Exhibit F –SoFIE S-band Link Budget Analysis Results

7/8/2026

The SoFIE mission uses an S-band downlink capability to receive science data from the spacecraft (1 Mbps). To ensure reliable download, the link budget is evaluated under a worst-case geometric scenario using the AMSAT/IARU Annotated Link Model System (V2.5.5). All calculations assume the spacecraft is positioned at its maximum slant range and at a minimum operational horizon elevation angle of 15° relative to the ground station.

Downlink Technical Analysis

The downlink path dictates the transmission of spacecraft science data from the SoFIE CubeSat back to the ground station. Calculations demonstrate that the spacecraft's Effective Isotropically Radiated Power provides sufficient signal energy per bit over noise density, or Eb/No, at maximum slant range to maintain link closure using QPSK modulation.

SoFIE	NOTE:	SoFIE	Date Data Last Modified:
Downlink Telemetry Budget:		**Version: 2.5.5**	**2016 October 20**

Parameter:	Value:	Units:	Comments:
Spacecraft:			
Spacecraft Transmitter Power Output:	0.7	watts	This value is transferred from "Transmitters" W/S, Cell [E50]
In dBW:	-1.5	dBW	Transmitter power expressed in dB above one watt
In dBm:	28.5	dBm	Transmitter power expressed in dB above one milliwatt
Spacecraft Total Transmission Line Losses:	2.2	dB	This value is transferred from "Transmitters" W/S, Cell [I68]
Spacecraft Antenna Gain:	7.3	dBi	This value is selected at "Antenna Gain" W/S, Cell [E41]
Spacecraft EIRP:	3.7	dBW	Spacecraft Effective Isotropic Radiated Power (EIRP) [EIRP=Pt x Ltl x Ga]
Downlink Path:			
Spacecraft Antenna Pointing Loss:	0.6	dB	This value is calculated in the "Antenna Pointing Losses" W/S, and trasferred from Cell [K85]
S/C-to-Ground Antenna Polarization Loss:	0.1	dB	This value is calculated in the "Polarization Loss" W/S and is transferred from Cell [F60].
Path Loss:	163.2	dB	Lp = 22 + 20LOG(D/λ); Transferred from "Frequency" W/S
Atmospheric Loss:	2.1	dB	This value is transferred from "Atmos. & Ionos. Losses" W/S, Cell [D23]
Ionospheric Loss:	0.1	dB	This value is transferred from "Atmos. & Ionos. Losses" W/S, Cell [D47:D50]
Rain Loss:	0.0	dB	This value should be estimated by the link model operator and place into Cell [B18]
Isotropic Signal Level at Ground Station:	-162.4	dBW	This is the signal level received at the Earth in the vacinity of the ground station using an omnidirectional antenna.
Ground Station (EbNo Method):			
------- Eb/No Method -------			
Ground Station Antenna Pointing Loss:	1.4	dB	This value is transferred from "Antenna Pointing Losses" W/S, Cell [K102]
Ground Station Antenna Gain:	32.0	dBi	This value is selected at "Antenna Gain" W/S, Cell [E58]
Ground Station Total Transmission Line Losses:	2.0	dB	This value is transferred from the "Receivers" W/S, Cell [J123]
Ground Station Effective Noise Temperature:	193	K	This value is calculated in the "Receivers" W/S and Transferred from Cell [J138]
Ground Station Figure of Merit (G/T):	7.2	dB/K	G/T = Ga-Ltl-10log(Ts). This is the uptimate measure of the receiver's performance.
G.S. Signal-to-Noise Power Density (S/No):	72.0	dBHz	Boltzman's Constant: -228.6 dBW/K/Hz
System Desired Data Rate:	1000000	bps	Operator selects this value. Be Careful! This is the data rate, not the symbol rate.
In dBHz:	60.0	dBHz	This is simply = 10log(R); R= data rate
Telemetry System Eb/No for the Downlink:	12.0	dB	
Demodulation Method Seleted:	QPSK		Values selected in "Modulation-Demodulation W/S, Cell [E30]
Forward Error Correction Coding Used:	CCSDS QPSK BCH FEC		Value selected in "Modulation-Demodulation" W/S, also Cell [E30]
System Allowed or Specified Bit-Error-Rate:	1.0E-05		The selected value is transferred from the "Modulation-Demodulation W/S, Cells [E33:E50]
Demodulator Implementation Loss:	2	dB	This value is transferred from the "Modulation-Demodulation W/S, Cell[E52]
Telemetry System Required Eb/No:	7.2	dB	The selected value is transferred from the "Modulation-Demodulation W/S, Cells [F33:F50]
Eb/No Threshold:	9.2	dB	This is the result of the "Modulation-Demodulation" W/S and is transferred from Cell [H32]
System Link Margin:	2.8	dB	
Ground Station Alternative Signal Analysis Method (SNR Computation):			
---------- SNR Method ----------			
Ground Station Antenna Pointing Loss:	1.4	dB	This value is transferred from "Antenna Pointing Losses" W/S, Cell [K102]
Ground Station Antenna Gain:	32.0	dBi	This value is selected at "Antenna Gain" W/S, Cell [E58]
Ground Station Total Transmission Line Losses:	2.0	dB	This value is transferred from the "Receivers" W/S, Cell [J123]

Ground Station Effective Noise Temperature:	193	K	This value is calculated in the "Receivers" W/S and Transferred from Cell [J138]
Ground Station Figure of Merit (G/T):	7.2	dB/K	G/T = Ga-Ltl-10log(Ts). This is the ultimate measure of the receiver's performance.
Signal Power at Ground Station LNA Input:	-133.8	dBW	Ps = Piso+Ga-Lpl-Ltl; This is the signal power that has arrived at the ground station receiver.
Ground Station Receiver Bandwidth (B):	840,000	Hz	Signal Spectrum Must Pass Through This Data Filter NOTE:
G.S. Receiver Noise Power (Pn = kTB)	-146.5	dBW	Pn = K + 10log(Ts) + 10log(B). This is the total noise power arriving at the ground station receiver.
Signal-to-Noise Power Ratio at G.S. Rcvr:	12.7	dB	Ps/Pn = Ps(in dBW) - Pn(in dBW)
Analog or Digital System Required S/N:	9.2	dB	If system is digital, use values from "Modulation-Demodulation" W/S. If analog, use appropriate value from text book.
System Link Margin	3.5	dB	

Figure 2: S-band Science Downlink Path under Worst-Case Spacecraft Slant Range using the AMSAT/IARU Model.

Summary

The calculated downlink margin of **(2.8dB)** confirms that the SoFIE mission maintains closing the communication link under Worst-Case 15° Horizon Elevation Angle. Science data may also be downloaded for lower elevation angles (e.g., 10°) by lowering the transmitted data rate.