GOBIERNO DEL PARAGUAY | AGENCIA ESPACIAL DEL PARAGUAY

SPACE lab

Link Budget

2025/07/17

Uplink Budget COM, APRS, LORA

PARAMETERS				
Objective		Command UHF (MAIN COM)	APRS DIGIPEATER VHF (EIRU-4S)	LORA UHF (STORE AND FORWARD)
Beam		U1	U2	U3
Frequency	[MHz}	435.XXX	145.825	436.9
Emission Type		8K5F1D	12K5F2D	125KF1D
Modulation		GMSK	AFSK	CSS (Chirp Spread Spectrum)
Data Rate	[bps]	4800	1200	976.56
Protocol		AX.25	AX.25	SFP (Simple Frame Protocol)
GROUND STATION				
Ground Station Transmitter Power Output	[W]	50.00	50.00	1.00
	[dBw]	16.99	16.99	0.00
Ground Station Total Transmission Line Losses	[dB]	3.00	1.50	1.00
Antenna Gain	[dBi]	19.00	7.00	5.50
Ground Station EIRP	[dBw]	32.99	22.49	4.50
UPLINK PATH				
Orbit Altitude	[km]	550.00	550.00	550.00
Minimal Elevation Angle	[degree]	**60.00**	**35.00**	**40.00**
Slant Range	[km]	627.00	892.00	812.00
Ground Station Antenna Pointing Loss	[dB]	2.00	2.00	1.00
Ground Station to Spacecraft Antenna Polarization Loss	[dB]	3.00	3.00	3.00
Path Loss	[dB]	141.16	134.73	143.44
Atmospheric Losses	[dB]	1.00	1.00	1.00
Ionospheric Losses	[dB]	0.50	0.80	0.40
Isotropic Signal Level at Spacecraft	[dBw]	-114.67	-119.04	-144.34

SPACECRAFT (RX Power Sensitivity Method)				
Spacecraft Antenna Pointing Loss	[dB]	5.00	5.00	5.00
Spacecraft Antenna Gain	[dBi]	2.15	2.15	2.15
Spacecraft Total Transmission Line Losses	[dB]	3.00	1.50	0.10
Received Power to the TRX	[dBw]	-120.52	-123.39	-147.29
	[dBm]	-90.52	-93.39	-117.29
Receiver Sensitivity	[dBm]	-94.00	-98.20	-132.00
System Link Margin	**[dB]**	**3.48**	**4.81**	**14.71**
SPACECRAFT (SNR Method)				
Spacecraft Effective Noise Temperature	[K]	1000.00	1000.00	1000.00
Spacecraft Receiver Bandwidth	[Hz]	8500.00	12500.00	125000.00
Spacecraft Receiver Noise Power	[dBW]	-159.31	-157.63	-147.63
Signal-to-Noise Power Ratio (SNR) at Spacecraft Receiver	[dB]	38.78	34.25	0.34
Required SNR for Spacecraft	[dB]	10.60	12.00	-15.00
System Link Margin	**[dB]**	**28.18**	**22.25**	**15.34**
SPACECRAFT (Eb/No Method)				
Spacecraft Figure of Merit (G/T)	[dB/K]	-30.85	-29.35	N/A
Spacecraft Signal-to-Noise Power Density (S/No)	[dBHz]	78.93	74.57	N/A
System Desired data Rate	[bps]	4800	1200	N/A
Command System Eb/No	[dB]	42.12	43.77	N/A
Specified BER		1.00E-05	1.00E-05	N/A
Eb/No Threshold	[dB]	10.6	24.2	N/A
System Link Margin	[dB]	**31.52**	**19.57**	**N/A**

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Downlink Budget COM, APRS, LORA

PARAMETERS					
Objective		Telemetry and other Mission Data UHF (MAIN COM)	CW Beacon UHF (MAIN COM)	APRS DIGIPEATER VHF (CABUREI-4S)	LORA STORE AND FORWARD UHF
Beam		U1	U1	U2	U3
Frequency	[MHz}	437.375	437.375	145.825	436.9
Emission Type		8K5F1D	500HA1A	12K5F2D	125KF1D
Modulation		GMSK	Morse Code (CW)	AFSK	Chirp Spread Spectrum (CSS)
Data Rate	[bps]	4800	20 wpm	1200	976.56
Protocol		AX.25	-	AX.25	SFP (Simple Frame Protocol)
SPACECRAFT					
Spacecraft Transmitter Power Output	[W]	0.80	0.10	1.00	0.60
	[dBw]	-0.97	-10.00	0.00	-2.22
Spacecraft Total Transmission Line Losses	[dB]	3.00	3.00	1.50	0.10
Spacecraft Antenna Gain	[dBi]	2.15	2.15	2.15	2.15
Spacecraft EIRP	[dBw]	-1.82	-10.85	0.65	-0.17
DOWNLINK PATH					
Orbit Altitude	[km]	550.00	550.00	550.00	550.00
Minimal Elevation Angle	[degree]	**35.00**	**25.00**	**40.00**	**30.00**
Slant Range	[km]	892.00	1123.00	812.00	993.00
Spacecraft Antenna Pointing Loss	[dB]	5.00	5.00	5.00	5.00
Spacecraft–to-Ground Station Antenna Polarization Loss	[dB]	3.00	3.00	3.00	3.00
Path Loss	[dB]	144.27	146.27	133.91	145.19
Atmospheric Losses	[dB]	1.00	1.00	1.00	1.00
Ionospheric Losses	[dB]	0.50	0.50	0.80	0.40
Isotropic Signal Level at Ground Station	[dBw]	-155.59	-166.62	-146.07	-154.76

GROUND STATION (RX Power Sensitivity Method)					
Ground Station Antenna Pointing Loss	[dB]	2.00	2.00	2.00	3.00
Ground Station Antenna Gain	[dBi]	19.00	19.00	7.00	5.50
Ground Station Total Transmission Line Losses	[dB]	3.00	3.00	1.50	1.00
Received Power at LNA Ground Station	[dBw]	-141.59	-152.62	-142.57	-153.26
	[dBm]	-111.59	-122.62	-112.57	-123.26
Receiver (Rx) Sensitivity	[dBW]	-146.00	-156.00	-151.90	-162.03
System Link Margin	[dB]	**4.41**	**3.38**	**9.33**	**8.77**
GROUND STATION (SNR Method)					
Ground Station Receiver Effective Noise Temperature	[K]	1000.00	1000.00	1000.00	1000.00
Ground Station Receiver Bandwidth	[Hz]	8500.00	500.00	12500.00	125000.00
Ground Station Receiver Noise Power	[dBW]	-159.31	-171.61	-157.63	-147.63
Signal-to-Noise Power Ratio (SNR) at Ground Station Receiver	[dB]	17.72	19.00	15.06	-5.62
Required SNR for Ground Station Rx	[dB]	10.60	10.00	12.00	-15.00
System Link Margin	[dB]	**7.12**	**9.00**	**3.06**	**9.38**
GROUND STATION (Eb/No Method)					
Ground Station Figure of Merit (G/T)	[dB/K]	-14.00	N/C	-24.50	N/C
Ground Station-to-Noise Power Density (S/No)	[dBHz]	57.02	N/C	56.03	N/C
System Desired data Rate	[bps]	4800.00	N/C	1200.00	N/C
Command System Eb/No	[dB]	20.20	N/C	25.24	N/C
Specified BER		0.00001	N/C	0.00001	N/C
Eb/No Threshold	[dB]	10.60	N/C	24.20	N/C
System Link Margin	[dB]	**9.60**	N/C	**1.04**	N/C