FCC RF Hazard Compliance Analysis for Speedcast ESV Terminals

In connection with this earth station application by Speedcast, for operation of five maritime ESIM (or ESV) terminals, 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 Overview of Earth Stations and Operational Characteristics

The relevant data for the subject operation is summarized below.

Maritime Terminal A

- Transmitting Frequency Band: 14.0-14.5 GHz
- Antenna Manufacturer / Model: Cobham Sailor 900
- Antenna Dimension: 1.0 meter radius
- Net Power Input to Antenna (at flange): 5.8 Watts
- Antenna gain: 41.6 dBi
- Maximum EIRP: 49.23 dBW

Maritime Terminal B

- Transmitting Frequency Band: 14.0-14.5 GHz
- Antenna Manufacturer / Model: Seatel 5012
- Antenna Dimension: 1.2 meter radius
- Net Power Input to Antenna (at flange): 8.4 Watts
- Antenna gain: 43.3 dBi
- Maximum EIRP: 52.54 dBW

Maritime Terminal C

- Transmitting Frequency Band: 14.0-14.5 GHz
- Antenna Manufacturer / Model: Intellian V150NX
- Antenna Dimension: 1.5 meter radius
- Net Power Input to Antenna (at flange): 13.0 Watts
- Antenna gain: 45.0 dBi
- Maximum EIRP: 56.14 dBW

Maritime Terminal D

- Transmitting Frequency Band: 14.0-14.5 GHz

- Antenna Manufacturer / Model: Intellian V240MT
- Antenna Dimension: 2.4 meter radius
- Net Power Input to Antenna (at flange): 33.0 Watts
- Antenna gain: 48.6 dBi
- Maximum EIRP: 63.79 dBW

Maritime Terminal E

- Transmitting Frequency Band: 5.850-6.425 GHz
- Antenna Manufacturer / Model: Intellian V240MT
- Antenna Dimension: 2.4 meter radius
- Net Power Input to Antenna (at flange): 33.0 Watts
- Antenna gain: 41.7 dBi
- Maximum EIRP: 56.89 dBW

2 Applicable MPE Limits

The MPE limits are described in the FCC Rules and Regulations. For the frequency ranges 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 resulting exposure values are compared to the latter limit in this analysis.

The occupational/controlled limit is applied to the maritime installations because the terminal(s) are mounted on the vessel superstructure or on elevated poles/masts in locations inaccessible to passengers and the general public. Access is restricted to operational and maintenance personnel who receive RF safety training and terminal-specific hazard briefings covering:

- Identification and avoidance of the RF hazard zone(s) around each terminal
- Required power-down / lock-out procedures before entering a hazard zone for maintenance
- Recognition of terminal labeling and posted RF warning signage

3 FCC Formulas and Calculations

FCC Bulletin OET 65 provides standardized formulas for calculating the power density in the regions of interest. Using the formulas from Bulletin OET 65, the exposure levels are reported for (1) 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. Each area of interest will be addressed below and the results of the calculations are given.

3.1 Maritime Terminal A

Table 1 provides the input parameters and resulting antenna surface, near field and far field power densities for Maritime Terminal A.

Table 1 – Maritime Terminal A Power Density Calculations

Power Flux Density Calculations - Marine Terminal A				
Input Parameters				
Item	**Symbol**	**Value**	**Units**	**Derivation**
Frequency	f	14250	MHz	input
Speed of light	c	299792458	m/s	constant
Wavelength	λ	0.02	m	c/f
Antenna diameter	D	1.00	m	input
Antenna surface area	A_{as}	0.79	m^2	$\pi(D/2)^2$
Antenna gain	G	41.60	dBi	input
Antenna efficiency	η	0.60	-	$G\lambda^2/(\pi D)^2$
Feed flange area	A_f		cm^2	input
Transmit power into antenna	P	5.80	W	input
Far Field Calculations				
Distance to far field	R_f	28.50	m	$0.6D^2/\lambda$
Maximum power density in far field	S_f	8.21	W/m^2	$GP/(4\pi R_f^2)$
		0.821	mW/cm^2	Convert W to mW and m^2 to cm^2
Near Field Calculations				
Distance to edge of near field	R_n	11.88	m	$D^2/4\lambda$
Maximum power density in near field (revised)	S_n'	49.232	W/m^2	4P/ηA (updated OET formula)
	S_n'	4.923	mW/cm^2	Convert W to mW and m^2 to cm^2
Antenna Surface Region Calculations				
Power density at antenna surface	S_{sur}	29.54	W/m^2	$4P/A_{as}$
		2.954	mW/cm^2	Convert W to mW and m^2 to cm^2

The maximum power densities at the antenna surface and the near field fall under the controlled, occupational MPE limit. The far field power density also does not exceed the uncontrolled general population MPE limit.

3.2 Maritime Terminal B

Table 2 provides the input parameters and resulting antenna surface, near field and far field power densities for Maritime Terminal B.

Table 2 – Maritime Terminal B Power Density Calculations

Power Flux Density Calculations - Marine Terminal B				
Input Parameters				
Item	**Symbol**	**Value**	**Units**	**Derivation**
Frequency	f	14250	MHz	input
Speed of light	c	299792458	m/s	constant
Wavelength	λ	0.02	m	c/f
Antenna diameter	D	1.20	m	input
Antenna surface area	A_{as}	1.13	m^2	$\pi(D/2)^2$
Antenna gain	G	43.30	dBi	input
Antenna efficiency	η	0.60	-	$G\lambda^2/(\pi D)^2$
Feed flange area	A_f	167.42	cm^2	input
Transmit power into antenna	P	8.40	W	input
Far Field Calculations				
Distance to far field	R_f	41.04	m	$0.6D^2/\lambda$
Maximum power density in far field	S_f	8.49	W/m^2	$GP/(4\pi R_f^2)$
		0.849	mW/cm^2	Convert W to mW and m^2 to cm^2
Near Field Calculations				
Distance to edge of near field	R_n	17.10	m	$D^2/4\lambda$
Maximum power density in near field (revised)	S_n'	49.515	W/m^2	4P/ηA (updated OET formula)
	S_n'	4.951	mW/cm^2	Convert W to mW and m^2 to cm^2
Antenna Surface Region Calculations				
Power density at antenna surface	S_{sur}	29.71	W/m^2	$4P/A_{as}$
		2.971	mW/cm^2	Convert W to mW and m^2 to cm^2

The maximum power densities at the antenna surface and the near field fall under the controlled, occupational MPE limit. The far field power density also does not exceed the uncontrolled general population MPE limit.

3.3 Maritime Terminal C

Table 3 provides the input parameters and resulting antenna surface, near field and far field power densities for Maritime Terminal C.

Table 3 – Maritime Terminal C Power Density Calculations

Power Flux Density Calculations Marine Terminal C				
Input Parameters				
Item	**Symbol**	**Value**	**Units**	**Derivation**
Frequency	f	14250	MHz	input
Speed of light	c	299792458	m/s	constant
Wavelength	λ	0.02	m	c/f
Antenna diameter	D	1.50	m	input
Antenna surface area	A_{as}	1.77	m^2	$\pi(D/2)^2$
Antenna gain	G	45.00	dBi	input
Antenna efficiency	η	0.60	-	$G\lambda^2/(\pi D)^2$
Feed flange area	A_f	167.42	cm^2	input
Transmit power into antenna	P	13.00	W	input
Far Field Calculations				
Distance to far field	R_f	64.13	m	$0.6D^2/\lambda$
Maximum power density in far field	S_f	7.96	W/m^2	$GP/(4\pi R_f^2)$
		0.796	mW/cm^2	Convert W to mW and m^2 to cm^2
Near Field Calculations				
Distance to edge of near field	R_n	26.72	m	$D^2/4\lambda$
Maximum power density in near field (revised)	S_n'	49.043	W/m^2	4P/ηA (updated OET formula)
	S_n'	4.904	mW/cm^2	Convert W to mW and m^2 to cm^2
Antenna Surface Region Calculations				
Power density at antenna surface	S_{sur}	29.43	W/m^2	$4P/A_{as}$
		2.943	mW/cm^2	Convert W to mW and m^2 to cm^2

The maximum power densities at the antenna surface and the near field fall under the controlled, occupational MPE limit. The far field power density also does not exceed the uncontrolled general population MPE limit.

3.4 Maritime Terminal D

Table 4 provides the input parameters and resulting antenna surface, near field and far field power densities for Maritime Terminal D.

Table 4 – Maritime Terminal D Power Density Calculations

Power Flux Density Calculations - Marine Terminal D				
Input Parameters				
Item	**Symbol**	**Value**	**Units**	**Derivation**
Frequency	f	14250	MHz	input
Speed of light	c	299792458	m/s	constant
Wavelength	λ	0.02	m	c/f
Antenna diameter	D	2.40	m	input
Antenna surface area	A_{as}	4.52	m^2	$\pi(D/2)^2$
Antenna gain	G	48.60	dBi	input
Antenna efficiency	η	0.60	-	$G\lambda^2/(\pi D)^2$
Feed flange area	A_f	167.42	cm^2	input
Transmit power into antenna	P	33.00	W	input
Far Field Calculations				
Distance to far field	R_f	164.16	m	$0.6D^2/\lambda$
Maximum power density in far field	S_f	7.06	W/m^2	$GP/(4\pi R_f^2)$
		0.706	mW/cm^2	Convert W to mW and m^2 to cm^2
Near Field Calculations				
Distance to edge of near field	R_n	68.40	m	$D^2/4\lambda$
Maximum power density in near field (revised)	S_n'	48.631	W/m^2	4P/ηA (updated OET formula)
	S_n'	4.863	mW/cm^2	Convert W to mW and m^2 to cm^2
Antenna Surface Region Calculations				
Power density at antenna surface	S_{sur}	29.18	W/m^2	$4P/A_{as}$
		2.918	mW/cm^2	Convert W to mW and m^2 to cm^2

The maximum power densities at the antenna surface and the near field fall under the controlled, occupational MPE limit. The far field power density also does not exceed the uncontrolled general population MPE limit.

3.5 Maritime Terminal E

Table 5 provides the input parameters and resulting antenna surface, near field and far field power densities for Maritime Terminal E.

Table 5 – Maritime Terminal E Power Density Calculations

Power Flux Density Calculations - Marine Terminal E				
Input Parameters				
Item	**Symbol**	**Value**	**Units**	**Derivation**
Frequency	f	6138	MHz	input
Speed of light	c	299792458	m/s	constant
Wavelength	λ	0.05	m	c/f
Antenna diameter	D	2.40	m	input
Antenna surface area	A_{as}	4.52	m^2	$\pi(D/2)^2$
Antenna gain	G	41.70	dBi	input
Antenna efficiency	η	0.60	-	$G\lambda^2/(\pi D)^2$
Feed flange area	A_f	167.42	cm^2	input
Transmit power into antenna	P	33.00	W	input
Far Field Calculations				
Distance to far field	R_f	70.70	m	$0.6D^2/\lambda$
Maximum power density in far field	S_f	7.77	W/m^2	$GP/(4\pi R_f^2)$
		0.777	mW/cm^2	Convert W to mW and m^2 to cm^2
Near Field Calculations				
Distance to edge of near field	R_n	29.46	m	$D^2/4\lambda$
Maximum power density in near field (revised)	S_n'	48.631	W/m^2	4P/ηA (updated OET formula)
	S_n'	4.863	mW/cm^2	Convert W to mW and m^2 to cm^2
Antenna Surface Region Calculations				
Power density at antenna surface	S_{sur}	29.18	W/m^2	$4P/A_{as}$
		2.918	mW/cm^2	Convert W to mW and m^2 to cm^2

The maximum power densities at the antenna surface and the near field fall under the controlled, occupational MPE limit. The far field power density also does not exceed the uncontrolled general population MPE limit.

4 Compliance Conclusion

Speedcast and end users will observe standard safety precautions with respect to operations and maintenance of the maritime antennas described herein, including:

- RF hazard warning signage posted at all points of access to each terminal, stating the applicable exposure limit and minimum safe approach distance
- Physical barriers, guardrails, or deck markings delineating the RF hazard zone around each terminal
- Minimum safe approach distance from antenna aperture for trained personnel without power-down
- Mandatory power-down / lock-out-tag-out procedure before any maintenance work within the hazard zone
- RF safety awareness training required for all crew and contractors working near the terminals.

For all terminals, given the location of antennas, 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, and in the near and far fields – and taking into account the access restrictions for trained persons and standard safety procedures, the operation of the terminals analyzed in this report are considered meeting the FCC's maximum permitted exposure guidelines.