

APPENDIX A: TRANSMISSION CHARACTERISTICS

A. Transmission Characteristics - Communications Uplinks and Downlinks

Tables A-1 through A-4 provide representative link budget calculations for downlink and uplink coverages in the Ka band. Each table illustrates the link performance in clear air and rain at the edge of the satellite footprint for typical ground terminal apertures in the 0.3 to 1 meter range. A worst case end-of-coverage area scenario, due to antenna beam rolloff and/or scanning loss, is assumed. Also, in order to fully represent the likely range of data rates and path conditions, two modulation formats (QPSK and 8PSK), each with forward error correction, are used. A target bit error rate of 10^{-9} is assumed for each link.

Rain loss figures are based on the ITU-R rain model in region K for the minimum elevation angle applicable to each earth terminal type.¹ These figures, averaged over the applicable range of elevation angles, do not exceed the level required to maintain the desired link budgets.

Each link includes adaptive power control to reduce transmitter power during clear air conditions.

¹ See NASA Reference Publication 1082(04).

	Uplink		Downlink	
	Clear	Rain	Clear	Rain
Frequency, MHz	30000	30000	20000	20000
Information Rate	2.048	2.048	16.384	16.384
Path Loss, dB	190.5	190.5	186.8	186.8
Atmospheric loss, dB	1.1	1.1	1.2	1.2
Rain Loss, dB	0.0	6.8	0.0	3.7
Polarization loss, dB	0.5	0.5	0.5	0.5
Attitude Error Loss, dB	1.0	1.0	1.0	1.0
Edge of Coverage Loss, dB	4.00	4.00	4.00	4.00
Power output, W	1.2	4.7	10.0	22.4
Output losses, dB	3.4	3.4	1.5	1.5
Antenna Gain, dB	35.6	35.6	32.8	32.8
Effective EIRP, dBW	33.2	39.0	41.3	44.8
Antenna Gain, dB	35.3	35.3	35.6	35.6
Effective G/T, dBK	7.2	7.2	7.3	6.5
Req. Eb/No (dB)	6.2	6.2	8.9	8.9
Excess Margin	1.0	0.0	1.0	0.0
PFD (dBW/sq-m/MHz)			-113.64	-113.84

Table A-1: Residential User Link Budget
(QPSK Modulation @ 2.048 Mbps Uplink & 16.384 Mbps Downlink)

	Uplink		Downlink	
	Clear	Rain	Clear	Rain
Frequency, MHz	30000	30000	20000	20000
Info. Rate Mbps	10	10	16.384	16.384
Path loss, dB	190.5	190.5	186.8	186.8
Atmospheric loss, dB	1.1	1.1	1.2	1.2
Rain Loss, dB	0.0	13.2	0.0	7.1
Polarization loss, dB	0.2	0.2	0.2	0.2
Attitude Error Loss, dB	1.0	1.0	1.0	1.0
Edge of Coverage Loss, dB	4.00	4.00	4.00	4.00
Power output, W	0.3	4.5	1.0	6.4
Output losses, dB	0.5	0.5	1.5	1.5
Antenna Gain, dB	45.9	45.9	32.8	32.8
Effective EIRP, dBW	39.8	52.0	31.3	39.3
Antenna Gain, dB	35.3	35.3	42.4	42.4
Effective G/T, dBK	7.2	7.2	17.0	15.1
Req. Eb/No (dB)	6.2	6.2	8.9	8.9
Excess Margin	1.0	0.0	1.0	0.0
PFD (dBW/sq-m/MHz)			-123.62	-122.69

Table A-2: Small Business Link Budget
(QPSK Modulation @ 10 Mbps Uplink & 16.384 Mbps Downlink)

	Uplink		Downlink	
	Clear	Rain	Clear	Rain
Frequency, MHz	30000	30000	20000	20000
Info. Rate, Mbps	51.84	51.84	51.84	51.84
Path loss, dB	190.5	190.5	186.8	186.8
Atmospheric loss, dB	1.1	1.1	1.2	1.2
Rain Loss, dB	0.0	13.2	0.0	7.1
Polarization loss, dB	0.2	0.2	0.2	0.2
Attitude Error Loss, dB	1.0	1.0	1.0	1.0
Edge of Coverage Loss, dB	4.00	4.00	4.00	4.00
Power output, W	1.1	19.0	1.4	8.7
Output losses, dB	0.5	0.5	1.5	1.5
Antenna Gain, dB	48.4	48.4	32.8	32.8
Effective EIRP, dBW	48.5	60.7	32.6	40.6
Antenna Gain, dB	35.3	35.3	44.9	44.9
Effective G/T, dBK	7.2	7.2	19.5	17.6
Req. Eb/No (dB)	8.0	8.0	8.0	8.0
Excess Margin	1.0	0.0	1.0	0.0
PFD (dBW/sq-m/MHz)			-127.05	-126.13

Table A-3: Large Business Link Budget
(QPSK Modulation @ 51.84 Mbps Up & Down)

	Uplink		Downlink	
	Clear	Rain	Clear	Rain
Frequency, MHz	30000	30000	20000	20000
Info. Rate, Mbps	155.52	155.52	155.52	155.52
Path loss, dB	191.2	191.2	187.7	187.7
Atmospheric loss, dB	1.1	1.1	1.2	1.2
Rain Loss, dB	0.0	10.5	0.0	5.7
Polarization loss, dB	0.1	0.1	0.1	0.1
Attitude Error Loss, dB	1.0	1.0	1.0	1.0
Edge of Coverage Loss, dB	0.00	0.00	0.00	0.00
Power output, W	0.9	7.8	1.0	5.0
Output losses, dB	0.5	0.5	1.5	1.5
Antenna Gain, dB	51.9	51.9	37.4	37.4
Effective EIRP, dBW	50.8	60.4	35.9	42.9
Antenna Gain, dB	40.9	40.9	48.4	48.4
Effective G/T, dBK	12.8	12.8	24.3	22.1
Req. Eb/No (dB)	14.3	14.3	14.3	14.3
Excess Margin	1.0	0.0	1.0	0.0
PFD (dBW/sq-m/MHz)			-127.92	-126.65

Table A-4: Gateway Link Budget
(8PSK Modulation @ 155.52 Mbps Uplink & Downlink)

Tables A-1 through A-4 include the estimated power flux densities (“PFD”) for various representative single-channel-per-carrier TDM transmissions for each type of earth terminal. In all cases, the maximum PFD limit of -105 dBW/m² specified in Section 25.208(c) of the Commission’s Rules is satisfied in any 1 MHz bandwidth at the edge of coverage (at a 16° elevation angle). For elevation angles between 16° and 90°, the satellite isoflux antenna characteristics maintain the PFD levels to within the limits specified in Section 25.208(c). At angles below 16°, the satellite antenna gain diminishes so that the PFD figures are even lower than those indicated in the tables.

Each PFD calculation includes a bandwidth spreading factor to accommodate the effects of spectral shaping, packet routing overhead, and bandwidth expansion due to forward error correction coding.

B. TT&C Links

All TT&C functions necessary for monitoring and controlling the satellite will be performed by the TT&C subsystem. TT&C earth stations will be designed to maintain highly reliable TT&C links with the satellites under all operating conditions. Table A-5 shows the typical TT&C link budget. Command signaling protocols will include authentication codes to prevent intentional or unintentional access to the satellite command functions.

Command and telemetry signaling will be assigned to frequencies at the lower ends of the primary service bands. As many as three channels will be available for TT&C signaling, allowing simultaneous communications with multiple satellites. Each such channel will use BPSK modulation. The channels will occupy no more than 2 MHz of bandwidth, which includes allowance for Doppler shift. A near-omnidirectional antenna will be used aboard each satellite, and a minimum command and telemetry data rate of 100 kbps will be maintained under all operating conditions.

	Uplink		Downlink	
	Clear	Rain	Clear	Rain
Frequency, MHz	30000	30000	20000	20000
Information Rate, Mbps	0.100	0.100	0.100	0.100
Path loss, dB	191.2	191.2	187.7	187.7
Atmospheric loss, dB	1.1	1.1	1.2	1.2
Rain Loss, dB	0.0	28.9	0.0	14.7
Polarization loss, dB	0.1	0.1	0.1	0.1
Attitude Error Loss, dB	1.0	1.0	1.0	1.0
Edge of Coverage Loss, dB	0.00	0.00	0.00	0.00
Power output, W	0.2	132.0	0.1	4.9
Output losses, dB	0.5	0.5	1.5	1.5
Antenna Gain, dB	60.5	60.5	0.0	0.0
Effective EIRP, dBW	53.3	81.2	-11.1	5.4
Antenna Gain, dB	0.00	0.00	57.0	57.0
Effective G/T, dBK	-28.1	-28.1	32.9	30.1
Req. Eb/No (dB)	9.0	9.0	9.0	9.0
Excess Margin	1.0	0.0	1.0	0.0
PFD (dBW/sq-m/MHz)			-146.01	-144.20

Table A-5: TT&C Link Budget
(BPSK Modulation)