THALES

EXHIBIT-C

Analysis of Non-Ionizing Radiation for a Ka-Band Aeronautical Earth Station System

This report analyzes the non-ionizing radiation levels for the Ka-Band Aeronautical Earth Station (AES) 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 dependent 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 Ka-Band AES system in the far-field, near-field, transition region, at the antenna surface, and between the antenna aperture 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
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 Width	W	Input	7.29 (18.52)	In (cm)
Antenna Length	D	Input	24 (60.96)	In (cm)
Antenna Surface Area	$A_{surface}$	WL	174.96 (1128.77)	In^2 (cm^2)
Frequency	F	Input	30,000	MHz
Wavelength	λ	30,000/F	1	cm
Tx Power @ Ant. Input	P	Input	8.32	W
Antenna Gain(dBi)	G_{es}	Input	39.8	dBi
Antenna Gain (factor)	G	Input	9549.93	n/a
Radome Insertion Loss	IL_{radome}	Input	2	dB
Pi	π	Constant	3.1415927	n/a
Antenna Efficiency	η	$G\ \lambda^2/(\ \pi D)^{1/2}$	0.673	n/a
Tx Power @ Radome Surface	P_{radome}	Input	5.25	W

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)
$= 22.3$ 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 $S_{ff} = G\ P_{radome} / (4\ \pi\ R_{ff}^{\ 2})$ (2)
$= 8.02$ W/m^2
$= 0.802$ mW/cm^2

On-Axis Power Density in the MPE Region. $R_{MPE} = 20$ m $S_{ff} = G\ P_{radome} / (4\ \pi\ R_{MPE}^{\ 2})$ (3)
$= 9.971$ W/m^2
$= 0.9971$ 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 $R_{nf} = D^2 / (4\ \lambda)$ (4)
$= 9.29$ m

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

Near Field Power Density $S_{nf} = 16.0\ \eta\ P_{radome} / (\pi\ D^2)$ (5)
$= 48.42$ W/m^2
$= 4.842$ 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 ($R_t = 15.0$m) $S_t = S_{nf}\ R_{nf} / R_t$ (6)
$= 3.00$ mW/cm^2

4. Aperture Region

The power density in the antenna aperture is determined from the following equation:

Power Density at the Aperture Surface $S_{surface} = 4\,P / A_{surface}$ (7)

$= 294.75\ W/m^2$

$= 29.475\ mW/cm^2$

5. Region between the Aperture and the Ground

Assuming uniform illumination of the aperture 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)

$= 73.69\ W/m^2$

$= 7.369\ mW/cm^2$

6. Thales Building 51 Roof-Top Ka-Band Antenna

Per radiation regulation, the required attenuation at 14° off boresight is about 18dB with respect to the attenuation level at 2° off boresight (see Figure 1).
Since the antenna look angle from Thales building 51 rooftop toward the POR and AOR satellites are about 14 degrees elevation (see Figure 2), we can use 18dB attenuation as minimum from the antenna boresight to the horizontal plane (i.e. ground plane of the rooftop antenna).
Therefore, the Power Density at the area surrounding and below the antenna horizontal surface can be determined as:

$S_{Ant\ Horizontal\ Surface} = 4P / A_{surface}\ - 18\ dB$ (9)

$= 294.75 / (10\string^(18/10))\ W/m^2$

$= 4.672\ W/m^2$

$= 0.4672\ mW/cm^2$

Since the Power Density level below the horizontal surface of the rooftop antenna during RF transmission toward the AOR or POR Inmarsat GX satellites is well below the 1 mW/cm^2 exposure limit requirement, personnel working near by and below the rooftop antenna will not be harmful due to antenna RF radiations.

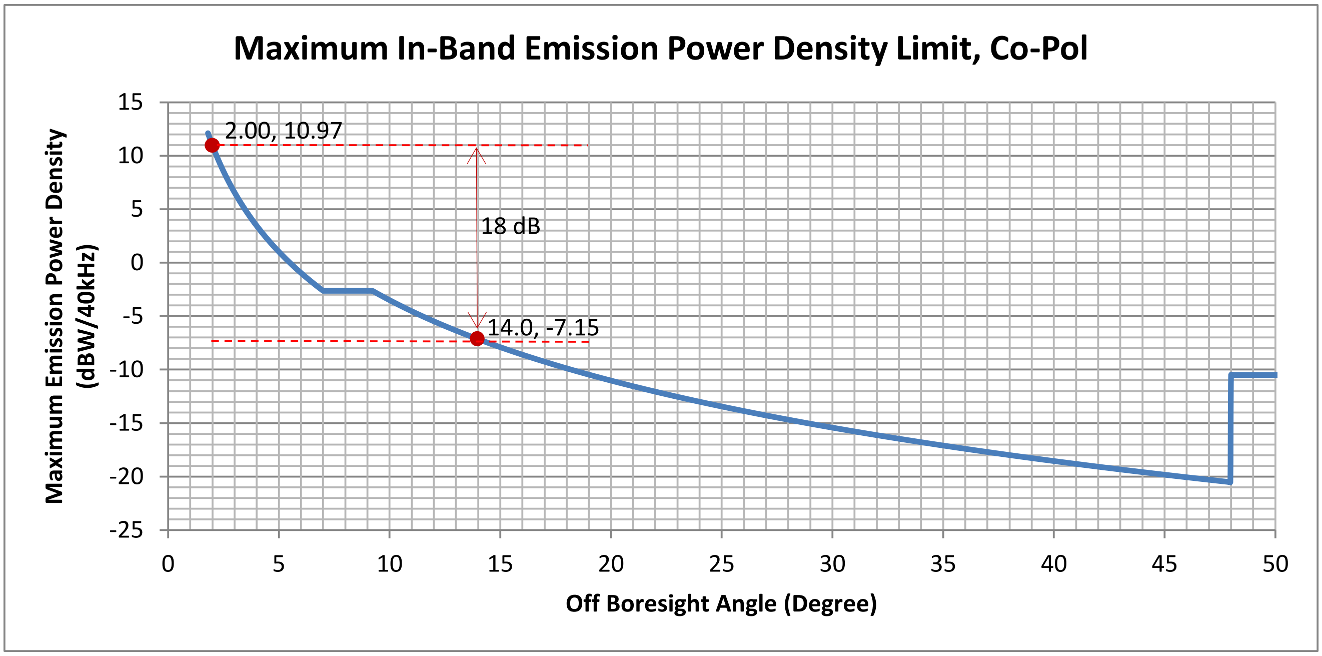

Figure 1: Emission Regulation

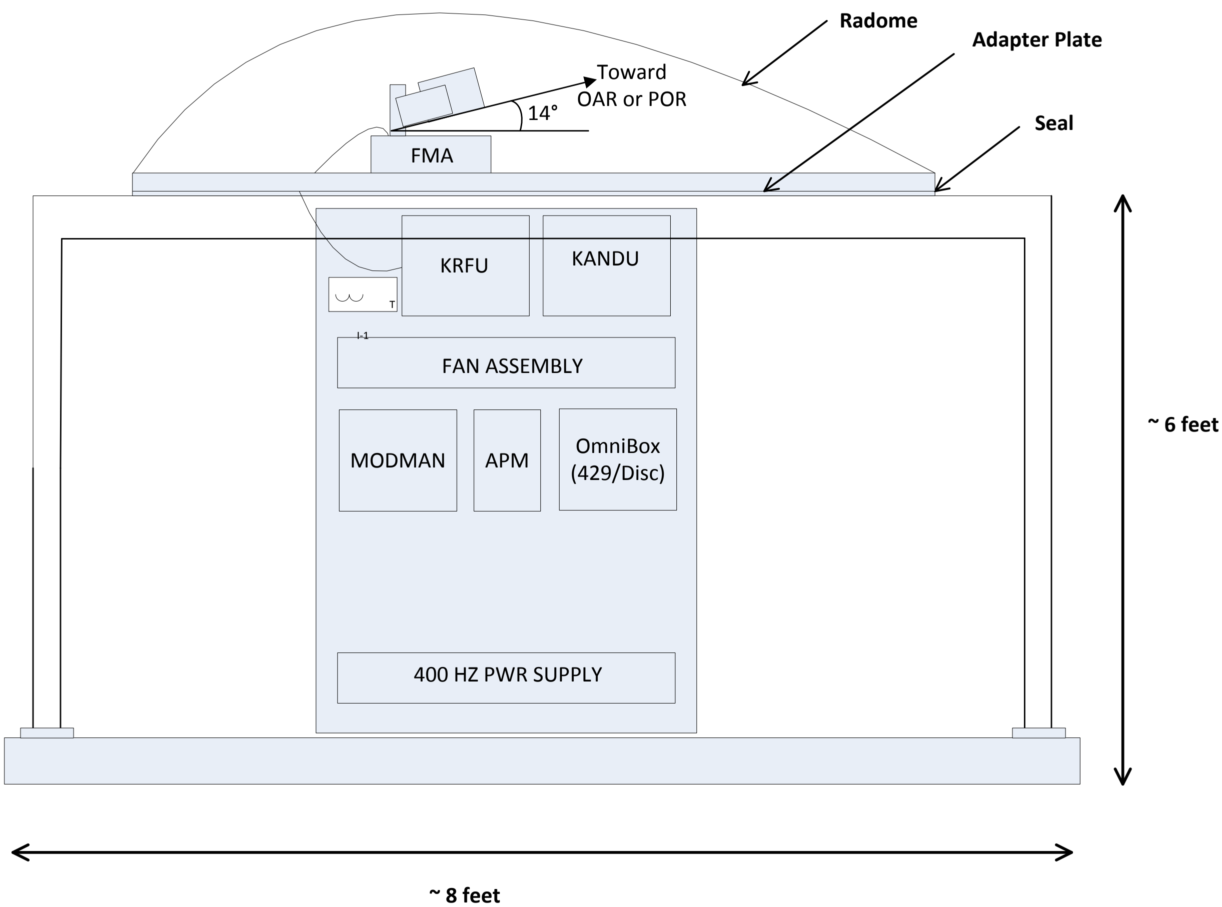

Figure 2: Thales Building 51 RoofTop Ka-Band Antenna System

7. Summary of Calculations

Table 4: Summary of Expected Radiation levels for Uncontrolled Environment

	Region	Symbol	Calculated Max. Radiation Power Density Level (mW/cm2)	Hazard Assessment
1	Far Field (R_{ff} = 22.3 m)	S_{ff}	0.802	Satisfies FCC MPE
2	Far Field (R_{MPE} = 20.0 m)	S_{MPE}	0.997	Satisfies FCC MPE
3	Near Field (R_{nf} = 9.29 m)	S_{nf}	4.842	Potential Hazard
4	Transition Region ($R_{nf} < R_t < R_{ff}$); R_t = 15.0m	S_t	3.00	Potential Hazard
5	Antenna Aperture	$S_{surface}$	29.475	Potential Hazard
6	Between Antenna Aperture and Ground	S_g	7.369	Potential Hazard
7	Below Antenna Horizontal Surface	$S_{Ant\ Horizontal\ Surface}$	0.4672	Satisfies FCC MPE Below Safety Hazard Limit

Table 5: Summary of Expected Radiation levels for Controlled Environment

	Region	Symbol	Calculated Max. Radiation Power Density Level (mW/cm2)	Hazard Assessment
1	Far Field (R_{ff} = 22.3 m)	S_{ff}	0.802	Satisfies FCC MPE
2	Far Field (R_{MPE} = 20.0 m)	S_{MPE}	0.997	Satisfies FCC MPE
3	Near Field (R_{nf} = 9.29 m)	S_{nf}	4.842	Satisfies FCC MPE
4	Transition Region ($R_{nf} < R_t < R_{ff}$); R_t = 15.0m	S_t	3.00	Satisfies FCC MPE
5	Antenna Aperture	$S_{surface}$	29.475	Potential Hazard
6	Between Antenna Aperture and Ground	S_g	7.369	Potential Hazard
7	Below Antenna Horizontal Surface	$S_{Ant\ Horizontal\ Surface}$	0.4672	Satisfies FCC MPE Below Safety Hazard Limit

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 this analysis it is concluded that the FCC RF Guidelines have been exceeded in the specific regions of Tables 4 and 5. The applicant proposes to comply with the Maximum Permissible Exposure (MPE) limits of 1 mW/cm^2 for the Uncontrolled areas and the MPE limits of 5 mW/cm^2 for the Controlled areas:

<u>Means of Compliance UnControlled Areas</u>

This antenna will be located on a building rooftop. The rooftop area will not be accessible to the general public. Access to the rooftop will be locked and radiation hazard signs will be posted. This will be sufficient to prohibit access to the areas that exceed the MPE limited. In addition, the general public will not have access to the areas within 18 meters from the antenna.

The applicant will ensure that the main beam of the antenna will be pointed at least 0.5m away from any building, or other obstacles in those areas that exceed the MPE levels. This is to ensure that the power level will be attenuated down at least 20 dB, or by a factor of 100 from the center of the main beam levels. This will prevent the potential hazards to the public and to the AES personnel.

It is no harmful to the personnel who stays below and around the Ka-Band antenna on rooftop of

Thales building 51 during the operations toward the POR and AOR Inmarsat GX satellites.

Means of Compliance Controlled Areas

The Aeronautical Earth Station's operational personnel will not have access to the areas that exceed the MPE levels while the AES is in operation.