CESIUM

Radiation Hazard Analysis

Cesium Mission 1

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1 PURPOSE

Per CFR 47, Section 1.1307.b(1), Table 1, all applications for experimental operations with an ERP greater than 100 W require evaluation for compliance with human exposure limits defined in Section 1.1310.

2 RADIO ANALYSES

Each transmitter within the mission that exceeds this ERP limit is listed here with its relevant specifications for calculations. These calculations provide validation for the results listed. For analyses involving power density calculations, the following equation is used:

$$\mathrm{P} = \frac{p_t g_t}{4\pi r^2}$$

P is the power density of the antenna (W/m^2) at a given distance r (m), p_t is the output power of the antenna (W), and g_t is the gain of the antenna. The distance r is the minimum safe distance from the antenna to the target area, and this equation is inverted to solve for r.

The below calculations define the minimum safe working distance for both Occupational and General Public, which are based on the maximum permissible exposure limits of 5 mW/cm^2 and 1 mW/cm^2 respectively.

2.1 NIGHTINGALE 1

The Cesium Nightingale 1 is an experimental Ka-band active phased antenna system mounted to the spacecraft in the mission. The antenna will be operated in space, where human exposure that would exceed safe working distances will not occur. For test operations on the ground, the antenna will be operated in a controlled area. Only persons authorized to work with this antenna will be allowed access to the area of operation. In addition, the transmitter will be secured prior to ground operation, and the area will be monitored during ground operation to ensure that personnel are clear of any radiation hazard area. This antenna only operates when there is a suitable link between the spacecraft and the ground station(s).

Transmitter Power (dBW):	4.15
Transmitter Power (W):	2.6
Maximum Antenna Gain (dBi):	27
Non-dimensional Antenna Gain:	501.19
ERP (dBW):	33
ERP (W):	1995.3

Minimum Safe Distance		
	Occupational	General Public
Meters:	1.45	3.23
Feet:	4.76	10.6

2.2 KA-BAND GROUND STATIONS

The Cesium Ka-band ground stations are designed to communicate with the spacecraft in the mission. The antenna will be operated in a controlled area. Only persons authorized to work with this antenna will be allowed access to the area of operation. In addition, the transmitter will be secured prior to operation, and the area will be monitored during operation to ensure that personnel are clear of any radiation hazard area. This antenna only operates when there is a suitable link between the spacecraft and the ground station(s)

with a minimum operational angle of 15 degrees above the horizon. Operation of the antenna will not be conducted in directions that would expose the general public or personnel to harmful radiation.

Transmitter Power (dBW):	10
Transmitter Power (W):	10
Maximum Antenna Gain (dBi):	56.6
Non-dimensional Antenna Gain:	457088.19
ERP (dBW):	66.1
ERP (kW):	4073.8

Minimum Safe Distance		
	Occupational	General Public
Meters:	85.3	190.72
Feet:	279.86	625.72

2.3 S-BAND GROUND STATIONS

The Cesium S-band ground stations are designed to communicate with the spacecraft in the mission. The antenna will be operated in a controlled area. Only persons authorized to work with this antenna will be allowed access to the area of operation. In addition, the transmitter will be secured prior to operation, and the area will be monitored during operation to ensure that personnel are clear of any radiation hazard area. This antenna only operates when there is a suitable link between the spacecraft and the ground station(s) with a minimum operational angle of 15 degrees above the horizon. Operation of the antenna will not be conducted in directions that would expose the general public or personnel to harmful radiation.

Transmitter Power (dBW):	6.02
Transmitter Power (W):	4
Maximum Antenna Gain (dBi):	31
Non-dimensional Antenna Gain:	1258.93
ERP (dBW):	36.75
ERP (W):	4732

Minimum Safe Distance		
	Occupational	General Public
Meters:	2.84	6.34
Feet:	9.32	20.8