FCC RF Hazard Compliance Analysis for Ball 9x9

In connection with this STA application by Intelsat License, LLC ("Intelsat"), for operation of a 0.46 m by 0.46 m Ku-band aircraft remote antenna, the following assessment is provided of compliance with the FCC limits for maximum permissible exposure (MPE) to RF fields.

Based on the mathematical analyses described herein, the potential RF exposure levels in the areas of possible interest for antenna operation can be considered in compliance with the applicable FCC limits for controlled or occupational exposure (access to the earth station antenna is restricted to trained personnel) and for protection of the general population. The proposed operation is therefore in compliance with the FCC regulations and exposure limits.

The sections that follow provide the analysis and conclusions regarding compliance.

1 Operational Data

The relevant data for the subject operation is summarized below:

Transmitting Frequency Band: 14.0-14.5 GHz
Antenna Manufacturer / Model: Ball Aerospace 9x9 Subarray Gen II 3S
Antenna Dimension: 0.46 meters by 0.46 meters
Net Power Input to Antenna (at flange): 50.0 Watts
Antenna Height AGL: 7.5 meters nominal

2 Applicable MPE Limits

The MPE limits are described in the FCC Rules and Regulations. For the frequency range of interest here, the applicable limit for acceptable, continuous exposure of the general population is 1.0 milliwatt per square centimeter (mW/cm^2), and for "controlled" occupational exposure, it is 5.0 mW/cm^2. Access to the antenna is restricted to trained personnel, and thus the latter limit is generally applicable. However, it is possible that untrained members of the general population could be within certain distances from the aircraft. Therefore, the MPE limit for the general population has also been examined.

3 FCC Formulas and Calculations

FCC Bulletin OET 65 provides standardized formulas for calculating the power density in the areas of interest here. Using the formulas from Bulletin OET 65, we report the exposure levels (1) at the surface of the antenna, (2) the near field of the antenna, (3) at the transition from near to far field, and (4) the far field of the antenna; and (5) to the side of the antenna. Each area of interest will be addressed below and the results of the calculations are given.

3.1 Potential exposure level directly in front of the antenna

The worst-case possible exposure occurs right at the surface (aperture) of the antenna. According to Bulletin OET 65, the applicable formula for power density, S, at the antenna surface is as follows:

$$S_{surface} = 4 * P / A$$

Where: P represents the antenna input power; and
A is the surface area of the antenna.

In this case, with 50 Watts of input power at the flange and an antenna diameter of 0.46 m, the power density at the antenna surface is 120.34 mW/cm^2, which exceeds the 5.0 mW/cm^2 MPE limit for controlled access. However, access to the antenna will be controlled while in operation.

In normal operation, this antenna is mounted on the top of the aircraft's tail. It is also possible to mount it on the aircraft fuselage. In both installations, the main beam points toward the sky at a typical elevation angle of 25 degrees such that direct human exposure is not possible. Additionally, any blockage (human or otherwise) will cause the transmitter to be disabled within milliseconds as the system does not transmit unless it can receive the downlink carrier from the satellite. Some testing of this terminal will occur on the ground when not installed on an aircraft. In these cases, access from the general public will be restricted and only authorized service personnel will have access. Therefore, prolonged exposure will not be possible in normal operation.

The antenna will be switched off completely (i.e., unpowered) when a technician needs to perform work in this area (which is more than 24 feet above ground level). Standard RF safety procedures will be applied and the power to the antenna will be removed during the period of the work.

3.2 Near field calculations

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 is determined from the following equation:

Extent of the Near Field:

$R_{nf} = D^2 / (4\lambda)$

$= 2.52$ m

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

Near Field Density:

$S_{nf} = 16.0\ \eta\ P / (\pi\ D^2)$

$= 121.39$ mW/cm^2

This is the exposure level directly in front of the antenna, up to 2.52 meters away. For the reasons stated above, there is no way for a technician or the general public to approach this close to the antenna while it is transmitting.

The near-field power density drops off dramatically outside the imaginary cylinder extending from the surface along the axis of the main beam of an aperture antenna. According to Bulletin OET 65, if the point of interest is at least one antenna diameter removed from the center of the main beam, the power density at that point would be at least a factor of 100 lower (20 dB) than the value calculated for the equivalent distance in the main beam.

In this particular case, the antenna will be mounted 7.5 m (29 feet) above the ground. Therefore, the closest that ground personnel and passengers could approach an operational antenna would be at least 7.5/0.46 = 16.3 antenna diameters below the main beam.

3.3 Transition region

The transition region covers the range between the near field distance of 2.52 meters and 6.05 meters from the antenna. The maximum power density at any point in this range will be less than the power density in the near field region found above, i.e., 121.39 mW/cm^2. The restrictions on general and occupational personnel described above will also apply to the transition region.

3.4 Far field calculations

The distance to the Far Field Region is calculated using the following equation:

Distance to Far Field Region:

$$R_{ff} = 0.6\ D^2 / \lambda$$

$$= 6.05 \text{ m}$$

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

On-axis Power Density in the Far Field:

$$S_{ff} = G\ P / (4\ \pi\ R_{ff}^2)$$

$$= 52.00 \text{ mW/cm}^2$$

For the deployments considered in this application, taking into account the terminal installation on board the aircraft and elevation angle, there should be no cases in which any person is within the main beam.

4 Compliance Conclusion

Intelsat and end users will observe standard safety precautions with respect to operations and maintenance of the Ball 9x9 antenna, including powering the antenna off in advance of maintenance activities. In addition, given the location of the antenna and automatic muting of transmissions with a blockage, the general public will not be allowed access in regions where MPE values may be exceeded. Based on the result of the analysis, the potential exposure levels in all respects – directly in front of the antenna, to the side of the antenna, and in the near and far fields – and taking into account the access restrictions for both trained and un-trained persons and standard safety procedures, the operation of the Ball 9x9 Ku-band antenna as a tail-mounted aircraft antenna satisfies the MPE compliance requirements in the FCC regulations.