Radiation Hazard Analysis
Swarm Customer Mobile Earth Station

Introduction

This analysis demonstrates compliance with applicable radiation limits for Swarm customer mobile earth station devices ("CMES devices"). The calculations performed in this analysis comply with the methods described in Federal Communications Commission Office of Engineering & Technology Bulletin, Number 65 (Edition 97-01) ("OET Bulletin 65") and demonstrate compliance with the Maximum Permissible Exposure ("MPE") limits set forth in Section 1.1310 of the Commission's rules.

Customer Mobile Earth Station Description and Operating Parameters

Swarm's CMES devices fulfill the criteria for mobile devices set forth in Section 2.1091(b) of the Commission's rules, as the devices can be readily relocated and are generally operated a minimum distance of 20 centimeters from the human body. The installation and operating manuals for the Swarm CMES devices will specify a minimum 20 cm separation distance between any person, including the user, and the earth station antenna while operating the device.

Section 1.1310 of the Commission's rules and OET Bulletin 65 specify radiation limits for two different scenarios: occupational/controlled exposures and general population/uncontrolled exposures. The limits for occupational/controlled exposure apply when 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. General population/uncontrolled exposure limits apply in situations in which the general public may be exposed, or in which persons that 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.

Swarm's CMES devices will be deployed in a wide variety of commercial and industrial applications. As such, the analysis below reflects the more restrictive general population/uncontrolled exposure limits to demonstrate compliance in all potential deployment environments and scenarios. The applicable MPE limits for general population/uncontrolled exposure for CMES devices are shown in Table 1.

Table 1. MPE limits for general population/uncontrolled exposure for Swarm CMES devices.[1]

Frequency Range (MHz)	Electric Field Strength (E) (V/m)	Magnetic Field Strength (H) (A/m)	Power Density (S) (mW/cm²)	Averaging Time $|E|^2$, $|H|^2$, or S (minutes)
30-300	27.5	0.073	0.2	30

As specified in Section 2.1091 of the Commission's rules, for mobile devices intended for use in general population/uncontrolled environments, "source-based" time-averaging based on an inherent property or duty-cycle of a device is permitted.[2] The maximum duty cycle of a Swarm CMES device is 1% over any fifteen-minute period. The maximum duty cycle over the averaging time of thirty minutes specified in Table 1 is also 1%, and the radiation hazard analysis below accounts for this maximum duty cycle value.

Analysis

As described in OET Bulletin 65, the following equation predicts RF field strength and power density levels around a radiating antenna:[3]

$$S = \frac{PG}{4\pi R^2}$$

where: S = power density
P = power input to the antenna
G = power gain of the antenna in the direction of interest relative to an isotropic radiator
R = distance to the center of radiation of the antenna

For a Swarm CMES device, the maximum power input to the antenna is 5.0W and the maximum gain is 5.5 dBi. The minimum operating distance between a user and the device is 20 cm. For evaluation of compliance with the time-averaged power density requirement over thirty minutes (see Table 1), the maximum power density level was multiplied by the maximum duty cycle of 1%.

$$S_{time\ avg} = 0.01 * \frac{5000\ mW * 10^{\frac{5.5}{10}}}{4 * \pi * (20\ cm)^2} = 0.035\ \frac{mW}{cm^2}$$

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[1]   *See* 47 C.F.R. § 1.1310(e) and Federal Communications Commission Office of Engineering & Technology Bulletin, Number 65 (Edition 97-01) ("OET Bulletin 65").

[2]   *See* 47 C.F.R. § 2.1091(d)(2).

[3]   As OET Bulletin 65 notes, "These equations are generally accurate in the far-field of an antenna but will over-predict power density in the near field, where they could be used for making a "worst case" or conservative prediction." OET Bulletin 65 at 19.

As shown, a Swarm CMES device operates with a maximum power density of 0.035 mW/cm^2 over the applicable averaging time, and therefore does not exceed the MPE limit of 0.2 mW/cm^2 averaged over a thirty-minute period.

Conclusion

As demonstrated in the analysis above, operation of Swarm's customer mobile earth stations will not result in exposure levels exceeding the applicable radiation hazard limits.