RADIATION HAZARD REPORT EXHIBIT

Contains Radiation Hazard Study Reports for:

4.8 Meter Ku-band Antenna (SAPA 08)

4.6 Meter Ku-band Antenna (SAPA 10)

7.3 Meter Ku-band Antenna (SAPA 19 & SAPA 40)

Analysis of Non-Ionizing Radiation for a 4.8-Meter Earth Station System

This report analyzes the non-ionizing radiation levels for a 4.8-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	4.8	m
Antenna Surface Area	$A_{surface}$	$\pi D^2 / 4$	18.10	m^2
Subreflector Diameter	D_{sr}	Input	35.6	cm
Area of Subreflector	A_{sr}	$\pi D_{sr}^2/4$	995.38	cm^2
Frequency	F	Input	14250	MHz
Wavelength	λ	$300 / F$	0.021053	m
Transmit Power	P	Input	400.00	W
Antenna Gain (dBi)	G_{es}	Input	55.2	dBi
Antenna Gain (factor)	G	$10^{Ges/10}$	331131.1	n/a
Pi	π	Constant	3.1415927	n/a
Antenna Efficiency	η	$G\lambda^2/(\pi^2 D^2)$	0.65	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)
$= 656.6$ 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)
$= 24.445$ W/m^2
$= 2.445$ 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)
$= 273.6$ 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)
$= 57.066$ W/m^2
$= 5.707$ 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)
$= 5.707$ mW/cm^2

4. Region between the Main Reflector and the Subreflector

Transmissions from the feed assembly are directed toward the subreflector surface, and are reflected back toward the main reflector. The most common feed assemblies are waveguide flanges, horns or subreflectors. The energy between the subreflector and the reflector surfaces can be calculated by determining the power density at the subreflector surface. This can be determined from the following equation:

Power Density at the Subreflector $S_{sr} = 4000\ P / A_{sr}$ (6)
$= 1607.423\ mW/cm^2$

5. Main Reflector Region

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

Power Density at the Main Reflector Surface $S_{surface} = 4\ P / A_{surface}$ (7)
$= 88.419\ W/m^2$
$= 8.842\ mW/cm^2$

6. Region between the Main 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)
$= 22.105\ W/m^2$
$= 2.210\ mW/cm^2$

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} = 656.6 m)	S_{ff}	2.445	Potential Hazard
2. Near Field (R_{nf} = 273.6 m)	S_{nf}	5.707	Potential Hazard
3. Transition Region ($R_{nf} < R_t < R_{ff}$)	S_t	5.707	Potential Hazard
4. Between Main Reflector and Subreflector	S_{sr}	1607.423	Potential Hazard
5. Main Reflector	$S_{surface}$	8.842	Potential Hazard
6. Between Main Reflector and Ground	S_g	2.210	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} = 656.6 m)	S_{ff}	2.445	Satisfies FCC MPE
2. Near Field (R_{nf} = 273.6 m)	S_{nf}	5.707	Potential Hazard
3. Transition Region ($R_{nf} < R_t < R_{ff}$)	S_t	5.707	Potential Hazard
4. Between Main Reflector and Subreflector	S_{sr}	1607.423	Potential Hazard
5. Main Reflector	$S_{surface}$	8.842	Potential Hazard
6. Between Main Reflector and Ground	S_g	2.210	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 antenna will be installed at Astrium Services Government's teleport facility in Southbury, Connecticut. The teleport is a gated and fenced facility with secured access in and around the proposed antenna. The earth station will be 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 might be working or otherwise present in or near the direct path of the main beam.

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.*

ANALYSIS OF NON-IONIZING RADIATION FOR A 4.6 METER EARTH STATION

This report analyzes the non-ionizing radiation levels for a 4.6 meter earth station. The Office of Engineering and Technology Bulletin, No. 65, Edition 97-01, specifies that there are two separate tiers of exposure limits that are dependent on the situation in which exposure takes place and/or the status of the individuals who are subject to the exposure. The Maximum Permissible Exposure (MPE) limit for persons in a Uncontrolled/Public environment to non-ionizing radiation over a thirty minute period is a power density equal to 1 mW/cm**2 (one milliwatts per centimeter squared). The Maximum Permissible Exposure (MPE) limit for persons in a Controlled/Occupational environment to non-ionizing radiation over a six minute period is a power density equal to 5 mW/cm**2 (five milliwatts per centimeter squared). It is the purpose of this report to determine the power flux densities of the earth station in the far field, near field, transition region, between the subreflector and main reflector surface, at the main reflector surface, and between the antenna edge and the ground.

The following parameters were used to calculate the various power flux densities for this earth station:

Antenna Diameter, (D)	= 4.6 meters	
Antenna surface area, (Sa)	= pi (D**2) / 4	= 16.62 m**2
Subreflector Diameter, (Ds)	= 61.0 cm	
Area of Subreflector, (As)	= pi (Ds**2)/ 4	= 2922.47 cm**2
Wavelength at 14.2500 GHz, (lambda)		= 0.021 meters
Transmit Power at Flange, (P)	= 358.50 Watts	
Antenna Gain, (Ges)	Antenna Gain at 14.2500 GHz Converted to a Power Ratio Given By: AntiLog (55.2 / 10)	= 3.311E+05 = 55.2 dBi
pi, (pi)	= 3.1415927	
Antenna aperture efficiency, (n)	= 0.55	

1. Far Field Calculations

The distance to the beginning of the far field region can be found by the following equation: (1)

Distance to the Far Field Region, (Rf) = 0.60(D**2) / lambda

= 603.1 m

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(1) Federal Communications Commission, Office of Engineering & Technology, Bulletin No. 65, pp. 17 & 18.

The maximum main beam power density in the far field can be calculated as follows: (1)

On-Axis Power Density in the Far Field, (Wf) = $\frac{(GES)\ (P)}{4(pi)(Rf**2)}$

= 25.98 W/m**2

= 2.60 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 region. The region is contained within a cylindrical volume having the same diameter as the antenna. Past the extent of the near field region the power density decreases with distance from the transmitting antenna.

The distance to the end of the near field can be determined by the following equation: (1)

Extent of near field, (Rn) = D**2 / 4(lambda) = 251.27 m

The maximum power density in the near field is determined by: (1)

Near field Power Density, (Wn) = $\frac{16.0(n)P}{pi(D**2)}$ mW/cm**2

= 47.46 W/m**2

= 4.75 mW/cm**2

3. Transition Region Calculations

The transition region is located between the near and far field regions. As stated above, the power density begins to decrease with 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 in the near field region, as shown above, will not exceed 4.75 mW/cm**2.

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4. Region Between Main Reflector and Subreflector

Transmissions from the feed horn are directed toward the subreflector surface, and are reflected back toward the main reflector. The energy between the subreflector and reflector surfaces can be calculated by determining the power density at the subreflector surface. This can be accomplished as follows:

Power Density at Subreflector, (Ws) = 4(P) / As

= 490.68 mW/cm**2

5. Main Reflector Region

The power density in the main reflector region is determined in the same manner as the power density at the subreflector, above, but the area is now the area of the main reflector aperture:

Power Density at Main Reflector Surface, (Wm) = (4(P) / Sa)

= 86.29 W/m**2

= 8.63 mW/cm**2

6. Region between Main Reflector and Ground

Assuming uniform illumination of the reflector surface, the power density between the antenna and ground can be calculated as follows:

Power density between Reflector and Ground, (Wg) = (P / Sa)

= 2.16 mW/cm**2

Table 1

Summary of Expected Radiation Levels

Based on (5 mW/cm**2) MPE for Controlled Environment

Region	Calculated Maximum Radiation Level (mW/cm**2)	Hazard Assessment
1. Far Field, (Rf)= 603.1 m	2.60	SATISFIES ANSI
2. Near Field, (Rn)= 251.27 m	4.75	SATISFIES ANSI
3. Transition Region, (Rt) Rn < Rt < Rf	4.75	SATISFIES ANSI
4. Between Main Reflector and subreflector	490.68	POTENTIAL HAZARD
5. Reflector Surface	8.63	POTENTIAL HAZARD
6. Between Antenna and Ground	2.16	SATISFIES ANSI

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

Table 2

Summary of Expected Radiation Levels

Based on (1 mW/cm**2) MPE for Uncontrolled Environment

Region	Calculated Maximum Radiation Level (mW/cm**2)	Hazard Assessment
1. Far Field, (Rf) = 603.1 m	2.60	POTENTIAL HAZARD
2. Near Field, (Rn) = 251.27 m	4.75	POTENTIAL HAZARD
3. Transition Region, (Rt) Rn < Rt < Rf	4.75	POTENTIAL HAZARD
4. Between Main Reflector and subreflector	490.68	POTENTIAL HAZARD
5. Reflector Surface	8.63	POTENTIAL HAZARD
6. Between Antenna and Ground	2.16	POTENTIAL HAZARD

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

7. Conclusions

Based upon the above analysis, it is concluded that harmful levels of radiation could exist in those regions noted for the Controlled (Table 1) and Uncontrolled Environments (Table 2).

The earth station facility is located in a rural area near Santa Paula, California, and is distant from any offices or buildings, which could be occupied by the public.

Further, the antenna facility is surrounded by a fence, which restricts any public access.

Since the facility is located in rural location, and is surrounded by a fence, which will restrict public access, and since one diameter removed from the center of main beam the levels are down at least 20 dB, or by a factor of 100, public safety, as well as operating personnel safety will be ensured.

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.

Analysis of Non-Ionizing Radiation for a 7.3-Meter Earth Station System

This report analyzes the non-ionizing radiation levels for a 7.3-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	7.3	m
Antenna Surface Area	$A_{surface}$	$\pi D^2 / 4$	41.85	m^2
Subreflector Diameter	D_{sr}	Input	104.2	cm
Area of Subreflector	A_{sr}	$\pi D_{sr}^2/4$	8527.57	cm^2
Frequency	F	Input	14250	MHz
Wavelength	λ	300 / F	0.021053	m
Transmit Power	P	Input	750.00	W
Antenna Gain (dBi)	G_{es}	Input	58.2	dBi
Antenna Gain (factor)	G	$10^{Ges/10}$	660693.4	n/a
Pi	π	Constant	3.1415927	n/a
Antenna Efficiency	η	$G\lambda^2/(\pi^2 D^2)$	0.56	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)
$= 1518.8$ 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)
$= 17.095\ W/m^2$
$= 1.710\ mW/cm^2$

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)
$= 632.8$ 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)
$= 39.907\ W/m^2$
$= 3.991\ mW/cm^2$

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)
$= 3.991\ mW/cm^2$

4. Region between the Main Reflector and the Subreflector

Transmissions from the feed assembly are directed toward the subreflector surface, and are reflected back toward the main reflector. The most common feed assemblies are waveguide flanges, horns or subreflectors. The energy between the subreflector and the reflector surfaces can be calculated by determining the power density at the subreflector surface. This can be determined from the following equation:

Power Density at the Subreflector $S_{sr} = 4000\ P / A_{sr}$ (6)
$= 351.800\ mW/cm^2$

5. Main Reflector Region

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

Power Density at the Main Reflector Surface $S_{surface} = 4\ P / A_{surface}$ (7)
$= 71.678\ W/m^2$
$= 7.168\ mW/cm^2$

6. Region between the Main 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)
$= 17.919\ W/m^2$
$= 1.792\ mW/cm^2$

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} = 1518.8 m)	S_{ff}	1.710	Potential Hazard
2. Near Field (R_{nf} = 632.8 m)	S_{nf}	3.991	Potential Hazard
3. Transition Region ($R_{nf} < R_t < R_{ff}$)	S_t	3.991	Potential Hazard
4. Between Main Reflector and Subreflector	S_{sr}	351.800	Potential Hazard
5. Main Reflector	$S_{surface}$	7.168	Potential Hazard
6. Between Main Reflector and Ground	S_g	1.792	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} = 1518.8 m)	S_{ff}	1.710	Satisfies FCC MPE
2. Near Field (R_{nf} = 632.8 m)	S_{nf}	3.991	Satisfies FCC MPE
3. Transition Region ($R_{nf} < R_t < R_{ff}$)	S_t	3.991	Satisfies FCC MPE
4. Between Main Reflector and Subreflector	S_{sr}	351.800	Potential Hazard
5. Main Reflector	$S_{surface}$	7.168	Potential Hazard
6. Between Main Reflector and Ground	S_g	1.792	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 the FCC MPE guidelines have been exceeded (or met) in the regions of Table 4 and 5. The applicant proposes to comply with the MPE limits by one or more of the following methods.

Radiation hazard signs will be posted while this earth station is in operation.

Due to the remote and secure location of the proposed earth station antenna at the Teleport, the area of operation around the antenna will be limited to those that have knowledge of the potential for radiation exposure. The applicant will ensure that no buildings or other obstacles will be in the areas that exceed the MPE levels.

Means of Compliance Controlled Areas

The earth station's operational staff will not have access to the areas that exceed the MPE levels while the earth station is in operation.

The transmitters will be turned off during antenna maintenance

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.*

I HEREBY CERTIFY THAT I AM THE TECHNICALLY QUALIFIED PERSON RESPONSIBLE FOR THE PREPARATION OF THE RADIATION HAZARD REPORT, AND THAT IT IS COMPLETE AND CORRECT TO THE BEST OF MY KNOWLEDGE AND BELIEF.

BY: _______________

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