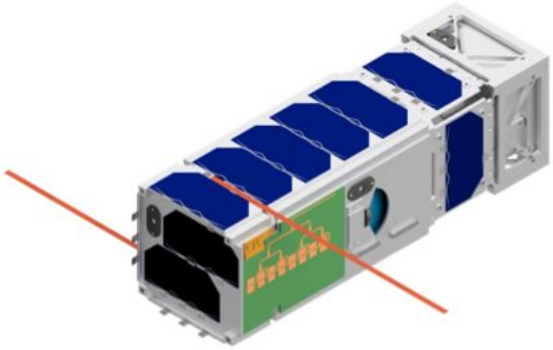
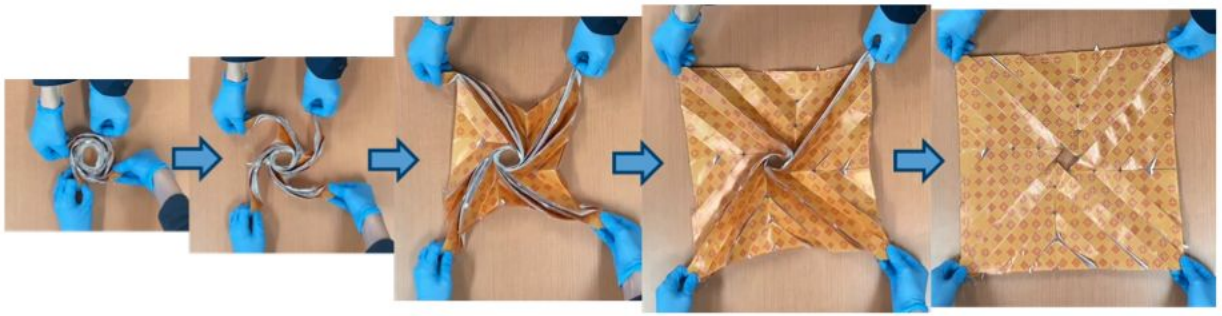
ORIGAMI
PROJECT

OrigamiSat-2

Overview as of May. 25 2023

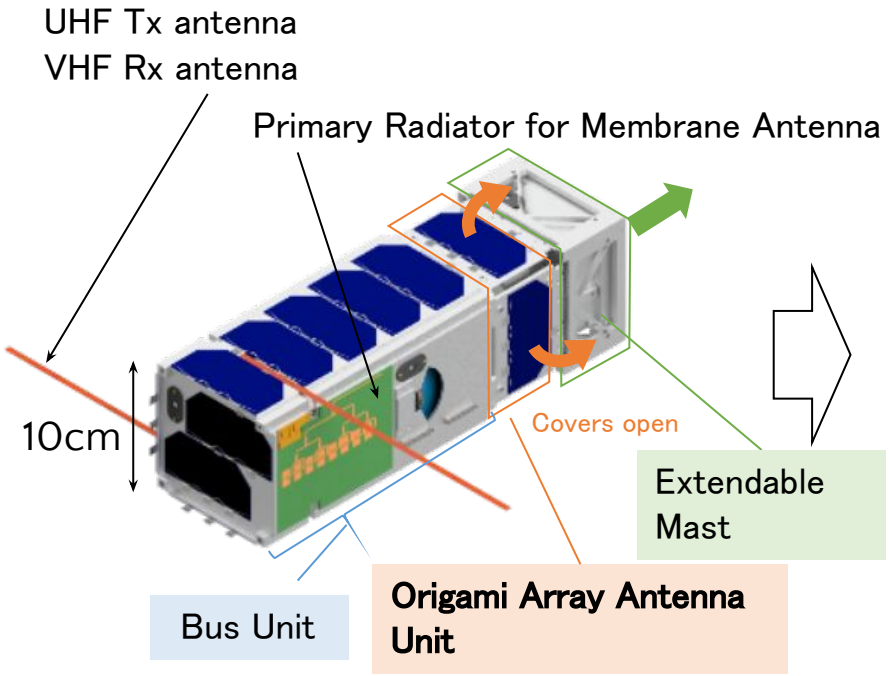


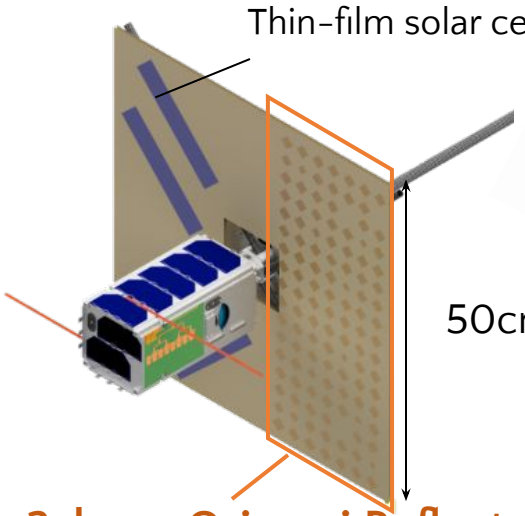


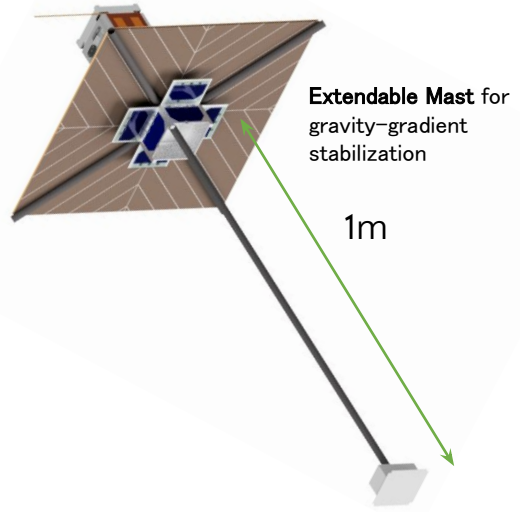
3U CubeSat OrigamiSat-2

Size	3U CubeSat (100 x 100 x 340.5 [mm])
Mass	4.0 kg

Uplink Freq1	145 MHz
Downlink Freq1	437.505 MHz (TBD)
Downlink Freq2	5.840 GHz (TBD)





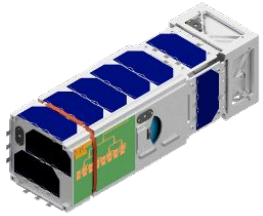


2-layer Origami Reflectarray Antenna (C-band 5.8GHz)

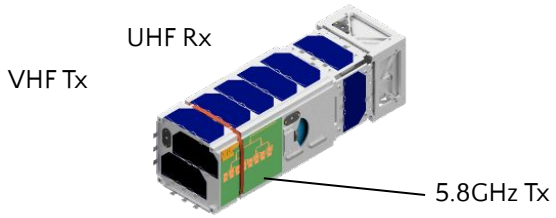
Mission

1. Contributing to the promotion and advancement of 5.8GHz amateur radio technology.
2. Deploying a reflectarray antenna made of 2-layer deployable membranes with light-weight and high packaging efficiency.
3. Demonstrating on orbit the high-gain antenna performance of the deployable membrane antenna.

3U CubeSat OrigamiSat-2 Mission Sequence



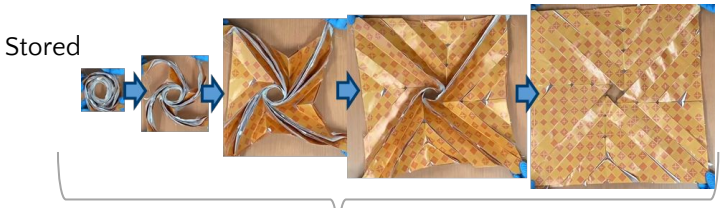
Release from rocket

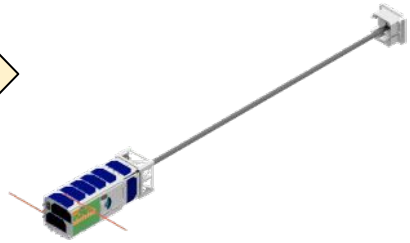


Initial operation, Functional tests

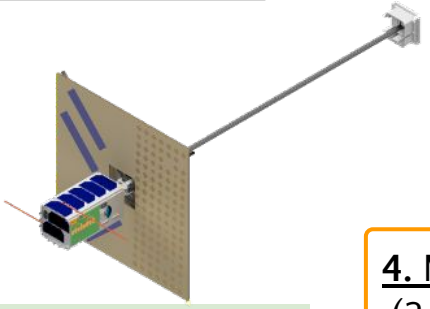
1. Critical phase (2-3 days)
Released to orbit, UHF/VHF Tx/Rx antenna deployment, Establishment of FM/CW communication, Orbit determination, Power/thermal balance identification

2. Initial phase (3 weeks)
Detumbling, 5.8GHz communication test, Camera test, Image data downlink

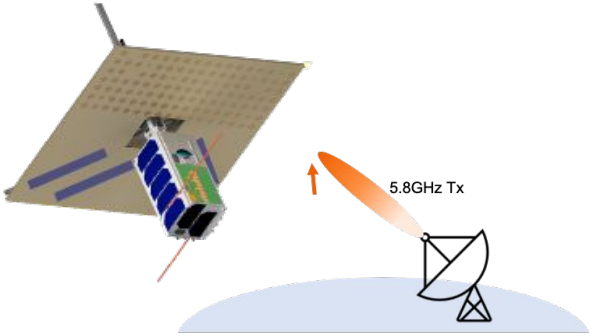




Extending gravity-gradient stabilization mast



Membrane antenna deployment



Communication by membrane antenna

3. Structure deployment phase: Mast (1 week), Membrane (1 week) Measurement of deployment behavior and deployed shape

4. Membrane antenna communication phase (3 months) Verify increase of reception gain

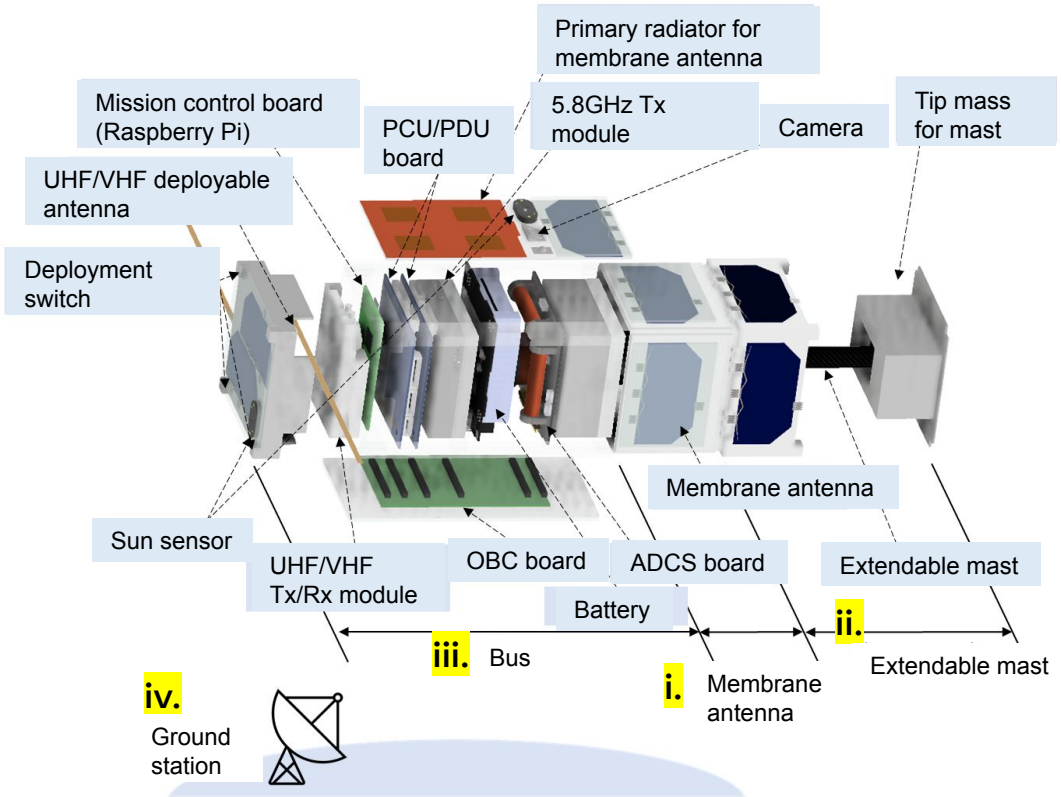
5. Late-stage operation phase (until reentry)
Periodic 5.8GHz downlink of photo data

Satellite basic configuration

Size : 100 x 100 x 340.5 [mm]
Mass : 4 kg
Major subsystems

i. Membrane antenna
ii. Extendable mast
iii. Bus
iv. Ground station

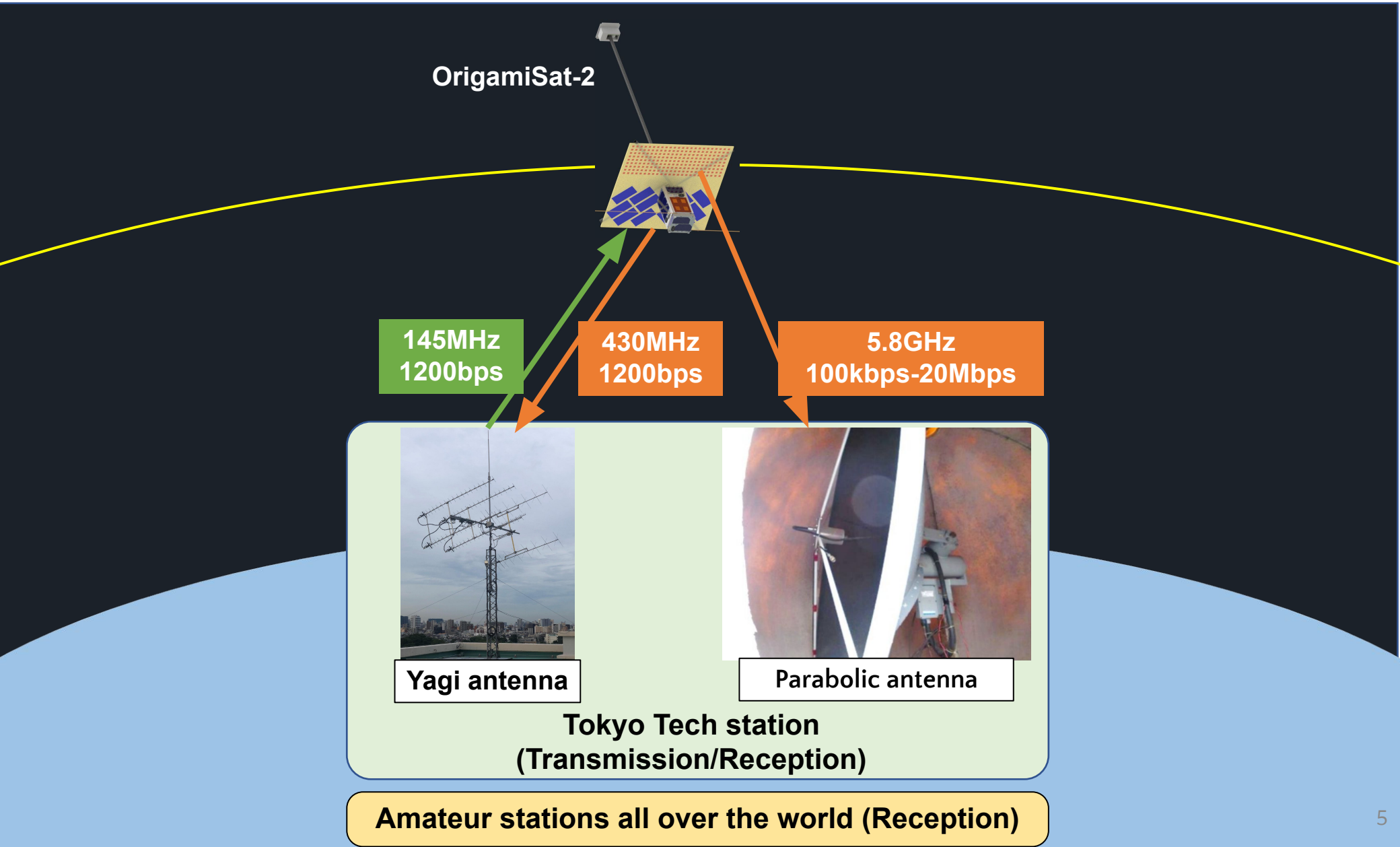
Configuration



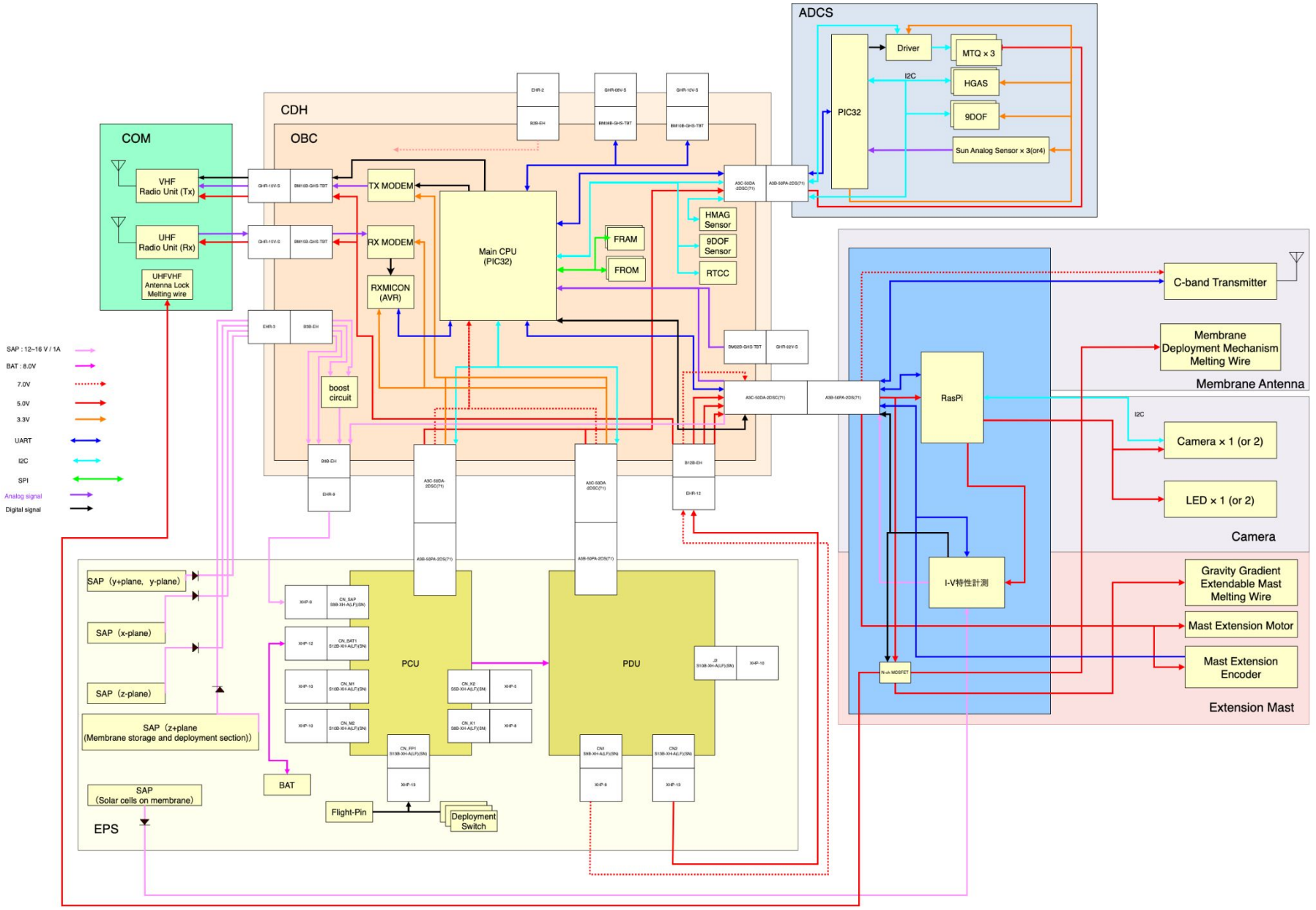
Mass budget

	Component	Mass [kg]
i. Membrane antenna	Deployable membrane antenna	0.660
	5.8GHz Tx module	0.250
	Control board	0.050
ii. Extendable mast	Tip mass	0.400
	Mast	0.300
iii. Bus	OBC Board	0.150
	ADCS Board	0.300
	PCU/PDU Board	0.100
	GaS solar cells	0.060
	Battery	0.250
	UHF/VHF Tx/Rx module	0.100
	UHF/VHF deployable antennas	0.030
Satellite structure		0.650
Other structural components (bolts, harness, spacers)		0.340
Total		3.640
Margin		0.360

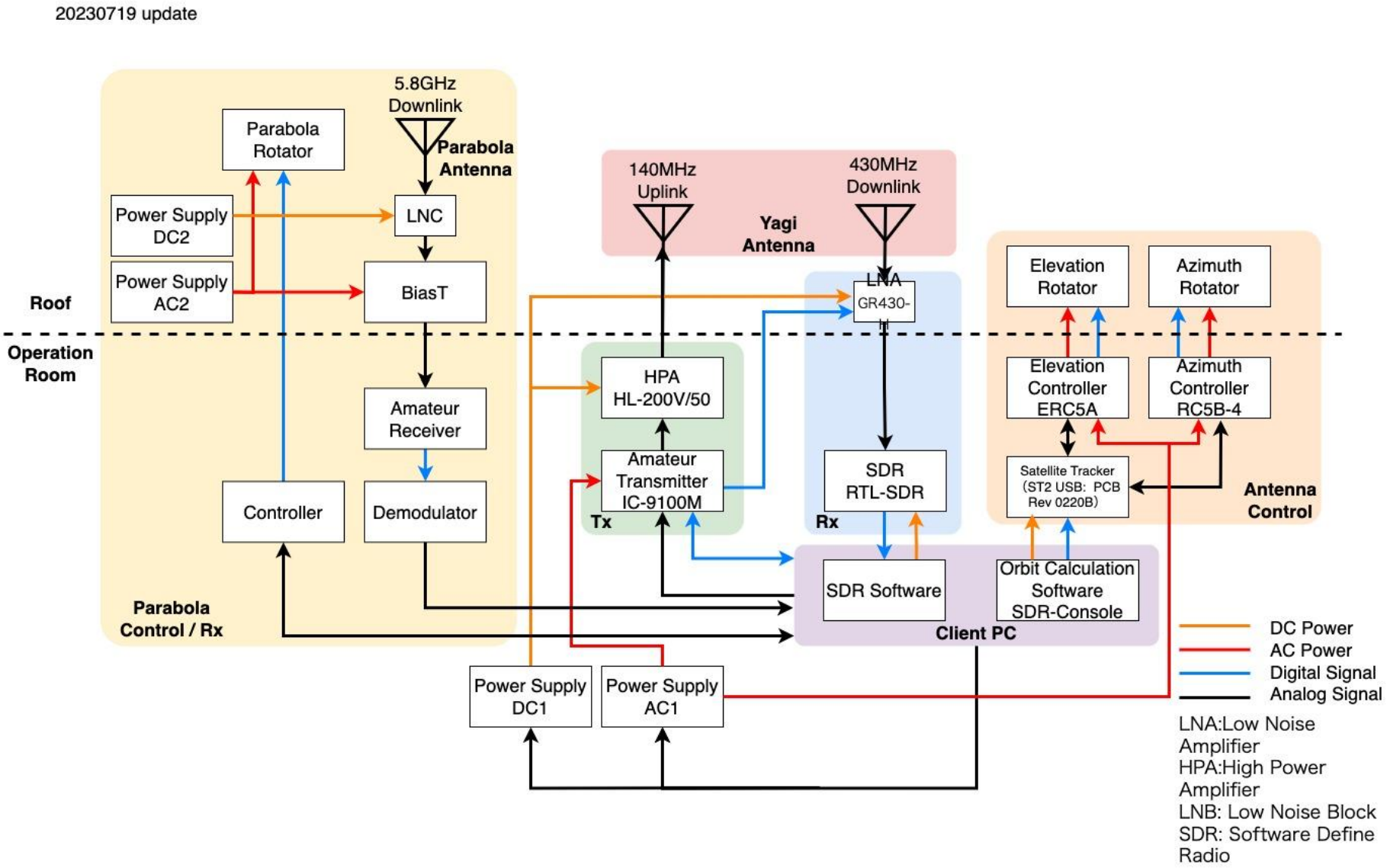
Communication between satellite and ground station



Origamisat2 System diagram

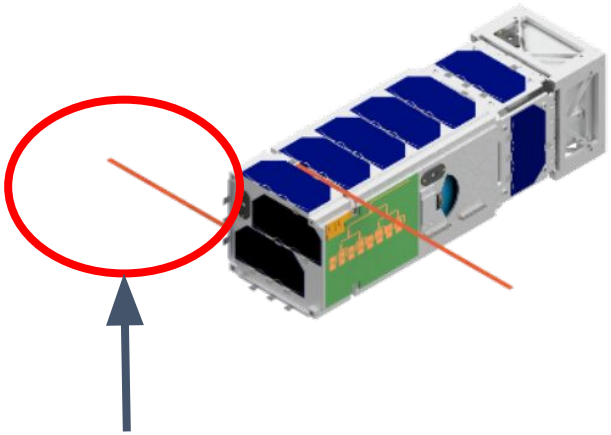


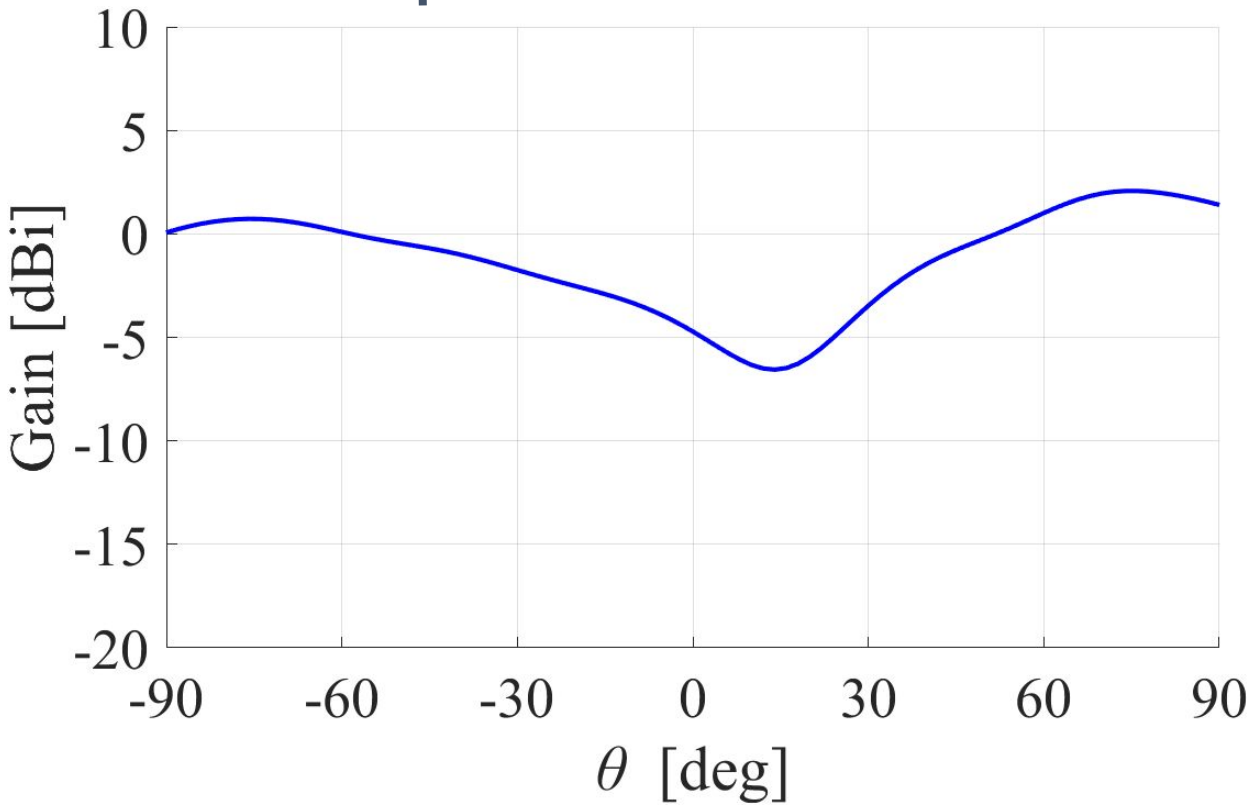
Tokyo Tech Ground Station Configuration



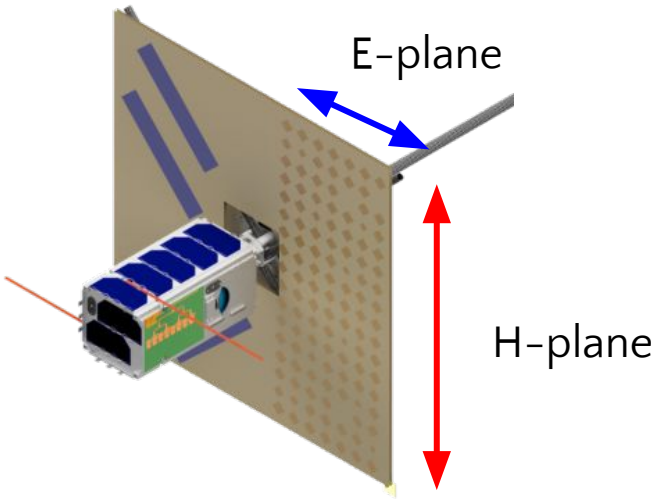
Ground station diagram

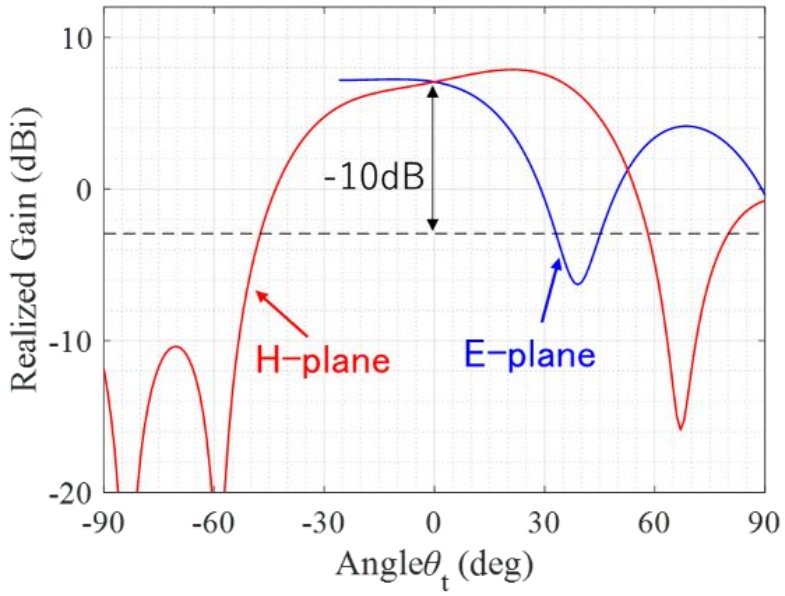
Antenna pattern of dipole antenna



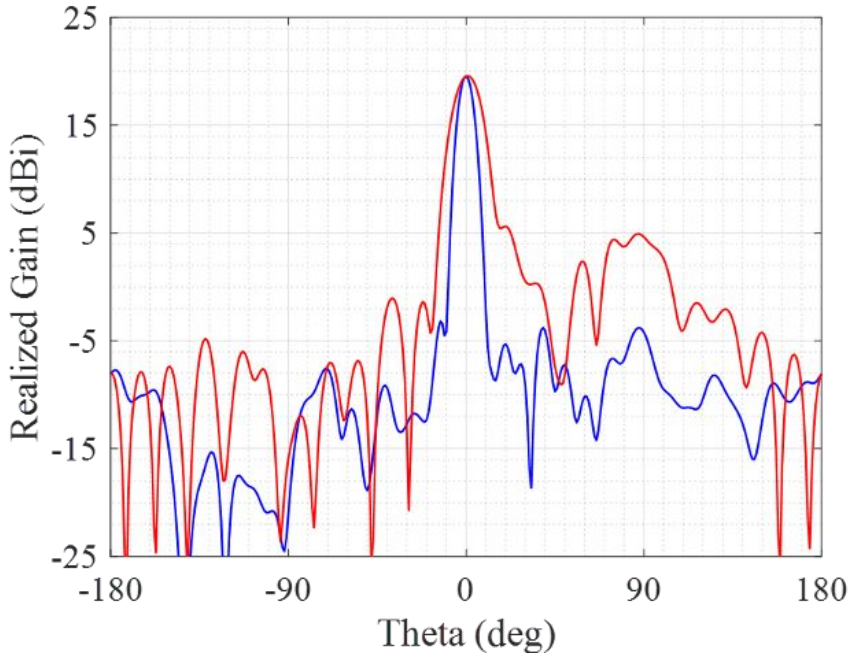


Antenna pattern of Reflectarray antenna



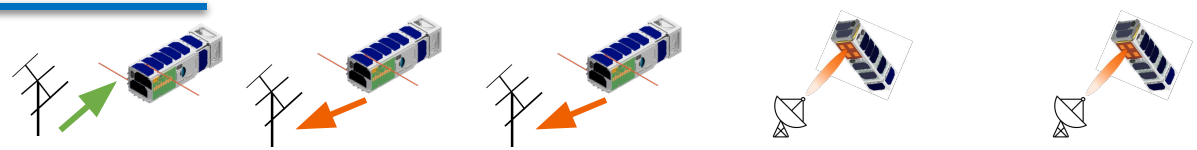


Primary radiator



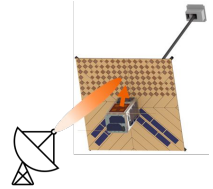
Reflect array antenna

Link Budget of UHF, VHF and c-band radiator



	Unit	UP LINK	DOWN LINK(FM)	DOWN LINK(CW)	CW(5.84GHz) Primary radiater	DOWN LINK(5.84GHz) Primary radiater
Data Rate	bps	1200	1200	CW	CW	100k
band width	Hz	16000	16000			400000
Freq	MHz	145.0	435.0	435.0	5840.0	5840.0
Altitude	km	540.0	540.0	540.0	540.0	540.0
Elevation	deg	5.0	5.0	5.0	5.0	5.0
Propagation distance	km	2179.8	2179.8	2179.8	2179.8	2179.8
EIRP	dBW	23.60	-1.11	-10.21	6.83	6.83
Transmission output	W	50.00	0.80	0.10	0.80	0.80
Transmission output	dBW	17.00	-0.90	-10.00	-0.97	-0.97
Power feed loss (Transmitting Antenna - Transmitter)	dB	2.70	0.21	0.21	0.20	0.20
Transmit antenna realized gain	dBi	9.30	0.00	0.00	8.00	8.00
Pointing loss	dB	3.00	3.00	3.00	3.00	3.00
Free space propagation loss	dB	142.45	151.99	151.99	174.55	174.55
Polarization loss	dB	3.00	3.00	3.00	1.00	3.00
Ionospheric absorption loss	dB	0.00	0.00	0.00	0.00	0.00
Atmospheric absorption loss	dB	0.00	0.00	0.00	0.00	0.00
Rainfall loss	dB	0.00	0.00	0.00	0.00	0.00
Receive G/T	dB/K	-33.24	-10.19	-10.19	11.78	11.78
Pointing loss	dB	3.00	3.00	3.00	3.00	3.00
Receiving Antenna Gain	dBi	-5.00	19.00	19.00	38.62	38.62
Power feed loss (Recieving Antenna - Reciever)	dB	0.45	4.30	4.30	0.50	0.50
System noise temperature	K	666.92	829.45	829.45	483.13	483.13
System noise temperature	dBK	28.24	29.19	29.19	26.84	26.84
Receive C/N0	dBHz	67.51	56.31	47.21	65.67	63.67
Required C/N0	dbHz	49.79	46.79	39.98	38.48	58.40
Bit rate	dBHz	30.79	30.79	23.98	23.98	50.00
Bit error rate		1.E-06	1.E-06	1.E-06	1.E-06	1.E-05
Required Eb/N0	dB	10.50	10.50	10.50	10.50	9.70
Modulation method		AFSK(1200bps)	AFSK(1200bps)	CW(80cpm)	CW(80cpm)	BPSK/QPSK(100k)
Modulation loss	dB	6.00	3.00	3.00	3.00	3.00
Hardware degradation loss	dB	2.50	2.50	2.50	1.00	1.00
Encoding method		AX.25	AX.25	Morse	Morse	(J=8,E=16;(255,223)Reed-Solomon code I=5 interleave)
Coding gain	dB	0.00	0.00	0.00	0.00	5.30
Link margin	dB	17.72	9.52	7.23	27.19	5.27

Link Budget of c-band Reflectarray



ORIGAMI PROJECT

	Unit	CW(5.84GHz) Reflect array	DOWN LINK(5.84GHz) Reflect array	DOWN LINK(5.84GHz) Reflect array	DOWN LINK(5.84GHz) Reflect array	DOWN LINK(5.84GHz) Reflect array	DOWN LINK(5.84GHz) Reflect array	DOWN LINK(5.84GHz) Reflect array
Data Rate	bps	CW	100k	500k	1M	5M	10M	20M
band width	Hz		400000	2000000	4000000	20000000	20000000	20000000
Freq	MHz	5840.0	5840.0	5840.0	5840.0	5840.0	5840.0	5841.0
Altitude	km	540.0	540.0	540.0	540.0	540.0	500.0	400.0
Elevation	deg	5.0	5.0	5.0	5.0	5.0	5.0	22.0
Propagation distance	km	2179.8	2179.8	2179.8	2179.8	2179.8	2077.1	922.9
EIRP	dBW	23.43	23.43	23.43	23.43	23.43	23.43	23.43
Transmission output	W	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Transmission output	dBW	-0.97	-0.97	-0.97	-0.97	-0.97	-0.97	-0.97
Power feed loss (Transmitting Antenna - Transmitter)	dB	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Transmit antenna realized gain	dBi	24.60	24.60	24.60	24.60	24.60	24.60	24.60
Pointing loss	dB	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Free space propagation loss	dB	174.55	174.55	174.55	174.55	174.55	174.13	167.08
Polarization loss	dB	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Ionospheric absorption loss	dB	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Atmospheric absorption loss	dB	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rainfall loss	dB	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Receive G/T	dB/K	11.78	11.78	11.78	11.78	11.78	11.78	11.78
Pointing loss	dB	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Receiving Antenna Gain	dBi	38.62	38.62	38.62	38.62	38.62	38.62	38.62
Power feed loss (Recieving Antenna - Reciever)	dB	0.50	0.50	0.50	0.50	0.50	0.50	0.50
System noise temperature	K	483.13	483.13	483.13	483.13	483.13	483.13	483.13
System noise temperature	dBK	26.84	26.84	26.84	26.84	26.84	26.84	26.84
Receive C/N0	dBHz	82.27	82.27	82.27	82.27	82.27	82.68	89.73
Required C/N0	dbHz	38.48	58.40	65.39	68.40	75.39	78.40	86.71
Bit rate	dBHz	23.98	50.00	56.99	60.00	66.99	70.00	73.01
Bit error rate		1.E-06	1.E-05	1.E-05	1.E-05	1.E-05	1.E-05	1.E-05
Required Eb/N0	dB	10.50	9.70	9.70	9.70	9.70	9.70	9.70
Modulation method		BPSK/QPSK(100k)	BPSK/QPSK(100k)	BPSK/QPSK(100k)	BPSK/QPSK(1M)	BPSK/QPSK(5M)	BPSK/QPSK(10M)	BPSK/QPSK(20M)
Modulation loss	dB	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Hardware degradation loss	dB	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Encoding method		(J=8,E=16;(255,223)Reed-Solomon code I=5 interleave)	(J=8,E=16;(255,223)Reed-Solomon code I=5 interleave)	(J=8,E=16;(255,223)Reed-Solomon code I=5 interleave)	(J=8,E=16;(255,223)Reed-Solomon code I=5 interleave)	(J=8,E=16;(255,223)Reed-Solomon code I=5 interleave)	(J=8,E=16;(255,223)Reed-Solomon code I=5 interleave)	
Coding gain	dB	0.00	5.30	5.30	5.30	5.30	5.30	0.00
Link margin	dB	43.79	23.87	16.88	13.87	6.88	4.28	3.02