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Federal Communication Commission
EQUIPMENT APPROVAL SERVICES
P.O. Box 358315
Pittsburgh, PA 15251-5315

ATTN: Authorization and Evaluation Division
PER: Maximum Permissible Emissions
RE: K6KJetWave

JETWAVE MAXIMUM PERMISSIBLE EMISSIONS

Enclosed in this document are details of the maximum permissible emissions levels for the JetWave™ components Aircraft Earth Station which supports Inmarsat Global Xpress Aviation data services.

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1 INTRODUCTION

This analysis calculates the non-ionizing radiation levels of the EMS Technologies Canada Ltd ("EMS") Inmarsat Global Express Aviation (GXA) aeronautical mobile earth station (AES) class A (with fuselage mounted antenna) and class B (with tail mounted antenna) terminal.

The calculations in this analysis comply with the methods described in the following document:
FCC Office of Engineering and Technology; Bulletin Number 65, Edition 97-01: Evaluating compliance with FCC Guidelines for human exposure to Radio Frequency Electromagnetic fields.

Bulletin 65 and CFR 47 section 1.1310 specify two separate exposure limits, occupational/ controlled exposure and general population/uncontrolled exposure.

Occupational/controlled exposure limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational / controlled exposure also apply in situations when a person is transient through a location where occupational / controlled limits apply provided he or she is made aware of the potential for exposure.

General population/uncontrolled exposure limits apply in situations in which the general public may be exposed, or in which persons who are exposed as a consequence of their employment may not be fully aware of the potential for exposure or cannot exercise control over their exposure.

The maximum permitted exposure limits are:

- Occupational/controlled exposure: 5mW/cm^2 averaged over 6 minutes.
- General population/uncontrolled exposure: 1mW/cm^2 averaged over 30 minutes.

This report analyzes the maximum power density levels in the vicinity of the AES antenna in 4 regions using the methods described in Bulletin 65:

- Region near the antenna surface
- Near Field
- Transition region between near and far field
- Far field

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2 AES TERMINAL DESCRIPTION

The Jetwave AES consists of 5 units, each unit's functionality is described below:

- ModMan: Contains the system modem and is also responsible for the management of the overall AES.
- APM: Stores installation and configuration information to allow simple replacement of other units.
- KANDU: Provides power and pointing information to the antenna, acts as a communications hub between the Modman and the KRFU and Antenna.
- KRFU: Sits between the Modman and the antenna providing a high power amplifier, block-up-converter and block down-converter.
- Fuselage Mount Antenna: Mechanically steered antenna mounted on the fuselage of the aircraft, located under a radome.

The system configurations are shown in Figure 3 and Figure 4.

The Jetwave AES uses the same underlying modem technology used in all of the Inmarsat GX terminals. The AES transmits bursts of information under the control of the network. The network controls the timing, frequency, duration, and modulation type of each burst.

The AES incorporates three fail safe features to limit the potential for human exposure to non-ionizing radiation:

1. The system will not transmit unless the receiver is receiving a valid signal, therefore if the received signal were to become blocked the transmitter would be disabled.
2. The antenna sub-system includes a hardware end-stop that prevents the antenna pointing more than two degrees below the horizontal. As the antenna is mounted on the top of the fuselage of the aircraft this would mitigate any hazard.
3. An input into the KANDU, wired on the aircraft to a switch in the cockpit, to disable the block-up-converter. This switch would be used to prevent any radiation from the antenna in the event of aircraft operations in the vicinity of the antenna, for instance when de-icing the aircraft. This would be achieved by a defined procedure on the aircraft.

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3 CLASS A SYSTEM

3.1 RESULTS OF ANALYSIS

Parameter and derived values can be found in Appendix A.

3.1.1 Antenna Surface

Power Density in front of the antenna without radome

$$S_{Surface} = \frac{4 \times P_{Antenna}}{A} = \frac{4 \times 12.6\,W}{1129} = 44.6\,mW/cm^2$$

3.1.2 Near Field Region

Extent of near field:

$$R_{NF} = \frac{D_{Maj}^2}{4\lambda} = \frac{0.61^2}{4 \times 0.01} = 9.30\,m$$

Power Density in near field

$$S_{nf} = \frac{16 \times \eta \times P_{Antenna}}{\Pi \times D_{Maj}^2} \times \frac{1}{10^{\frac{L_{Radome}}{10}}} = \frac{16 \times 0.0.71 \times 12.6W}{\Pi \times 61^2} \times \frac{1}{10^{\frac{0.2}{10}}} = 10.9\ mW/cm^2$$

3.1.3 Transition Region

The far field analysis (see section 3.1.4) shows that the power density at the edge of the far field is below the levels for the occupational/controlled exposure levels but above the levels for general population/uncontrolled exposure levels. Therefore occupational /controlled exposure levels are calculated in the transition region:

$$R_{tr\_ce} = \frac{S_{nf} \times R_{nf}}{S_{ce}} = \frac{10.9 \times 9.3}{5} = 20.3\,m$$

3.1.4 Far Field Analysis

Beginning of far field:

$$R_{ff} = \frac{0.6 \times D_{Maj}^2}{\lambda} = \frac{0.6 \times 0.61^2}{0.01} = 22.3\,m$$

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Power Density at edge of Far field:

$$S_{ff} = \frac{EIRP}{4 \times \pi \times R_{ff}^2} \times \frac{1}{10^{\frac{L_{Radome}}{10}}} = \frac{120.2kW}{4 \times \pi \times 2230^2} \times \frac{1}{10^{\frac{0.8}{10}}} = 1.71\, mW/cm^2$$

Minimum distance to be below General population/uncontrolled exposure levels:

$$R_{ff\_gp} = \sqrt{\frac{EIRP}{4 \times \pi \times S_{ue}} \times \frac{1}{10^{\frac{L_{Radome}}{10}}}} = \sqrt{\frac{120.2kW}{4 \times \pi \times 1} \times \frac{1}{10^{\frac{0.8}{10}}}} = 29.2m$$

3.2 EXPLANATION OF ANALYSIS

The above analysis shows that a human radiation hazard does exist, at up to a distance of 20.3m for occupational / controlled exposure and up to 29.2m for general population / uncontrolled exposure.

Figure 1 shows the areas in which the risk exists, based upon the installation location on the aircraft (the top of the tail section on the aircraft) and the hardware end stop described in section 2. This shows personnel operating on the apron, both general population and for transient personnel in the controlled exposure category will not be exposed levels in excess of the limits.

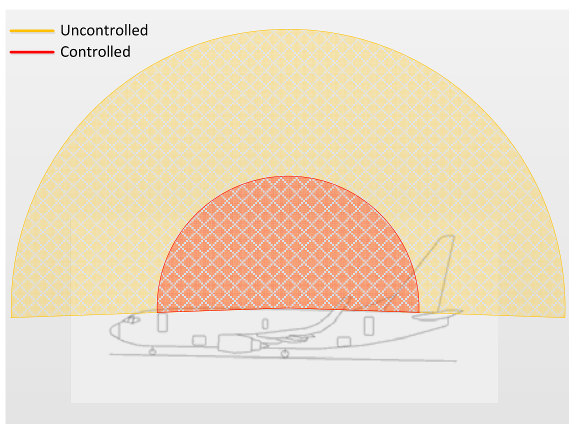

Figure 1 Exposure Areas

Maintenance personnel working close to the top of the fuselage can be protected by disabling the transmitter before they approach that area of the aircraft. This will be detailed in the system installation manual.

The analysis present the worst case levels of exposure, in many cases the level will be reduced by:

- The system is not continuously transmitting (analysis assumes 100% duty cycle).
- The system RF power level is reduced under control of the network.
- RF losses between the KRFU and the Antenna maybe higher than the minimum used here.

3.3 CONCLUSION

The radiation hazard analysis shows that the levels exceed the allowed levels, but with the end stop design feature for both controlled and uncontrolled environment operation and procedures for controlled environment operation the GXA system with a fuselage mount antenna does not create a human exposure radiation hazard.

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4 CLASS B SYSTEM

4.1 RESULTS OF ANALYSIS

Parameter and derived values can be found in Appendix B.

4.1.1 Antenna Surface

Power Density in front of the antenna

$$S_{Surface} = \frac{4 \times P_{Antenna}}{A} = \frac{4 \times 12.0\,W}{683} = 70.4 mW/cm^2$$

4.1.2 Near Field Region

Extent of near field:

$$R_{NF} = \frac{D^2}{4\lambda} = \frac{0.295^2}{4 \times 0.01} = 2.18m$$

Power Density in near field

$$S_{nf} = \frac{16 \times \eta \times P_{Antenna}}{\Pi \times D^2} \times \frac{1}{10^{\frac{L_{Radome}}{10}}} = \frac{16 \times 0.584 \times 12.0W}{\Pi \times 29.5^2} \times \frac{1}{10^{\frac{0.5}{10}}} = 36.6\ mW/cm^2$$

4.1.3 Transition Region

As the power density levels are exceeded in the far field no analysis of the transition region is required

4.1.4 Far Field Analysis

Beginning of far field:

$$R_{ff} = \frac{0.6 \times D^2}{\lambda} = \frac{0.6 \times 0.295^2}{0.01} = 5.22m$$

Power Density at edge of Far field:

$$S_{ff} = \frac{EIRP}{4 \times \Pi \times R_{ff}^2} \times \frac{1}{10^{\frac{L_{Radome}}{10}}} = \frac{60.3kW}{4 \times \Pi \times 5.22^2} \times \frac{1}{10^{\frac{0.5}{10}}} = 15.7\ mW/cm^2$$

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Minimum distance to be below Occupational/controlled exposure levels:

$$R_{ff\_ce} = \sqrt{\frac{EIRP}{4 \times \Pi \times S_{ce}} \times \frac{1}{10^{\frac{L_{Radome}}{10}}}} = \sqrt{\frac{60.3kW}{4 \times \Pi \times 5} \times \frac{1}{10^{\frac{0.5}{10}}}} = 9.24m$$

Minimum distance to be below General population/uncontrolled exposure levels:

$$R_{ff\_gp} = \sqrt{\frac{EIRP}{4 \times \Pi \times S_{ue}} \times \frac{1}{10^{\frac{L_{Radome}}{10}}}} = \sqrt{\frac{60.3kW}{4 \times \Pi \times 1} \times \frac{1}{10^{\frac{0.5}{10}}}} = 20.7m$$

4.2 EXPLANATION OF ANALYSIS

The above analysis shows that under the worst case conditions that the human radiation exposure limits are exceeded up to a distance of 9.24m for occupational/controlled exposure and up to 20.7m for general population /uncontrolled exposure.

Figure 2 shows the areas in which the risk exists, based upon the installation location on the aircraft (the top of the tail section on the aircraft) and the hardware end stop described in section 2. This shows personnel operating on the apron, both general population and for transient personnel in the controlled exposure category will not be exposed levels in excess of the limits.

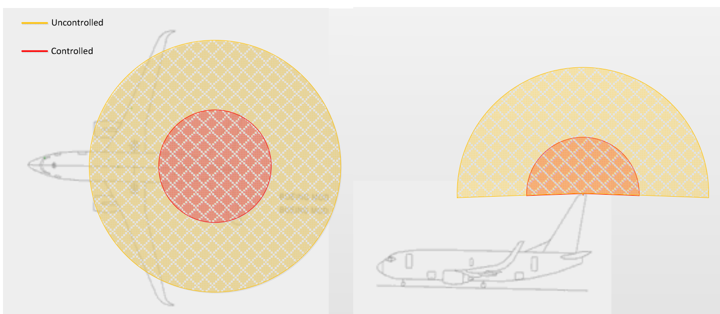

Figure 2 Exposure Areas

Maintenance personnel working close to the tail can be protected by disabling the transmitter before they approach that area of the aircraft. This will be detailed in the system installation manual.

The analysis present the worst case levels of exposure, in many cases the level will be reduced by:

- The system is not continuously transmitting (analysis assumes 100% duty cycle).
- The system RF power level is reduced under control of the network.

- RF losses between the KRFU and the Antenna maybe higher than the values used here.

4.3 CONCLUSION

The radiation hazard analysis shows that the levels exceed the allowed levels, but with the end stop design feature for both controlled and uncontrolled environment operation and procedures for controlled environment operation the GXA system with a tail mount antenna does not create a human exposure radiation hazard.

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Appendix A CLASS A: DEFINITIONS AND CALCULATED VALUES

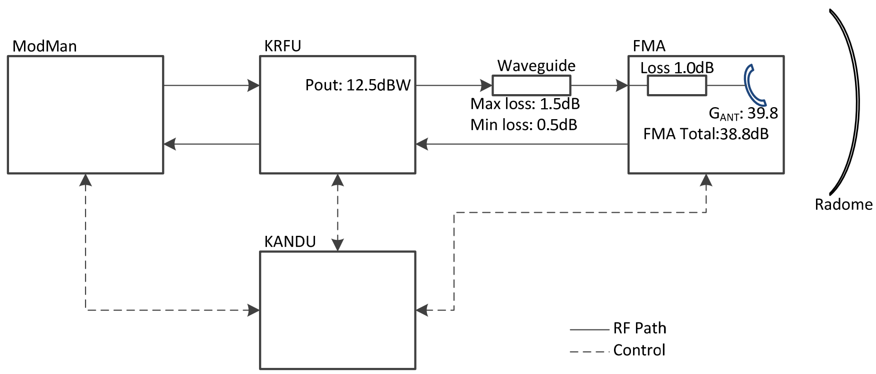

Figure 3 Class A system configuration

A.1 Definitions

Aperture size	$D_{maj} = 61cm$
Aperture Area	$A = 1129\ cm^2$
Frequency	$F = 30\ GHz$
Minimum Radome Loss	$L_{Radome} = 0.5dB$
Aperture efficiency	$\eta = 0.71$
EIRP[1]	$EIRP = 50.8dBW = 120.2kW$
Power into Antenna[2]	$P_{Antenna} = 11dBW = 12.6W$
FMA antenna gain	$G_{Antenna} = 39.8dB = 9550$

[1] Based upon 12.5dBW from KRFU, 0.5 dB loss to Antenna and 39.8dB Gain in Antenna LRU
[2] Based upon 12.5dBW from KRFU, 0.5 dB loss to Antenna and 1.0 dB loss in Antenna LRU prior to aperture

Calculated Values

Wavelength $\lambda = \frac{c}{F} = \frac{3\times10^{8}}{30\times10^{9}} = 0.01m$

Effective Diameter $D_{eff} = \sqrt{\frac{4\times A}{\pi}} = 37.9\ cm$

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Appendix B CLASS B: DEFINITIONS AND CALCULATED VALUES

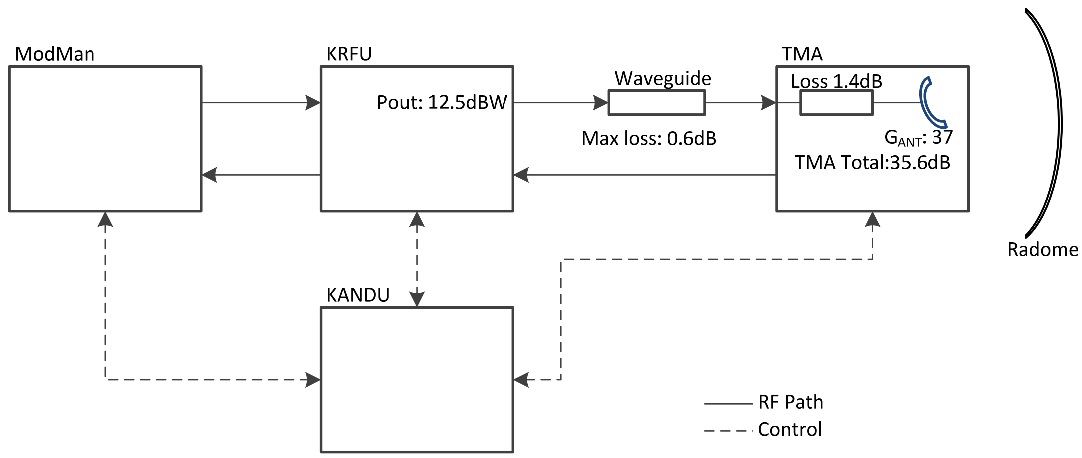

Figure 4 Class B system configuration

B.1 Definitions

Antenna Aperture $D = 29.5cm$

Frequency $F = 30\ GHz$

Minimum Radome Loss $L_{Radome} = 0.5dB$

EIRP[3] $EIRP = 47.8dBW = 60.3kW$

Power into Antenna[4] $P_{Antenna} = 10.8dBW = 12.0W$

TMA Antenna Gain $G_{Ant} = 37dB = 5010$

Calculated Values

Wavelength $\lambda = \frac{c}{F} = \frac{3\times10^8}{30\times10^9} = 0.01m$

[3] Based upon 12.5dBW from KRFU, 0.3dB waveguide loss to TMA and 35.6dB overall gain in the TMA. Assumes 100% duty cycle, unlikely to be seen in a real situation, but theoretically possible

[4] Based upon 12.5dBW from KRFU, 0.3dB waveguide loss to TMA and 1.4dB loss in TMA prior to aperture

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Aperture Area $A = \frac{\pi \times D^2}{4} = 683\ cm^2$

Aperture efficiency $\eta = \frac{\frac{G_{Ant} \times \lambda^2}{4 \times \pi}}{\frac{\pi \times D^2}{4}} = \frac{\frac{[illegible] \times [illegible]^2}{4 \times \pi}}{\frac{\pi \times [illegible]^2}{4}} = 0.584$