INTRODUCTION

The FCC adopted new guidelines and procedures in 1996 for evaluating environmental effects of radio frequency (RF) emissions. In order to provide assistance in determining whether proposed or existing transmitting facilities comply with the new guidelines, the FCC Office of Engineering and Technology revised OET Bulletin 65. The revised version updates limits for Maximum Permissible Exposure (MPE) in terms of electric and magnetic field strength and power density for transmitters operating at frequencies between 300 kHz and 100 GHz. This bulletin was adopted by the FCC in their General Docket No. 97-303 on August 25, 1997. In order to comply with the requirements of the Report and Order, calculations to determine the power flux densities in the far field, near field, and reflector regions of the earth station antenna have been made and are contained in this study.

The FCC guidelines incorporate two separate tiers of exposure limits that are dependent on the situation in which the exposure takes place and the status of the individuals who are subject to exposure. The earth station transmitting equipment and antenna are located within a controlled area and not accessible to the general public. Entry is restricted to employees who have been made fully aware of the potential for human exposure and can exercise control over their exposure. Therefore occupational / controlled exposure maximum power density limits are used in this study.

The FCC Office of Engineering and Technology suggests a method for calculating the maximum values of the power densities emanating from an aperture antenna in OET bulletin 65. This method is used to determine the power densities associated with the satellite antenna.

The Seatel 4412 Ka-Band satellite antenna will be equipped with an amplifier supplying a maximum output power, *P*, at the antenna flange of *P*= 12.3 Watts. The transmitter will feed the antenna with diameter *D* = 1.1 meters. Its efficiency is η=0.57. The highest frequency of the transmitted signal is 29,100 MHz, corresponding to a wavelength of λ = 0.0103 m. Its peak gain is *G* = 48.1 dBi.

Antenna Surface: The maximum power density at the antenna surface, $S_{surface}$ may be expressed as:

$$S_{surface} = \frac{4P}{A}$$

Using the parameters for the antenna:

$$A = (\pi (D / 2)^2)$$
$$= (\pi (1.1 \text{ m} / 2)^2)$$
$$= 0.95 \text{ m}^2$$

$S_{surface}$ = 4 (12.3 W) / 0.95 m^2
= 49.2 W / 0.95 m^2
= 51.8 W / m^2
= 5.18 mW / cm^2

Near- Field Region: In the near field of the main beam the power density can reach a maximum before it begins to decrease with distance. The extent of the near field, R_{nf}, can be described by the following equation:

$$R_{nf} = \frac{D^2}{4\lambda}$$

Using the parameters for this antenna:

R_{nf} = $(1.1 \text{ m})^2$ / 4(0.0103 m)
= 1.21 m^2 / .04 m
= 29.4 m

The magnitude of the on axis power density varies according to location in the near field. However, the maximum value of the near field, on axis, power density, S_{nf}, can be expressed by the following equation:

$$S_{nf} = \frac{16\eta P}{\pi D^2}$$

Using the parameters for this antenna:

S_{nf} = 16 (.57) (12.3 W) / π $(1.1 \text{ m})^2$
= 112.18 W / 3.8 m^2
= 29.5 W / m^2
= 2.95 mW / cm^2

Far Field Region: For purposes of evaluating RF exposure, the distance to the beginning of the far field region, R_{ff}, can be approximated by the following equation:

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

Using the parameters for this antenna:

R_{ff} = 0.6 (1.1 m) ^{2} / .0103 m
= 70.5 m

The power density in the far field region of the antenna pattern decreases inversely as the square of the distance. The on-axis power density, S_{ff}, in the far field region of the radiation pattern can be estimated by the equation:

$$S_{ff} = PG / 4\pi R^2$$

where R = distance to the point of interest

Using the parameters for this antenna, the maximum power in the far field, at R = 131 m is:

S_{ff} = 12.3 W ($10^{(48.1\ dBi/10)}$) / 4 (π) (70.5)^2
= 2582617 /62406.2
=12.7 W / m^2
= 1.27 mW / cm^2

CONCLUSION

The results of the above calculations are summarized in the following table.

Region		Power Density	Remarks
Antenna Surface		5.2 mW/cm²	**Hazardous**
Near Field	**<** 29.4 meters	3.0 mW/cm²	Safe Level
Far Field	> 70.5 meters	1.3 mW/cm²	Safe Level

Results of this hazard study indicate that the antenna does not exceed the 5 mW/cm² MPE limit for Occupational/Controlled Exposure in the 1500 – 100,000 MHz range in areas directly in front of the antenna in the near field and the far field. The only area where the antenna exceeds the limit is at its surface. To ensure there is no harmful exposure to personnel, they will not be positioned directly at the antenna while it is operating. Whenever they are required to work on the radiating or reflecting parts of the antenna, the transmitter will be turned off.

The antenna will be located in a fenced-off area sufficient to ensure near field is not publically accessible.

Based on this study of predicted radio frequency levels, the conclusion is that the operation of this satellite earth station meets OET Bulletin 65 maximum permissible exposure limits and that no harmful effects will occur to station personnel or anyone within proximity of the station.

Therefore, in accordance with 47 CFR § 1.1307 (b) of the Commission's Rules, preparation and submission of an Environmental Assessment (EA) is not required.

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The FCC guidelines incorporate two separate tiers of exposure limits that are dependent on the situation in which the exposure takes place and the status of the individuals who are subject to exposure. The earth station transmitting equipment and antenna are located within a controlled area and not accessible to the general public. Entry is restricted to employees who have been made fully aware of the potential for human exposure and can exercise control over their exposure. Therefore occupational / controlled exposure maximum power density limits are used in this study.

The FCC Office of Engineering and Technology suggests a method for calculating the maximum values of the power densities emanating from an aperture antenna in OET bulletin 65. This method is used to determine the power densities associated with the satellite antenna.

The Viasat GAT-5530 Ka-Band satellite antenna will be equipped with an amplifier supplying a maximum output power, *P*, at the antenna flange of *P*= 19.1 Watts. The transmitter will feed the antenna with diameter *D* = 0.77 meters. Its efficiency is η=0.16. The highest frequency of the transmitted signal is 29,100 MHz, corresponding to a wavelength of λ = 0.0103 m. Its peak gain is *G* = 39.4 dBi. The area of the antenna, given its dimensions, is 0.77 m*0.15 m=0.12 m^2

Antenna Surface: The maximum power density at the antenna surface, $S_{surface}$ may be expressed as:

$$S_{surface} = \frac{4P}{A}$$

Using the parameters for the antenna:

$S_{surface}$ = 4 (19.1 W) / 0.12 m^2
= 654.5 W / m^2
= 65.5 mW / cm^2

Near- Field Region: In the near field of the main beam the power density can reach a maximum before it begins to decrease with distance. The extent of the near field, R_{nf} , can be described by the following equation:

$$R_{nf} = \frac{D^2}{4\lambda}$$

Using the parameters for this antenna:

$$R_{nf} = (0.77 \text{ m})^2 / 4(0.0103 \text{ m})$$
$$= 14.3 \text{ m}$$

The magnitude of the on axis power density varies according to location in the near field. However, the maximum value of the near field, on axis, power density, S_{nf} , can be expressed by the following equation:

$$S_{nf} = \frac{16\eta P}{\pi D^2}$$

Using the parameters for this antenna:

$$S_{nf} = 16\ (.16)\ (19.2 \text{ W}) / \pi\ (0.77 \text{ m})^2$$
$$= 26.5 \text{ W} / \text{m}^2$$
$$= 2.65 \text{ mW} / \text{cm}^2$$

Far Field Region: For purposes of evaluating RF exposure, the distance to the beginning of the far field region, R_{ff}, can be approximated by the following equation:

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

Using the parameters for this antenna:

R_{ff} = 0.6 (0.77 m) ^{2} / .0103 m
= 34.3 m

The power density in the far field region of the antenna pattern decreases inversely as the square of the distance. The on-axis power density, S_{ff}, in the far field region of the radiation pattern can be estimated by the equation:

$$S_{ff} = PG / 4\pi R^2$$

where *R* = distance to the point of interest

Using the parameters for this antenna, the maximum power in the far field, at *R* = 34.3 m is:

S_{ff} = 19.2 W ($10^{(39.4 \text{ dBi}/10)}$) / 4 ($\pi$) (34.3) ^{2}
=11.3 W / m ^{2}
= 1.13 mW / cm ^{2}

CONCLUSION

The results of the above calculations are summarized in the following table.

Region	Power Density	Remarks
Antenna Surface	65.4 mW/cm²	**Hazardous**
Near Field ≤ 14.3 meters	2.7 mW/cm²	Safe Level
Far Field ≥ 34.3 meters	1.1 mW/cm²	Safe Level

Results of this hazard study indicate that the antenna does not exceed the 5 mW/cm² MPE limit for Occupational/Controlled Exposure in the 1500 – 100,000 MHz range in areas directly in front of the antenna in the near field and the far field. The only area where the antenna exceeds the limit is at its surface. To ensure there is no harmful exposure to personnel, they will not be positioned directly at the antenna while it is operating. Whenever they are required to work on the radiating or reflecting parts of the antenna, the transmitter will be turned off.

The antenna will be located in a fenced-off area sufficient to ensure it is not publicly accessible.

Based on this study of predicted radio frequency levels, the conclusion is that the operation of this satellite earth station meets OET Bulletin 65 maximum permissible exposure limits and that no harmful effects will occur to station personnel or anyone within proximity of the station.

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The FCC guidelines incorporate two separate tiers of exposure limits that are dependent on the situation in which the exposure takes place and the status of the individuals who are subject to exposure. The earth station transmitting equipment and antenna are located within a controlled area and not accessible to the general public. Entry is restricted to employees who have been made fully aware of the potential for human exposure and can exercise control over their exposure. Therefore occupational / controlled exposure maximum power density limits are used in this study.

The FCC Office of Engineering and Technology suggests a method for calculating the maximum values of the power densities emanating from an aperture antenna in OET bulletin 65. This method is used to determine the power densities associated with the satellite antenna.

The Viasat G-12 Ka-Band satellite antenna will be equipped with an amplifier supplying a maximum output power, P, at the antenna flange of P= 21.9 Watts. The transmitter will feed the antenna with diameter D = 0.30 meters. Its efficiency is η=0.44. The highest frequency of the transmitted signal is 29,100 MHz, corresponding to a wavelength of λ = 0.0103 m. Its peak gain is G = 35.8 dBi.

Antenna Surface: The maximum power density at the antenna surface, $S_{surface}$ may be expressed as:

$$S_{surface} = \frac{4P}{A}$$

where A is the area of the antenna

Using the parameters for the antenna:

$A = (\pi (D / 2)^2)$
$= (\pi (0.30 \text{ m} / 2)^2)$
$= 0.073 \text{ m}^2$

$S_{surface} = 4 (21.9 \text{ W}) / 0.073 \text{ m}^2$
$= 1199 \text{ W} / \text{m}^2$
$= 119.9 \text{ mW} / \text{cm}^2$

Near- Field Region: In the near field of the main beam the power density can reach a maximum before it begins to decrease with distance. The extent of the near field, R_{nf}, can be described by the following equation:

$$R_{nf} = \frac{D^2}{4\lambda}$$

Using the parameters for this antenna:

$R_{nf} = (0.30 \text{ m})^2 / 4(0.0103 \text{ m})$
$= 2.3 \text{ m}$

The magnitude of the on axis power density varies according to location in the near field. However, the maximum value of the near field, on axis, power density, S_{nf}, can be expressed by the following equation:

$$S_{nf} = \frac{16\eta P}{\pi D^2}$$

Using the parameters for this antenna:

$S_{nf} = 16 (0.44) (21.9 \text{ W}) / \pi (0.30 \text{ m})^2$
$= 528 \text{ W} / \text{m}^2$
$= 52.8 \text{ mW} / \text{cm}^2$

Far Field Region: For purposes of evaluating RF exposure, the distance to the beginning of the far field region, R_{ff}, can be approximated by the following equation:

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

Using the parameters for this antenna:

$$R_{ff} = 0.6\ (0.30\ \text{m})^2 / .0103\ \text{m}$$
$$= 5.41\ \text{m}$$

The power density in the far field region of the antenna pattern decreases inversely as the square of the distance. The on-axis power density, S_{ff}, in the far field region of the radiation pattern can be estimated by the equation:

$$S_{ff} = PG / 4\pi R^2$$

where *R* = distance to the point of interest

Using the parameters for this antenna, the maximum power in the far field, at *R* = 5.41 m is:

$$S_{ff} = 21.9\ \text{W}\ (10^{(35.8\ \text{dBi}/10)}) / 4\ (\pi)\ (5.41)^2$$
$$= 226\ \text{W} / \text{m}^2$$
$$= 22.6\ \text{mW} / \text{cm}^2$$

CONCLUSION

The results of the above calculations are summarized in the following table.

Region	Power Density	Remarks
Antenna Surface	119.9 mW/cm²	**Hazardous**
Near Field ≤ 2.3 meters	52.8 mW/cm²	**Hazardous**
Far Field ≥ 5.4 meters	22.6 mW/cm²	**Hazardous**

Results of this hazard study indicate that the antenna significantly exceeds the 5 mW/cm² MPE limit for Occupational/Controlled Exposure in the 1500 – 100,000 MHz range in the near field, the far field, and at the antenna surface.

The antenna will be located in a fenced-off area sufficient to ensure it is not publicly accessible. To ensure there is no harmful exposure to personnel, they will not be permitted within 5.4 m of the antenna while it is operating. This places them away from the antenna surface and outside of the near field and transition regions. Whenever they are required to work on the radiating or reflecting parts of the antenna, the transmitter will be turned off.

The far field begins 5.4 m from the antenna. Given that the antenna height above ground level is 2.0 m, the assumed maximum height of any personnel is 2.0m, and the minimum elevation angle is 20°, the minimum separation angle between the center of the antenna beam and a person in the far field is 20°.

At 20° off-bore, the antenna gain falls within the envelope of 29-25*log(θ). This means the gain is 29-25*log(20) = -3.5 dBi. This is 39.3 dBi below the peak antenna gain value of 35.8 dBi towards the center of the beam, and therefore the maximum power density that anyone in the far field standing on the ground would be exposed to is 22.6 mW/cm² (max density in beam center) – 39.3 = -16.7 mW/cm². This is well below the 5 mW/cm² MPE limit. Therefore no further restrictions are required beyond keeping personnel at least 5.4 m from the antenna.

Based on this study of predicted radio frequency levels, the conclusion is that, given the above restrictions, the operation of this satellite earth station meets OET Bulletin 65 maximum permissible exposure limits and that no harmful effects will occur to station personnel or anyone within proximity of the station.

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The FCC Office of Engineering and Technology suggests a method for calculating the maximum values of the power densities emanating from an aperture antenna in OET bulletin 65. This method is used to determine the power densities associated with the satellite antenna.

The Viasat G-18 Ka-Band satellite antenna will be equipped with an amplifier supplying a maximum output power, *P*, at the antenna flange of *P*= 15.9 Watts. The transmitter will feed the antenna with diameter *D* = 0.46 meters. Its efficiency is η=0.54. The highest frequency of the transmitted signal is 29,100 MHz, corresponding to a wavelength of λ = 0.0103 m. Its peak gain is *G* = 40.2 dBi.

Antenna Surface: The maximum power density at the antenna surface, $S_{surface}$ may be expressed as:

$$S_{surface} = \frac{4P}{A}$$

where *A* is the area of the antenna

Using the parameters for the antenna:

$A = (\pi\,(D / 2)^2)$
$= (\pi\,(0.46\text{ m} / 2)^2)$
$= 0.16\text{ m}^2$

$S_{surface} = 4\,(15.9\text{ W}) / 0.16\text{ m}^2$
$= 368\text{ W} / \text{m}^2$
$= 36.8\text{ mW} / \text{cm}^2$

Near- Field Region: In the near field of the main beam the power density can reach a maximum before it begins to decrease with distance. The extent of the near field, R_{nf}, can be described by the following equation:

$$R_{nf} = \frac{D^2}{4\lambda}$$

Using the parameters for this antenna:

$R_{nf} = (0.46\text{m})^2 / 4(0.0103\text{ m})$
$= 5.1\text{ m}$

The magnitude of the on axis power density varies according to location in the near field. However, the maximum value of the near field, on axis, power density, S_{nf}, can be expressed by the following equation:

$$S_{nf} = \frac{16\eta P}{\pi D^2}$$

Using the parameters for this antenna:

$S_{nf} = 16\,(0.54)\,(15.9\text{ W}) / \pi\,(0.46\text{ m})^2$
$= 528\text{ W} / \text{m}^2$
$= 20.8\text{ mW} / \text{cm}^2$

Far Field Region: For purposes of evaluating RF exposure, the distance to the beginning of the far field region, R_{ff} , can be approximated by the following equation:

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

Using the parameters for this antenna:

R_{ff} = 0.6 (0.46 m) ^{2} / .0103 m
= 12.2 m

The power density in the far field region of the antenna pattern decreases inversely as the square of the distance. The on-axis power density, S_{ff} , in the far field region of the radiation pattern can be estimated by the equation:

$$S_{ff} = PG / 4\pi R^2$$

where *R* = distance to the point of interest

Using the parameters for this antenna, the maximum power in the far field, at *R* = 5.41 m is:

S_{ff} = 15.9W ($10^{(40.2\ dBi/10)}$) / 4 (π) (12.2) ^{2}
= 226 W / m ^{2}
= 8.9 mW / cm ^{2}

CONCLUSION

The results of the above calculations are summarized in the following table.

Region	Power Density	Remarks
Antenna Surface	36.8 mW/cm²	**Hazardous**
Near Field ≤ 5.1 meters	20.8 mW/cm²	**Hazardous**
Far Field ≥ 12.2 meters	8.9 mW/cm²	**Hazardous**

Results of this hazard study indicate that the antenna exceeds the 5 mW/cm² MPE limit for Occupational/Controlled Exposure in the 1500 – 100,000 MHz range in the near field, the far field, and at the antenna surface.

The antenna will be located in a fenced-off area sufficient to ensure it is not publicly accessible. To ensure there is no harmful exposure to personnel, they will not be permitted within 12.2 m of the antenna while it is operating. This places them away from the antenna surface and outside of the near field and transition regions. Whenever they are required to work on the radiating or reflecting parts of the antenna, the transmitter will be turned off.

The far field begins 12.2 m from the antenna. Given that the antenna height above ground level is 2.0 m, the assumed maximum height of any personnel is 2.0m, and the minimum elevation angle is 20°, the minimum separation angle between the center of the antenna beam and a person in the far field is 20°.

At 20° off-bore, the antenna gain falls within the envelope of 29-25*log(θ). This means the gain is 29-25*log(20) = -3.5 dBi. This is 39.3 dBi below the peak antenna gain value of 35.8 dBi towards the center of the beam, and therefore the maximum power density that anyone in the far field standing on the ground would be exposed to is 8.9 mW/cm² (max density in beam center) – 39.3 = -30.4 mW/cm². This is well below the 5 mW/cm² MPE limit. Therefore no further restrictions are required beyond keeping personnel at least 12.2 m from the antenna.

Based on this study of predicted radio frequency levels, the conclusion is that, given the above restrictions, the operation of this satellite earth station meets OET Bulletin 65 maximum permissible exposure limits and that no harmful effects will occur to station personnel or anyone within proximity of the station.

Therefore, in accordance with 47 CFR § 1.1307 (b) of the Commission's Rules, preparation and submission of an Environmental Assessment (EA) is not required.