Radiation Hazard Analysis for AURA LE

This report analyzes the non-ionizing radiation levels for the AURA LE antenna. This report is developed in accordance with the prediction methods contained in OET Bulletin No. 65, Evaluating Compliance with FCC Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields, Edition 97-01.

Bulletin No. 65 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 General Population/ Uncontrolled Environment and the Controlled Environment, where the general population does not have access.

The maximum level of non-ionizing radiation to which individuals may be exposed is limited to a power density level of 5 milliwatts per square centimeter (5 mW/cm^2) averaged over any 6 minute period in a controlled environment, and the maximum level of non-ionizing radiation to which the general public is exposed is limited to a power density level of 1 milliwatt per square centimeter (1 mW/cm^2) averaged over any 30 minute period in a uncontrolled environment.

In the normal range of transmit powers for satellite antennas, the power densities at or around the antenna surface are expected to exceed safe levels. This area will not be accessible to the general public. Operators and technicians will receive training specifying this area as a high exposure area. Procedures will be established to ensure that all transmitters are turned off before this area may be accessed by operators, maintenance or other authorized personnel.

Near Field Exposure

The AURA LE antenna potentially exceeds MPE limits in the near field within the rectangular volume directly in front of the panels (7.0 mW/cm^2). For this calculation, it was assumed that all 10 watts from each SSPA module are uniformly distributed across the surface area of the panel. There are two SSPA modules, one for each antenna panel. This is a reasonable assumption for a flat panel waveguide fed phased array with minimal sidelobe tapering.

The extent of the near field region is defined by the following

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

8.9 meters

Where D is the width of the panel (0.86 meters)

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

$$S_{nf} = P_{SSPA} / A$$
$$7 \text{ mW/ cm}^2$$

Where A is the surface area of the panel and P is the power available from the SSPA.

In normal operation, this antenna is mounted on a rooftop with the main beam pointed toward the sky at a minimum elevation angle of 28 degrees such that human exposure in the near field is not possible. Furthermore, normal TDMA operation uses a duty cycle of 10% or less, reducing maximum near field exposure by an order of magnitude to 0.7 mW/cm^2. Additionally, in normal operation, any blockage in the near field (human or otherwise) will cause the transmitter to be disabled within seconds as the system does not transmit unless it can receive the downlink carrier from the satellite. Therefore, prolonged exposure in the near field is not possible in normal operation.

Far Field Exposure (in main beam)

$$R_{ff} = 0.60D^2 / \lambda$$
$$22 \text{ m}$$

$$S_{ff} = P_{EIRP} /(4\pi R_{ff}^2)$$
$$1.0 \text{ mW/ cm}^2$$

At a distance of 22 meters, the power density of the Aura LE is 1.0 mW/cm^2, which is within the limits of General Population/Uncontrolled Exposure (MPE) even in the direction of the main beam of the antenna. As noted previously, the antenna will be mounted on a building or vehicle rooftop with the main beam pointed to the sky at a minimum elevation angle of 28 degrees. In this case, maximum far field exposure to humans would be due to a sidelobe which is at least 15 dB below the main beam. At a distance of 22 meters, the exposure to humans would be less than 0.032 mW/cm^2.

Transition Region Exposure (in main beam)

At a distance of 13 m from the antenna, maximum exposure in the main beam is 5 mW/cm^2. This assumes that PFD decreases linearly from 7 mW/cm^2 to 1.0 mW/cm^2 in this region between the near field and far field (8.9 m to 22 m from the antenna).

Exposure to personnel located below antenna height

The antenna will be mounted at a height above personnel. In this case, the worst case exposure is due to the first elevation sidelobe at a level of -15 dB. For the AURA LE antenna, the far field distance in the elevation plane is approximately 0.8 meters. The 5 mW/cm^2 threshold is reached at a distance of 1.8 meters and the 1 mW/cm^2 threshold is reached at a distance of 4.0 m. Observing the safe radius distance noted above during transmit operations will ensure that the threshold will not be exceeded.

Table 1: Parameters Used for Determining PFD (Aura LE)

Antenna Width	34	0.8636	m
Antenna Height	6.5	0.1651	m
Antenna Surface Area		0.14258	m^2
Frequency		14250	MHz
Wavelength		0.021	m
Transmit Power		10	W
Antenna Gain		38	dBi
Antenna Gain		6309.573	
EIRP		48	dBW
Far Field Boundary (Azimuth)		22.0	m
Power Density at far field boundary (Azimuth)		1.0	mW/cm^2
Near Field Distance (Azimuth)		8.9	m
Near Field Power Density (Azimuth)		7.0	mW/cm^2
Elevation sidelobe level		-15.0	dB
Far Field Boundary (Elevation)		0.8	m
Power Density at far field boundary (Elevation)		26.3	mW/cm^2
Safe Far Field Distance (Elevation)		1.8	m
Power Density		4.9	mW/cm^2
Safe Far Field Distance (Elevation)		4.0	m
Power Density		1.0	mW/cm^2

Conclusions

The worse-case radiation hazards exist along the main beam axis. In the case of the proposed experimental operations, it is highly unlikely that the antenna axis will be aligned with any uncontrolled area since experiments will be carefully monitored and limited in time, the antenna will be mounted on a building or vehicle rooftop, and transmit operations will only be conducted with a clear field of view towards the serving satellite. In this case, the safety radius where the General Population/Uncontrolled Exposure limits are satisfied is 4.0 meters.

That said, commissioning and testing of the Aura LE antenna will only be conducted by trained personnel in a controlled environment. By maintaining a safety radius of 22 meters during transmit operations, it can be guaranteed that the General Population/Uncontrolled Exposure limits will not be exceeded under any test conditions.