LINK LEDGER · BLANK · SERVICE LEDGER

Link id (LL-year-nn) Date System Status: Planned | In service | Suspended | Retired | Failed | Not checked

Class: full | service only | budget only

1 Requirement What must be delivered: size, deadline, coverage, availability.	
2 Ends and path Who talks to whom; the path as it really is (transparent, regenerative, crosslinked, store and forward).	
3 Orbit and time Altitude, pass or continuous; delay one way and round trip; scheduling and queueing; Doppler.	
4 Band and permission Frequencies per hop; who holds the license, under which rule, in which country.	
5 Capacity Up and down separately; peak against sustained; contention.	
6 Who owns each end Space segment, ground segment, customer relationship, the exit.	
7 Trust Who can command it; whose keys; how it is updated and recovered; jamming and spoofing.	
8 How it fails, and how we would see it Silent failure named; the evidence that shows it.	
9 Cost shape Per minute, per megabyte, per month or per terminal; per kilogram for launch; a price only with its date and what it leaves out.	
10 Evidence Each number with its evidence class, source and date; an assumption is marked so.	

The six questions

1. What must be delivered, and by when?
2. How is the work divided between user, space and ground?
3. Does each hop close, with what margin, under which assumptions?
4. Who owns each end, and who gave permission?
5. How does it fail, who can interfere, and what would show us?
6. What can I use or rent before I build?

The evidence classes

measured From an instrument or a log; who and when.
calculated From stated inputs by a formula the text gives.
simulated From a named model and its settings.
operator claim Stated by the operator; not independently checked.
standard From a named standard or rule, clause or table.
assumption To verify: no primary source read; name what settles it.
published history Published history: an agency history or labeled scholarship.

LINK LEDGER · BLANK · HOP BUDGET

Hop name: _____ (one block per radio hop; a variant of it is a case: Case A, Case B)

From ___ to ___ · frequency · distance · reference plane · information rate · symbol rate · stated error rate

Part	Line	Value, in its own unit	dB, signed	Evidence	Source and date
TRANSMIT POWER AND ANTENNA GAIN	Transmitter output (dBW)				
	Feeder loss				
	Transmit antenna gain (dBi)				
LOSSES	Free space path loss				
	Atmosphere and rain				
	Polarization and pointing				
RECEIVE SENSITIVITY	Receive G/T: antenna gain less system noise temperature (dB/K)				
	Boltzmann's constant: add 228.6 dB (it is -228.6 dBW/K/Hz)				
BANDWIDTH	Information rate (bit/s): for Eb/N0, subtract 10 log10 of it				
	Symbol rate (baud): for Es/N0, subtract 10 log10 of it instead				
INTERFERENCE	Interference, as the step from C/N0 to C/(N0+I0)				
CODING	Modulation, code and implementation loss				
REQUIRED SIGNAL QUALITY	Required Eb/N0, Es/N0 or C/N0 (choose one; the same quantity as above) for the stated error rate				
RESULT	**Achieved Eb/N0, Es/N0 or C/N0: the sum of every line above the required one**			calculated	
	Required: the Eb/N0, Es/N0 or C/N0 for the stated error rate			source:	
	Margin: achieved less required			design minimum: ___ dB	

Verdict (circle one): CLOSES · DOES NOT CLOSE, with a margin of _____ dB

Operating point (rate, direction, elevation, weather, availability):

Source of the required value (a standard or a published curve):

If it does not close, the line that fails, and by how many dB:

Transparent circuit: the combined line. Combine C/N0 (or C/(N0+I0)) of each hop, before the rate and the implementation loss. Uplink C/N0: _____ dBHz. Downlink C/N0: _____ dBHz. Combined (the inverse ratios add): _____ dBHz. Less the rate and the implementation loss, once: _____ dB. Required: _____ dB. Margin: _____ dB. Two passing hops are not a passing circuit.

How to add it up. Write every line in decibels with its sign: gains positive, losses negative. Beside each number you may write the level after that line (dBW after the transmitter, dBW/K after G/T, dBHz after Boltzmann's constant, dB after the rate). After Boltzmann's constant the level is C/N0 in dBHz. Es/N0 = C/N0 minus 10 log10(symbol rate in baud); Eb/N0 = C/N0 minus 10 log10(information rate in bit/s). Compare like with like: the required value is the same quantity as the achieved one. Write a dB value on one rate line only, and on neither for C/N0. The achieved value is the sum of every line above the required one. The margin is the achieved value less the required value. The hop closes when the margin is at or above the design minimum you wrote down before you started.

LINK LEDGER · BLANK · OPTICAL HOP BUDGET

Hop name: _____ (one block per optical hop; a variant of it is a case: Case A, Case B)

From ____ to ____ · wavelength · range · direct detection or coherent · stated rate

Part	Line	Value, in its own unit	dB, signed	Evidence	Source and date
TRANSMIT OPTICAL POWER AND APERTURE	Transmit optical power (dBm)				
	Transmit gain, from aperture and beam divergence				
LOSSES	Range loss				
	Pointing loss				
	Atmospheric and cloud loss				
RECEIVE APERTURE	Receive aperture gain				
	Receive optics loss				
RECEIVER SENSITIVITY	Sensitivity in dBm at the stated rate, in the dark (convert photons per bit to dBm first)				
	Background light: the rise in the sensitivity it causes (dB, positive)				
RESULT	**Achieved received power (dBm): the sum of every line above the required one**			calculated	
	Required: the sensitivity plus the background light, in dBm at the stated rate			source:	
	Margin: achieved less required			design minimum: ____ dB	

Verdict (circle one): CLOSES · DOES NOT CLOSE, with a margin of _____ dB

Operating point (rate, direction, elevation, weather, availability):

Source of the required value (a standard or a published curve):

If it does not close, the line that fails, and by how many dB:

How to add it up. Write every line in decibels with its sign: gains positive, losses negative. Start from the transmit power in dBm and keep every line in dB, so the sum is a power in dBm. The received power is the sum of every line above the sensitivity. Background light does not lower the received power: it raises the power the receiver needs, so it is added to the sensitivity. The margin is the received power less the required power. Cloud is a line, not a footnote: write the budget for clear air and again for the cloud you must survive.

BUDGET SHEET · TWO HOPS SIDE BY SIDE

Part	Line	Hop up: from, to, frequency			Hop down: from, to, frequency		
		Value	dB	Class, source, date	Value	dB	Class, source, date
TRANSMIT POWER AND ANTENNA GAIN	Transmitter output (dBW)						
	Feeder loss						
	Transmit antenna gain (dBi)						
LOSSES	Free space path loss						
	Atmosphere and rain						
	Polarization and pointing						
RECEIVE SENSITIVITY	Receive G/T (dB/K)						
	Boltzmann's constant: add 228.6 dB						
BANDWIDTH	Information rate (bit/s), for Eb/N0						
	Symbol rate (baud), for Es/N0						
INTERFERENCE	Interference, as the step from C/N0 to C/(N0+I0)						
CODING	Modulation, code and implementation loss						
REQUIRED SIGNAL QUALITY	Required Eb/N0, Es/N0 or C/N0						
Achieved Eb/N0, Es/N0 or C/N0 (sum)							
Required, the same quantity, for the stated error rate							
Margin: achieved less required							
Design minimum margin							
Closes, or does not close, at the operating point below							

Operating point (rate, direction, elevation, weather, availability):
Source of the required value:

Transparent circuit: the combined line. Combine C/N0 of the two hops, before the rate and the implementation loss: _____ dBHz (the inverse ratios add). Less the rate and the implementation loss, once: _____ dB. Required: _____ dB. Margin: _____ dB. Two passing hops are not a passing circuit.

The arithmetic, in words

Power in dBW is 10 times the base-10 logarithm of the power in watts.
Free space path loss in dB is 92.45, plus 20 times the logarithm of the distance in kilometers, plus 20 times the logarithm of the frequency in gigahertz. Enter it as a negative number.
When the receive line is G/T in dB per kelvin, add 228.6 for Boltzmann's constant.
After Boltzmann's constant the level is C/N0 in dBHz. Subtract 10 times the logarithm of the information rate in bits per second for Eb/N0, or of the symbol rate in baud for Es/N0. Compare it with a required value of the same quantity.
Interference is a line: the step down from C/N to C/(N+I), entered as a negative number.
Combined line: turn each hop's result from decibels into a ratio, add the inverses, invert the sum, and turn it back into decibels. The result is always below the weaker hop.
The margin is the achieved value less the required value. Write the design minimum before you start.

The evidence classes

measured From an instrument or a log; who and when.
calculated From stated inputs by a formula the text gives.
simulated From a named model and its settings.
operator claim Stated by the operator; not independently checked.
standard From a named standard or rule, clause or table.
assumption To verify: no primary source read; name what settles it.
published history Published history: an agency history or labeled scholarship.