition Region ($R_{nf} < R_t < R_{ff}$) | $S_t$ | 3.847 | Potential Hazard |
| 4. Between Feed Assembly and Antenna Reflector | $S_{fa}$ | 947.856 | Potential Hazard |
| 5. Main Reflector | $S_{surface}$ | 6.066 | Potential Hazard |
| 6. Between Reflector and Ground | $S_g$ | 1.517 | Potential Hazard |

Table 5. Summary of Expected Radiation levels for Controlled Environment

| Region | Calculated Maximum Radiation Power Density Level ($mW/cm^2$) | | Hazard Assessment |
|---|---|---|---|
| 1. Far Field ($R_{ff}$ = 16.0 m) | $S_{ff}$ | 1.648 | Satisfies FCC MPE |
| 2. Near Field ($R_{nf}$ = 6.7 m) | $S_{nf}$ | 3.847 | Satisfies FCC MPE |
| 3. Transition Region ($R_{nf} < R_t < R_{ff}$) | $S_t$ | 3.847 | Satisfies FCC MPE |
| 4. Between Feed Assembly and Antenna Reflector | $S_{fa}$ | 947.856 | Potential Hazard |
| 5. Main Reflector | $S_{surface}$ | 6.066 | Potential Hazard |
| 6. Between Reflector and Ground | $S_g$ | 1.517 | Satisfies FCC MPE |

It is the applicant's responsibility to ensure that the public and operational personnel are not exposed to harmful levels of radiation.

## 8. Conclusions

Based upon the above analysis, it is concluded that harmful levels of radiation may exist in those regions noted for the Uncontrolled (Table 4) and Controlled (Table 5) environments.

The earth station will be mounted aboard a ship, and it is recommended that the lower edge of the antenna should be at least 2 meters above the deck. If this is not the case, additional procedures will be instituted to ensure the safety of the Public in the vicinity of the antenna.

The applicant will ensure that the main beam of the antenna will be pointed at least one diameter away from any buildings, or other obstacles in those areas that exceed the MPE levels. Since one diameter removed from the center of the main beam the levels are down at least 20 dB, or by a factor of 100, public safety will be ensured.

The earth station will marked with the standard radiation hazard warnings, as well as the area in the vicinity of the earth station, to inform those in the general population, who may be working, or otherwise present on the roof, deck, and in or near, the main beam of the antenna.

Finally, occupational exposure will be limited, and the transmitter will be turned off during periods of maintenance, so that the MPE standard of 5.0 mw/cm**2 will be complied with for those regions in close proximity to the main reflector, and subreflector, which could be occupied by operating personnel.

The applicant agrees to abide by the conditions specified in Condition 5208 provided below:

> *Condition 5208 - The licensee shall take all necessary measures to ensure that the antenna does not create potential exposure of humans to radiofrequency radiation in excess of the FCC exposure limits defined in 47 CFR 1.1307(b) and 1.1310 wherever such exposures might occur. Measures must be taken to ensure compliance with limits for both occupational/controlled exposure and for general population/uncontrolled exposure, as defined in these rule sections. Compliance can be accomplished in most cases by appropriate restrictions such as fencing. Requirements for restrictions can be determined by predictions based on calculations, modeling or by field measurements. The FCC's OET Bulletin 65 (available on-line at www.fcc.gov/oet/rfsafety) provides information on predicting exposure levels and on methods for ensuring compliance, including the use of warning and alerting signs and protective equipment for worker.*