

NEW: All the link budgets shown in this document are based on Measured Radiation Pattern for the onboard antenna. Antenna directivity was measured at 2400 MHz in configuration C2 (i.e. with absorbers around the plate hosting the antenna, see report from Wroclaw). Antenna losses of 1.7 dB was assumed (an average value between 1.5 and 1.9 reported from Pawel Kabacik) Radiation pattern was averaged among 8 equispaced cuts. See plot below.

HAMTV Link Budget BASELINE CONFIGURATION (SIF, 1.3 MSym/s)

	Value	Value	Value	Value	Value	Value	Value	Unit
Downlink frequency	2.400	2.400	2.400	2.400	2.400	2.400	2.400	GHz
Boltzmann's constant	-228.60	-228.60	-228.60	-228.60	-228.60	-228.60	-228.60	dBW/K-Hz
ISS to E/S range	1000	900	800	700	600	500	420	km
ISS-to-E/S off-nadir angle	61.3	58.8	55.4	50.7	43.7	31.7	0.0	°
E/S elevation angle	20.8	24.3	28.7	34.4	42.5	55.9	90.0	°

EARTH STATION CHARACTERISTICS								
Antenna diameter	1.00	1.00	1.00	1.00	1.00	1.00	1.00	meters
Efficiency	50%	50%	50%	50%	50%	50%	50%	
RX Antenna gain	25.0	25.0	25.0	25.0	25.0	25.0	25.0	dBi
Antenna Noise Temperature ⁽¹⁾	100	100	100	100	100	100	100	K
Implementation losses (@ 290 K)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	dB
Implementation equiv noise temp	59.6	59.6	59.6	59.6	59.6	59.6	59.6	K
RX Antenna pointing losses	1.0	1.0	1.0	1.0	1.0	1.0	1.0	dB
LNB gain	40	40	40	40	40	40	40	dB
LNB noise figure	0.7	0.7	0.7	0.7	0.7	0.7	0.7	dB
LNB equiv noise temp	50.7	50.7	50.7	50.7	50.7	50.7	50.7	K
System Noise Temp (@ LNB input)	189.8	189.8	189.8	189.8	189.8	189.8	189.8	K
System Noise Figure (@ LNB input)	2.2	2.2	2.2	2.2	2.2	2.2	2.2	dB
G/T	1.2	1.2	1.2	1.2	1.2	1.2	1.2	dB/K

CARRIER CHARACTERISTICS								
Data Bit Rate (net)	1198	1198	1198	1198	1198	1198	1198	kbps
Reed Solomon	188/204	188/204	188/204	188/204	188/204	188/204	188/204	
Overhead due to IP Encapsulator	0	0	0	0	0	0	0	%
Modulation	QPSK	QPSK	QPSK	QPSK	QPSK	QPSK	QPSK	
FEC	1/2	1/2	1/2	1/2	1/2	1/2	1/2	
Symbol Rate	1300	1300	1300	1300	1300	1300	1300	kbaud
Roll-off (%)	0.35	0.35	0.35	0.35	0.35	0.35	0.35	
Video resolution	SIF	SIF	SIF	SIF	SIF	SIF	SIF	
Bandwidth	1755.1	1755.1	1755.1	1755.1	1755.1	1755.1	1755.1	kHz

Downlink								
TX output power	10.0	10.0	10.0	10.0	10.0	10.0	10.0	dBW
Cable, connector & mismatch losses ⁽²⁾	8.0	8.0	8.0	8.0	8.0	8.0	8.0	dB
TX Antenna gain (boresight) measured	7.6	7.6	7.6	7.6	7.6	7.6	7.6	dBi
TX Antenna pointing losses from RP meas.	12.0	11.3	10.3	8.9	7.0	3.8	0.0	dB
Downlink e.i.r.p. toward earth receive station	-2.4	-1.7	-0.7	0.7	2.6	5.8	9.6	dBW
Path loss (free space)	160.1	159.2	158.2	157.0	155.7	154.1	152.6	dB
Atmospheric losses	0.0	0.0	0.0	0.0	0.0	0.0	0.0	dB
Noise increase due to precipitation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	dB
Rain attenuation losses	0.0	0.0	0.0	0.0	0.0	0.0	0.0	dB

Eb/No required for QEF	4.5	4.5	4.5	4.5	4.5	4.5	4.5	dB
C/No required for QEF	65.3	65.3	65.3	65.3	65.3	65.3	65.3	dBHz
C/No (Available)	66.3	68.0	70.0	72.5	75.8	80.5	85.8	dBHz
Eb/NO (Available)	5.5	7.2	9.2	11.7	15.0	19.8	25.1	dB
Link Margin	1.0	2.7	4.7	7.2	10.5	15.3	20.6	dB

**HAMTV Link Budget (ESA requested alternative configuration)
(SIF, 2.0 MSym/s)**

	Value	Value	Value	Value	Value	Value	Value	Unit
Downlink frequency	2.400	2.400	2.400	2.400	2.400	2.400	2.400	GHz
Boltzmann's constant	-228.60	-228.60	-228.60	-228.60	-228.60	-228.60	-228.60	dBW/K-Hz
ISS to E/S range	1000	900	800	700	600	500	420	km
ISS-to-E/S off-nadir angle	66.1	64.2	61.7	58.3	53.3	45.6	34.9	°
E/S elevation angle	15.7	18.5	21.9	26.3	32.3	41.2	53.0	°

EARTH STATION CHARACTERISTICS								
Antenna diameter	1.00	1.00	1.00	1.00	1.00	1.00	1.00	meters
Efficiency	50%	50%	50%	50%	50%	50%	50%	
RX Antenna gain	25.0	25.0	25.0	25.0	25.0	25.0	25.0	dBi
Antenna Noise Temperature ⁽¹⁾	100	100	100	100	100	100	100	K
Implementation losses (@ 290 K)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	dB
Implementation equiv noise temp	59.6	59.6	59.6	59.6	59.6	59.6	59.6	K
RX Antenna pointing losses	1.0	1.0	1.0	1.0	1.0	1.0	1.0	dB
LNB gain	40	40	40	40	40	40	40	dB
LNB noise figure	0.7	0.7	0.7	0.7	0.7	0.7	0.7	dB
LNB equiv noise temp	50.7	50.7	50.7	50.7	50.7	50.7	50.7	K
System Noise Temp (@ LNB input)	189.8	189.8	189.8	189.8	189.8	189.8	189.8	K
System Noise Figure (@ LNB input)	2.2	2.2	2.2	2.2	2.2	2.2	2.2	dB
G/T	1.2	1.2	1.2	1.2	1.2	1.2	1.2	dB/K

CARRIER CHARACTERISTICS								
Data Bit Rate (net)	1843	1843	1843	1843	1843	1843	1843	kbps
Reed Solomon	188/204	188/204	188/204	188/204	188/204	188/204	188/204	
Overhead due to IP Encapsulator	0	0	0	0	0	0	0	%
Modulation	QPSK	QPSK	QPSK	QPSK	QPSK	QPSK	QPSK	
FEC	1/2	1/2	1/2	1/2	1/2	1/2	1/2	
Symbol Rate	2000	2000	2000	2000	2000	2000	2000	kbaud
Roll-off (%)	0.35	0.35	0.35	0.35	0.35	0.35	0.35	
Video resolution	SIF	SIF	SIF	SIF	SIF	SIF	SIF	
Bandwidth	2700.1	2700.1	2700.1	2700.1	2700.1	2700.1	2700.1	kHz

Downlink								
TX output power	10.0	10.0	10.0	10.0	10.0	10.0	10.0	dBW
Cable, connector & mismatch losses ⁽²⁾	8.0	8.0	8.0	8.0	8.0	8.0	8.0	dB
TX Antenna gain (boresight) measured	7.6	7.6	7.6	7.6	7.6	7.6	7.6	dBi
TX Antenna pointing losses from RP meas.	12.0	11.3	10.3	8.9	7.0	3.8	0.0	dB
Downlink e.i.r.p. toward earth receive station	-2.4	-1.7	-0.7	0.7	2.6	5.8	9.6	dBW
Path loss (free space)	160.1	159.2	158.2	157.0	155.7	154.1	152.6	dB
Atmospheric losses	0.0	0.0	0.0	0.0	0.0	0.0	0.0	dB
Noise increase due to precipitation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	dB
Rain attenuation losses	0.0	0.0	0.0	0.0	0.0	0.0	0.0	dB

Eb/No required for QEF	4.5	4.5	4.5	4.5	4.5	4.5	4.5	dB
C/No required for QEF	67.2	67.2	67.2	67.2	67.2	67.2	67.2	dBHz
C/No (Available)	66.3	68.0	70.0	72.5	75.8	80.5	85.8	dBHz
Eb/NO (Available)	3.6	5.3	7.3	9.8	13.1	17.9	23.2	dB
Link Margin	-0.9	0.8	2.8	5.3	8.6	13.4	18.7	dB