Uplink Budget

Parameter Name	*Equation*	*Units*
Free Space Path Loss	$L_p = 20 * log_{10}(\frac{4\pi Sf}{v_p})$	[dB]
Slant Range	$S = r_e * \left[\sqrt{\frac{(r_e+A_s)^2}{r_e^2} - cos^2\theta} - sin\theta \right]$	[m]
Total Losses of Ground Station Transmitter	$L_{T(GS)} = L_{TxC(GS)} + connector\ losses + filter\ insertion\ losses + other\ in\ line\ device\ losses + antenna\ mismatch\ losses$	[dB]
CubeSat Receiver System Noise Temperature	$T_{sys(CS)} = (T_{A(CS)} * \alpha_{CS}) + T_{o(CS)} * (1 - \alpha_{CS}) + T_{LNA(CS)} + \frac{T_{2stage}}{G_{LNA(CS)}}$	[K]
Power Delivered to CubeSat Antenna	$P_{d(CS)} = P_{t(GS)} - total\ GS\ antenna\ \ losses$	[dBW]
Ground Station Antenna Pointing Losses	$L_{pl(GS)} = 12 * (\frac{P_e}{42})^2$	[dB]
Uplink Antenna Polarization Loss	$L_{up} = \frac{1}{2} * \left\{ 1 + \frac{[(1-AR_{Tx(GS)}{}^2)*(1-AR_{Rx(CS)}{}^2)*cos(2*\theta_p)+(4*AR_{Tx(GS)}*AR_{Rx(CS)})]}{(1+AR_{Tx(GS)}{}^2)*(1+AR_{Rx(CS)}{}^2)} \right\}$	[Linear units]
CubeSat Received Power	$P_{r(CS)} = P_{t(GS)} + G_{t(GS)} + G_{r(CS)} - L_p$	[dBW]
Effective Isotropic Radiative Power	$EIRP = P_{t(GS)} - L_{tl(GS)} + G_{t(GS)}$	[dBW]
Uplink SNR Power Ratio at Ground Station Receiver	$P_{SNR(GS)} = P_{LNA(CS)} + P_{N(CS)}$	[dBW]
Signal Power at CubeSat LNA Input	$P_{LNA(CS)} = G_{r(CS)} + isotropic\ signal\ level\ at\ CS - L_{pl(CS)} - CS\ receiver\ in\ line\ loss$	[dBW]

CubeSat Receiver Noise Power	$P_{N(CS)} = k_B + 10 * log_{10}(T_{sys(CS)}) + 10 * log_{10}(B_r)$	[dBW]

Downlink Budget

Parameter Name	*Equation*	*Units*
Total Losses of CubeSat Transmitter	$L_{T(CS)} = L_{TxC(CS)} + connector\ losses + filter\ insertion\ losses + other\ in\ line\ device\ losses + antenna\ mismatch\ losses$	[dB]
Ground Station Receiver System Noise Temperature	$T_{sys(GS)} = (T_{A(GS)} * \alpha_{GS}) + T_{o(GS)} * (1 - \alpha_{GS}) + T_{LNA(GS)} + \frac{T_{comRcvr}}{\left[\frac{G_{LNA(GS)}}{10^{\frac{L_{RxC(GS)}}{10}}}\right]}$	[K]
Downlink Antenna Polarization Loss	$L_{dp} = \frac{1}{2} * \left\{1 + \frac{[(1-AR_{Tx(CS)}{}^2)*(1-AR_{Rx(GS)}{}^2)*cos(2*\theta_p)+(4*AR_{Tx(CS)}*AR_{Rx(GS)})]}{(1+AR_{Tx(CS)}{}^2)*(1+AR_{Rx(GS)}{}^2)}\right\}$	[Linear units]
Downlink SNR Ratio	$P_{SNR(CS)} = P_{r(GS)} + P_{N(GS)}$	[dB]
Actual Received Signal Power at Ground Station	$P_{r(GS)} = P_{t(CS)} + G_{t(CS)} + G_{r(GS)} - L_{T(CS)} - L_p - L_{pl(GS)} - L_{dp} - atmospheric\ losses - ionospheric\ losses - other\ in\ line\ losses\ of\ GS\ antenna$	[dBm]
CubeSat Receiver Noise Power	$P_{N(GS)} = 10 * log_{10}(k_B * T_{sys(GS)} * B_r)$	[dBm]

Uplink & Downlink Budget

Parameter Name	*Equation*	*Units*
Channel Capacity	$C = B_r * log_2(1 + SNR)$	[bits/ second]