PARAMETER	UPLINK (Earth - Spacecraft)	DOWNLINK (Spacecraft - Earth)	UNITS	Symbol	Reference
Speed of Light	3.00E+08	3.00E+08	m/s	C=l*f	constant
Frequency	1.20E+10	1.20E+10	Hz	f	Up/Down/Crosslink Ka band (25.5-30 GHz), Earth downlink S band (2-4 GHz)
Wavelength	2.50E-02	2.50E-02	m	λ	calculated from given
Range	2.00E+07	2.00E+07	km	R	Uplink/Downlink - L2 max, Crosslink - MOO, Earth Downlink - L2 to Groundstation
Boltzman's Constant	1.38E-23	1.38E-23	W/(Hz-K)	k	constant
Data Parameters	Uplink	Downlink	Units	Symbol	Reference
Bit Error Rate / Probablility of Bit Error	1.00E-05	1.00E-05	[-]	BER	Reference: Dr. Palo and Trades
Data Coding Scheme	QPSK	QPSK			Input: chosen modulation (SMAD Tab.13-10)
Required Bit Energy to Noise Ratio	9.8	9.8	dB	Eb/No	Approximated using SMAD Figure 13.9
Data Rate	2.56E+05	6.40E+04	bps (Hz)	R	Input: based on mission / objective - C1,C2,C3
Required Carrier to Noise Ratio	63.88239965	57.86179974	dB	C/No	C/No = Pr/No = (Eb/No)*R
Required Design Margin	6	6	dB		Input: design rule (Hoffmann chap. 9.4.4)(3,6,10 db) (low,decent,comfortable)
Minimum C/No	**69.88239965**	**63.86179974**	**dB-Hz**		Hoffmann 9.4.4 & SMAD 13-15a | Minimum C/No = C/No + Margin = Eb/No
Noise (applies to receiving elements)	Uplink	Downlink	Units	Symbol	Reference
Reference Temperature	290	290	K	To	SMAD Eqn13-24 (Generally constant) Always 290 K - Dr. Palo
Receive Antenna Efficiency	0.4	0.4	[-]	h	Constant for parabolic antenna - Brodie - for now assume 40% efficient
Receive Antenna Physical Temperature (User)	400	286.15	K	Tphys	Actual measured or theoretical temp at that position - Worst case HOT (Kelvin)
External "scene" Noise Temperature	250	300	K	Text	Uplink: Receiver on the S/C looks at Earth which is 260K | Downlink: Receiver looks at Space which is 25K, From Palo
Antenna Noise Temperature	340	291.69	K	Tant	Tant = eff*Text+(1-eff)*Tphys - This should be btwn Tphys and Text
Receiver Cable Loss	-1	-1	dB	Lc	SMAD Table 13-10, higher frequency increases. (reference LMR-400)
Receiver Cable Loss	0.7943282347	0.7943282347	Linear	Lc	Lc_Linear = 10^(Lc_dB/10)
Receiver Noise Figure (based on receiver)	3.773213792	2.988832814	dB	NF	NF = 10*log10(F)
Receiver Noise Factor	2.384083045	1.990138408	[-]	F	F = 1 + (Tphys/Tr)
Receiver Noise Temperature	289	289	K	Tr	SMAD Table 13-10 (20 GHz) - vender specific
Receiver System Noise Temperature	879	880.69	K	Ts	Sum of noises (usually 700-750 K) Currently Ts = Text + Tant + Tr
Receiver System Noise Power	-199.1613204	-199.1529785	dBW-Hz	No	Need equation, No = k*Ts (NEED TO CONVERT TO DB)
Receiver Parameters:	Uplink	Downlink	Units	Symbol	Reference
Receive Antenna Diameter	5	10	m	D	Earth - DSN 34 m | Assumption - Only Parabolic antennas - Consider Smaller Antennas
Receive Antenna Area	19.63495408	78.53981634	m^2	A	Assumption - parabolic = pi*r^2
Receive Antenna Efficiency	0.4	0.4	[-]	h	Source - Brodie Wllace - Dr. Palo's Phd student
Receive Antenna Gain	50.76361653	56.78421644	dBi	Gr	function of diameter G = 10log10(4*pi*Ae/λ^2)
Receive Antenna Effective Area	10.79922475	43.19689899	m^2	Ae	Ae = 0.55 * A (Parabolic reduced equation)
Receive Antenna Beamwidth	3.50E-01	1.75E-01	degrees	qr	Directivity vs Gain function qr = 70 * (λ/D)
Receive Antenna Pointing Accuracy	0.1	0.1	degrees	er	const (solve once) - SMAD pg 130
Receive Antenna Pointing Loss	-3	-3	dB	Lpr	SMAD 13-21 | -12(e/qr)^2 loss from angle errors (Assumption - 3 db loss)
Receiver Cable Loss (see noise)	-1	-1	dB	Lc	Input: typical value
Receiver Figure of Merit	21.32372778	27.33598579	dB/K	FOM	FOM = Gr - 10log10(Ts)
Propagation Parameters:	Uplink	Downlink	Units	Symbol	Reference
Space Loss	-260.045997	-260.045997	dB	Ls	from altitude - free space path loss (using isotropic equation currently, change this to reflect directivity)
Atmospheric Attenuation (clear air)	0	-7	dB	La	Worst case - Avg 7db Attenuation Daily
Polarization Loss			dB	Lp	Input: typical value constant - decide polarization, right or left hand circular
Propagation Losses	-260.045997	-267.045997	dB		Sum of all propagation losses = space + atmospheric attenuation

Transmitter Parameters:	*Uplink*	*Downlink*	*Units*	*Symbol*	*Reference*
Transmit Antenna Diameter	*10*	5	m	D	reciprocity Tx is Rx and Rx is Tx: Linked to row 33 but swapped - **Design Variable**
Transmit Antenna Area	*78.53981634*	*19.63495408*	m^2	A	reciprocity Tx is Rx and Rx is Tx: Linked to row 34 but swapped - **pi*r^2**
Transmit Antenna Efficiency	*0.4*	0.4	[-]	h	*Reciprocity - Refer Row 39*
Transmit Antenna Effective Area	43.19689899	10.79922475	m2	Ae	Need to decide user antenna for Uplink| Currently assuming all parabolic
Transmit Antenna Gain	56.78421644	50.76361653	dBi	Gt	G = 10log10(4*pi*Ae/λ^2) (25-35 dB = Dr. Palo) possibly
Transmit Antenna Beamwidth	3.50E-01	3.50E-01	degrees	qt	Reciprocity - Refer Row 42
Transmit Antenna Pointing Accuracy	*0.1*	*0.1*	degrees	et	Assumption
Transmit Antenna Pointing Loss	-3	-3	dB	Lpt	Assumption* double check number
Transmit Line Loss	*-0.5*	*-0.5*	*dB*	*Lt*	*Input: based on chosen cable/geometry, asume same as reciever*
Tramsmit Power, Linear	1000	1.00E+03	W		*Input: chosen transmitter DSN data & trade*
Transmit Power	*30*	*30*	dBW	Pt	Converted from linear
Effective Isotropic Radiated Power	86.28421644	80.26361653	dBW	EIRP	EIRP = Pt + Gt (in dB)

Link Budget:	*Uplink*	*Downlink*	*Units*	*Symbol*	*Reference*
Effective Isotropic Radiated Power (63)	86.28421644	80.26361653	dBW	EIRP	linked to row 66
Pointing Losses	-3	-3	dB		sum of transmit and receive pointing losses 1/10 -> few db (can assume 3db)
Propagation Losses (49)	-261.045997	-268.045997	dB	L	linked to row 47 (should be negative)
Receive Antenna Gain (38)	50.76361653	56.78421644	dB	Gr	linked to row 36
Received Power	-125.998164	-132.998164	dBW	Pr	Pr = EIRP + Lpointing +Lprop + Gr (asuuming the losses are negative)
Receiver System Noise Power (31)	-199.1613204	-199.1529785	dBW-Hz	No	linked to row 30
Received Carrier to Noise Ratio	73.16315634	66.15481444	dB-Hz	C/No	Received power - system noise power
Minimum C/No (20)	69.88239965	63.86179974	dB-Hz	C/No	linked to row 20
Link Margin	**3.280756684**	**2.293014697**	**dB**		received C/No - Minimum Pr/No **(Link Closes if more than 6 dB)**