LightCube
Interplanetary Initiative Lab
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Lightcube Radio Link Budget

Edits:

Initial Draft	Chandler Hutchens, 1/31/2022
Addition of Tables and References	Chandler Hutchens, 2/04/2022

Summary:
A margin of 25.18 dBm and 13.12 dBm is shown when taking a few best or worst case scenarios for the radio link between an average user and Lightcube. The best time to communicate for a flash will be when Lightcube is closest to the user.

Background and Specifications:
Lightcube is an outreach cubesat mission whose purpose is to get people interested in space! To the average person, space is very far away and being able to feel a part of it can be very impactful. Lightcube is different from the typical satellite, in that it is able to be interacted by the average person. Although anyone with a radio license and an antenna can technically “communicate” or listen to a satellite, with Lightcube, it's a visual communication. When you dial with a radio and point towards the sky as it passes overhead, you should be able to see a flash of light signifying that it heard you loud and clear.

The average person, after getting a radio license, will use some radio (ex. baofeng) and connect an antenna to the top of it (ex. whip antenna). Making some educated assumptions of some popular radios and antennas, radio link budgets found in Table 1 and Table 2 were created to detail the amount of margin between an average user uplink to Lightcube. The purpose of the analysis is to confirm that the average person will be capable, given the worst and best conditions, to communicate between Lightcube and witness a flash.

The analysis does make a few assumptions, such as the radio frequency, connector and cable losses, and worst/best case scenarios. Although these are assumptions, they are highly probable and the difference wouldn’t make a huge significance to the margin value. An example of this shown in the table is the altitude. Lightcube will be orbiting on a similar orbit as the International Space Station, which has a fairly low Earth Orbit at an average of 420km when directly overhead. However, there is a worst case scenario that the satellite gets placed or drifts out of orbit further than expected. This worst case scenario, along with the furthest site being at the horizon was set to 1000km. This is less likely but even if we assume such a large distance away from the user, the margin is still doable.

Table 1: Worst Case Radio Link Budget

Variable Name	Input	Unit	Definition	Notes About Input
Ptx	36.90	dBm	Transmitter Output Power	5W Transmitter
Gtx	0.00	dBi	Transmitter Antenna Gain	Whip Antenna[1]
Grx	0.00	dBi	Receiver Antenna Gain	Quad Turnstile
Ltx	0.00	dB	Transmit Feeder and Associated Losses (Feeder, Connectors)	
Distance	1,000.00	km	Estimated Length Between	Worst Case Altitude (i.e. Horizon)[2]
Frequency	437.00	MHz	Frequency Operating At	Highly Probable Frequency
Lfs	145.25	dB	Free Space/Path Loss	
La	0.50	dB	Atmospheric Loss	Not Exactly Relevent under 1GHz[3]
Lp	0.03	dB	Miscellaneous signal Propagation loss (Cables)	10cm of .8"
Lrx	0.00	dB	Receiver Feeder and Associated Losses (Feeder, Connectors)	
Prx	-108.88	dBm	Received Power	
Noise	-122.00	dBm	Receiver Sensitivity	2+/-[4]
Margin	13.12	dBm	Tolerance	
SNR	122.00	dB	Signal Power to the Noise Ratio	

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[1] " Nagoya NA-771," *BaoFeng Radios - Purchase, Software, and Support for BaoFeng and BTECH Radios* Available: https://baofengtech.com/product/nagoya-na-771/.

[2] Barbaric, D., *Dubravko Babić - Info stranice djelatnika* Available: https://www.fer.unizg.hr/dubravko.babic.

[3] "Attenuation by atmospheric gasses" Available: https://www.itu.int/dms_pubrec/itu-r/rec/p/R-REC-P.676-12-201908-I!!PDF-E.pdf.

[4] "DRA818U Uhf band voice transceiver module "Available: http://www.dorji.com/docs/data/DRA818U.pdf.

Table 2: Best Case Radio Link Budget

Variable Name	Input	Unit	Definition	Notes About Input
Ptx	36.90	dBm	Transmitter Output Power	5W Transmitter
Gtx	2.00	dBi	Transmitter Antenna Gain	Whip Antenna
Grx	0.00	dBi	Receiver Antenna Gain	Quad Turnstile
Ltx	0.00	dB	Transmit Feeder and Associated Losses (Feeder, Connectors)	
Distance	420.00	km	Estimated Length Between	Best Case Altitude (i.e. Overhead)[5]
Frequency	437.00	MHz	Frequency Operating At	Highly Probable Frequency
Lfs	137.71	dB	Free Space/Path Loss	
La	0.00	dB	Atmospheric Loss	Not Exactly Relevent under 1GHz
Lp	0.01	dB	Miscellaneous signal Propagation loss (Cables)	10cm of .8"
Lrx	0.00	dB	Receiver Feeder and Associated Losses (Feeder, Connectors)	
Prx	-98.82	dBm	Received Power	
Noise	-124.00	dBm	Receiver Sensitivity	2+/-[6]
Margin	25.18	dBm	Tolerance	
SNR	124.00	dB	Signal Power to the Noise Ratio	

Conclusion:

After reviewing the results of the analysis, it seems rather interesting, yet expected, that the best case is also the period when Lightcube would be directly overhead. This creates the shortest distance between the two radios and lowers the value of free space loss. When looking at the worst case scenario, the user would be trying to contact Lightcube when it is at the horizon, placing the radios furthest away (in the essence of line of sight), and they still have a usable margin, but it wouldn't be favorable to communicate within these parameters.

[5] *ISS - orbit* Available: https://www.heavens-above.com/orbit.aspx?satid=25544.

[6] "DRA818U Uhf band voice transceiver module "Available: http://www.dorji.com/docs/data/DRA818U.pdf.