PFD Analysis For SC1 S Band Downlink

In connection with application 0409-EX-CN-2024, FCC has requested the following Power Flux Density (PFD) analysis for the S Band downlink of the spacecraft.

PFD Analysis Method:

PFD (dBW/m2-4kHz) is a function of:

EIRP: Effective, or Equivalent, Isotropically Radiated Power. The center beam equivalent power from the spacecraft antenna, in dBW. This is based on the power necessary to close the link at the desired encoded bit rate of 100 kbits/sec. This yields an EIRP of –1.99 dBW.

Bandwidth Spreading: The spectrum over which the power of the signal is distributed. This is a function of the telemetry bit rate, the coding rate and the modulation. Hz, which collectively determine symbol rate. The bandwidth is used is 200 kHz, which is the required bandwidth.

Reference Bandwidth: This is set by the Applicable Standard at 4 kHz.

Slant Distance to Earth: this is calculated based on the (minimum) altitude of the satellite, and the elevation angle relative to the horizon at the point where the center beam lands on the Earth Surface.

Beam Spreading Loss: the loss based on attenuation due to the distance the beam travels from the satellite to the point where the center beam lands on the Earth Surface. This is proportional to the square of the distance.

Atmospheric Attenuation Loss: This is a combination of the attenuation due to gases in the atmosphere, and attenuation due to the ionosphere.

Applicable Standard:

Radio Regulations, edition of 2016 Vol. 1: Articles, in Table 21-4 (Rev. WRC-15), in the row for 2200 to 2300 MHz, shows emission limits, expressed in units of dBW/m2-4kHz.

TABLE **21-4** (Rev.WRC-15)

Frequency band	**Service***	**Limit in dB(W/m²) for angles of arrival (δ) above the horizontal plane**				**Reference bandwidth**
		0°-5°	**5°-25°**		**25°-90°**	
1 670-1 700 MHz	Earth exploration-satellite Meteorological-satellite	−133 (value based on sharing with meteorological aids service)				1.5 MHz
1 518-1 525 MHz (Applicable to the territory of the United States in Region 2 between the longitudes 71° W and 125° W)	Mobile-satellite (space-to-Earth)	**0° ≤ δ ≤ 4°**	**4° < δ ≤ 20°**	**20° < δ ≤ 60°**	**60° < δ ≤ 90°**	4 kHz
		−181.0	−193.0 + 20 log δ	−213.3 + 35.6 log δ	−150.0	
1 518-1 525 MHz (Applicable to all other territory of the United States in Region 2)	Mobile-satellite (space-to-Earth)	**0° ≤ δ ≤ 43.4°**	**43.4° < δ ≤ 60°**		**60° < δ ≤ 90°**	4 kHz
		−155.0	−213.3 + 35.6 log δ		−150.0	
1 525-1 530 MHz [7] (Region 1, Region 3) 1 670-1 690 MHz [12] 1 690-1 700 MHz (Nos. **5.381** and **5.382**) 1 700-1 710 MHz 2 025-2 110 MHz 2 200-2 300 MHz	Meteorological-satellite (space-to-Earth) Space research (space-to-Earth) (space-to-space) Space operation (space-to-Earth) (space-to-space) Earth exploration-satellite (space-to-Earth) (space-to-space)	**0°-5°**	**5°-25°**		**25°-90°**	4 kHz
		−154 [9]	−154 + 0.5(δ − 5) [9]		−144 [9]	

To determine conformance, the calculated PFD is compared to the ITU PFD limit. It must be less than this limit, to be in conformance.

PFD Calculation Results:

Tables 1 and 2 show the calculated PFD at 5 degrees and at 90 degrees, and shows that in each case, the calculated PFD is lower than the ITU PFD limit.

Conclusion:

The SC-1 mission will conform to the ITU PFD limit.

Summary of Calculation

Table 1 PFD Calculation at 5 Degrees Elevation

Parameter	Value
Tx Power, dBW	-6.99
Connector Loss, dBi	2.00
Gain, dB	7.00
EIRP, dBW	-1.99
Bandwidth, Hz	200,000
Bandwidth, dBHz	53
Reference Bandwidth, Hz	4000
Reference Bandwidth, dbHz	36
EIRP Power Flux Density, dBW/4kHz	-18.99
Slant distance to Earth surface at minimum operating elevation, km	2083
Beam Spreading Loss to Earth Surface, dB	137.4
Atmospheric Attenuation Loss at Earth Surface, dB	2.2
Power Flux Density, at Earth Surface, dBW/m^2-4kHz	-158.59
PFD Limit, 5 degree elevation, From RR Article 21.16, Table 21-4, dBW/m^2-4kHz	-154
Margin, dBW/m^2-4kHz	4.59

Table 2 PFD Calculation at 90 Degrees Elevation

Parameter	Value
Tx Power, dBW	-6.99
Connector Loss, dBi	2.00
Gain, dB	7.00
EIRP, dBW	-1.99
Bandwidth, Hz	200,000
Bandwidth, dBHz	53
Reference Bandwidth, Hz	4000
Reference Bandwidth, dbHz	36
EIRP Power Flux Density, dBW/4kHz	-18.99
Distance to Nadir Point, Minimum, km	502
Beam Spreading Loss to Earth Surface, dB	125
Atmospheric Attenuation Loss at Earth Surface, dB	0.1
Power Flux Density, at Earth Surface, dBW/m^2-4kHz	-144.09
PFD Limit, 90 degree elevation, From RR Article 21.16, Table 21-4, dBW/m^2-4kHz	-144
Margin, dBW/m^2-4kHz	0.09