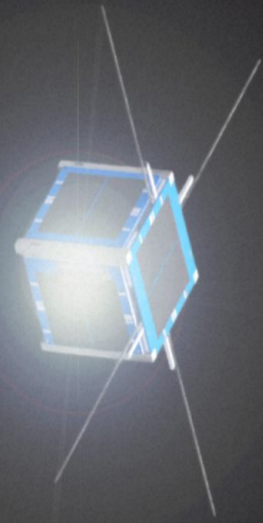


Demodulation Demonstration using the LightCube CubeSat

Libby Berkhout, GRCON 2023



Students sending stuff to space



- Space missions are more accessible than ever
 - CubeSats offer opportunities to launch new technology for relatively low-cost and low-consequence
 - Projects like GNURadio and SatNOGS make support communications easy for beginners
- LightCube as a “case study” of the next generation of mission designers learning to actually build and operate spacecraft
 - I am not a comms engineer
 - Astronomy is usually not actively trying to talk or us or prevent itself from being heard*
 - Here’s some tools that were useful to me!

*Depends on personal views about the cold indifference of the universe

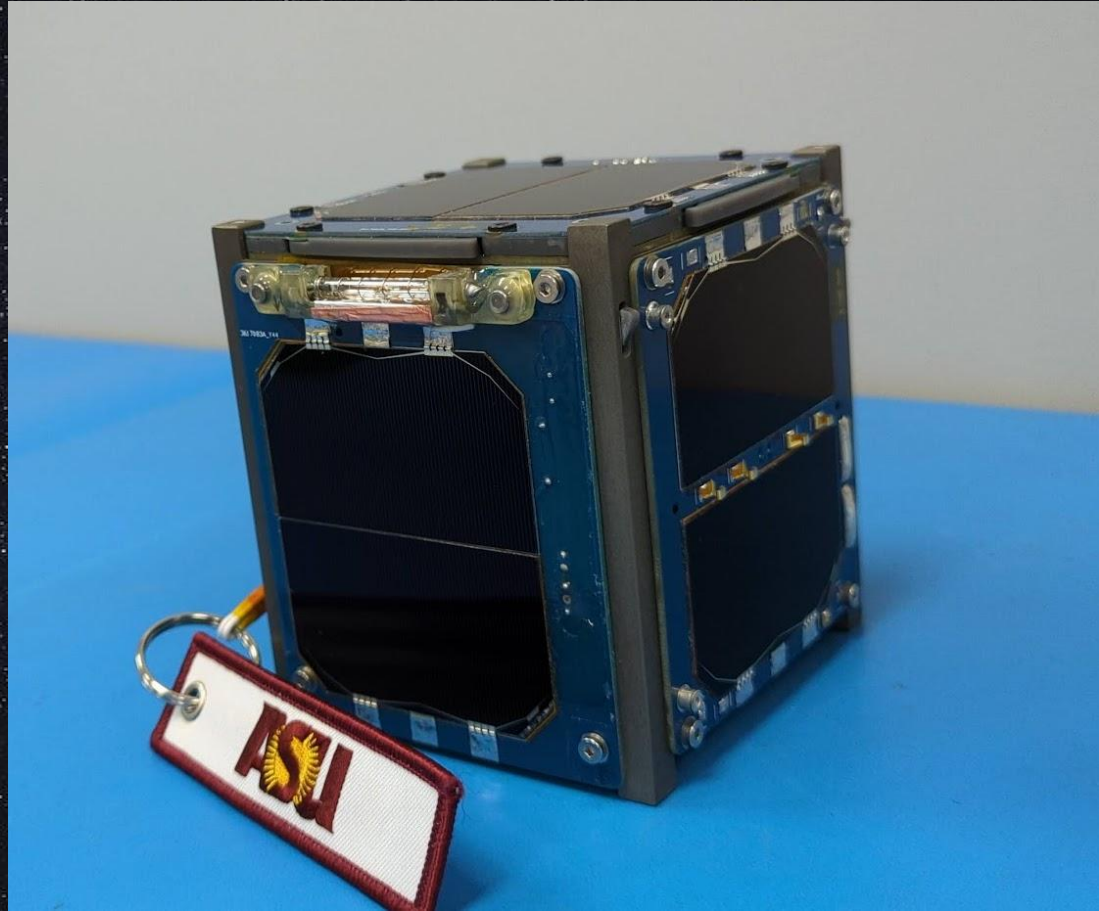
InterPlanetary Lab

- Student space lab
- Spaceflight testing equipment
 - Thermal Vac
 - Vibe testbed
 - Anechoic chamber
 - ADCS pointing testbed



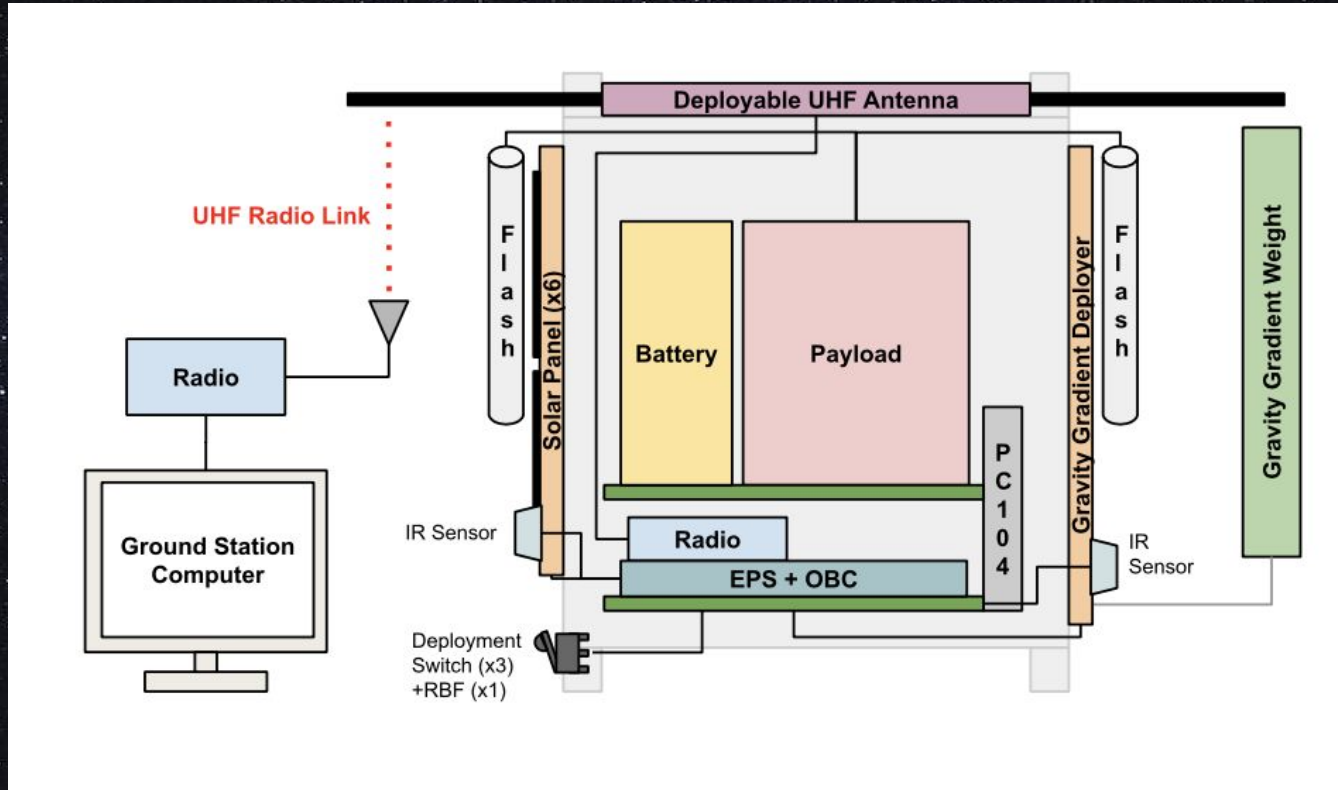
LightCube

- Educational mission
 - Built by students, operated by anyone*!
- Xenon flash tube triggered by HAM radio operators produces naked-eye visible flash.
- Launched April 24th from ISS, operated for just under 24 hours before comms failure



*with a HAM radio license

Block Diagram



Telemetry

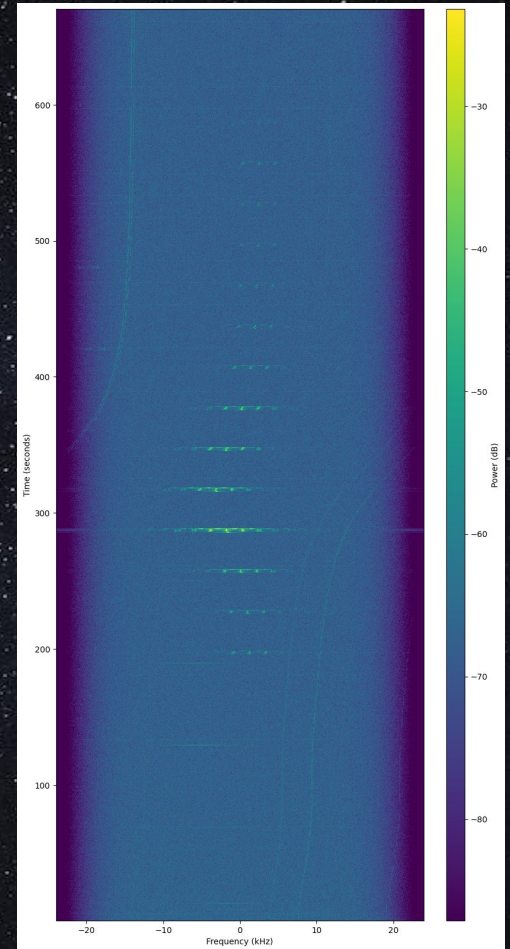
- Hearbeat, Full telemetry, and Orientation packets
- Commanded over DTMF, telemetry over AFSK

Table 1. Scheme, protocol, and carrier information for Lightcube.

	Scheme	Carrier
Downlink	RTTY(AFSK)	437.175 MHz
Uplink	DTMF	437.175 MHz

Table 3. Baud rate and mark/space frequency information for the Bell 103 protocol used for downlink telemetry

Bell 103 FSK Mode	Min	Typ.	Max	Units
Baud rate		300		
Mark (logical 1)	2222	2225	2228	Hz
Space (logical 0)	2022	2025	2028	Hz



SatNOGS Observation by Fredy Damkalis
on station owned by Mike Rupprecht

SatNOGS

SatNOGS DB

Search

- Home
- About
- All Satellites
- All Transmitters
- Statistics

LightCube (99165)

Info Map Transmitters Data Sign Up / Log In

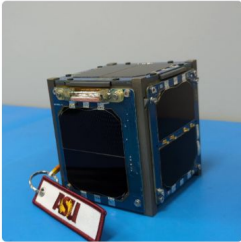
Mission information

Name	LightCube
Alternate Names	KJ7TZG
Satellite ID	EKAU-1559-4596-9876-0364
Temporary NORAD ID	99165
Followed NORAD ID	56314
Website	https://interplanetary...
Country of Origin	United States of America

Status

Operational
Satellite is in orbit and operational

Image



Description

LightCube is a 1U Cubesat with an outreach and accessibility goal of providing an immediate and powerful connection to space and to the night sky. It does this by providing a momentary flash of light that is visible to the naked eye and can be triggered by any amateur radio operator.

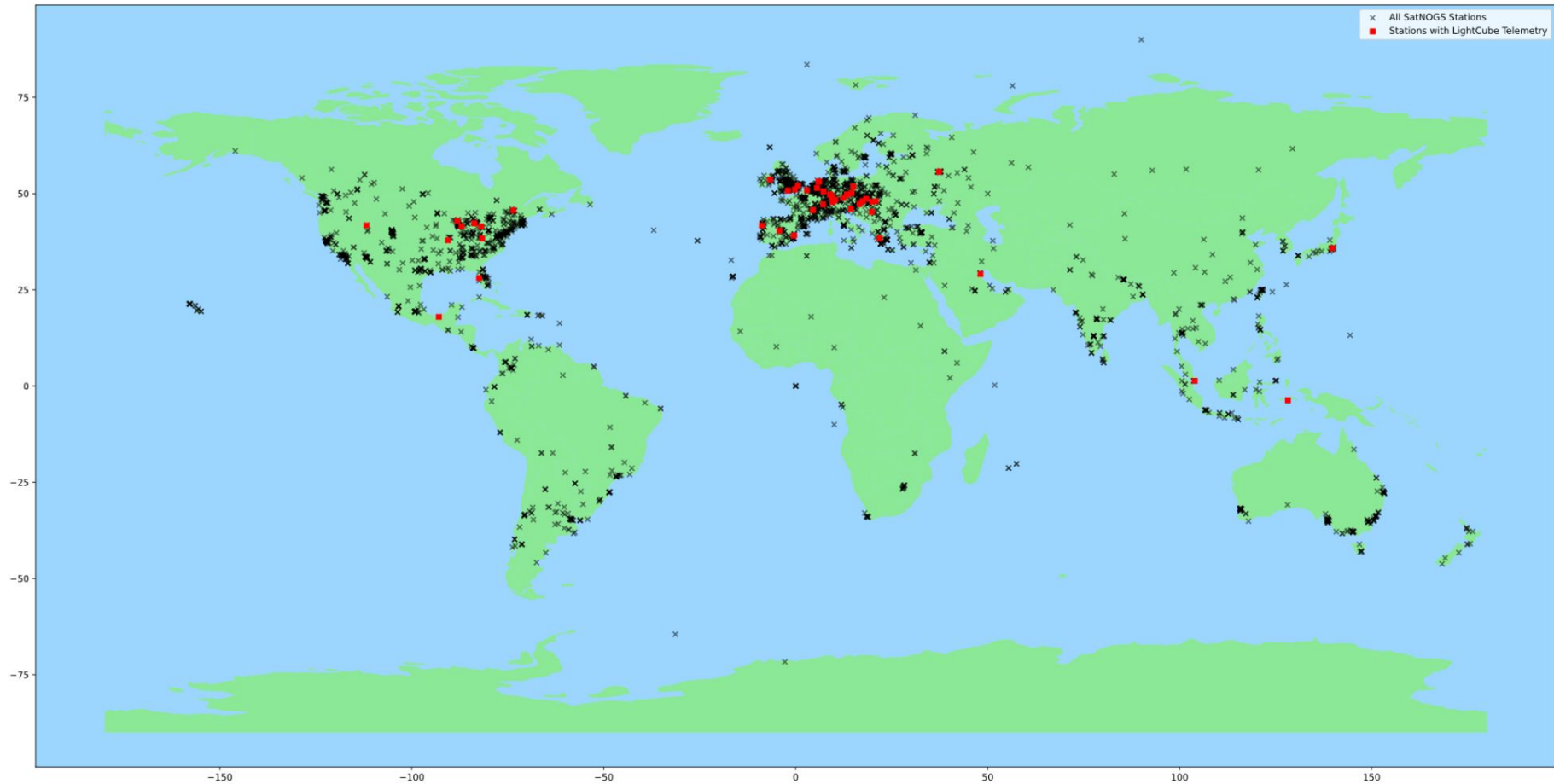
Mission timeline

Deploy Date	2023-04-24T12:05:00+00:00
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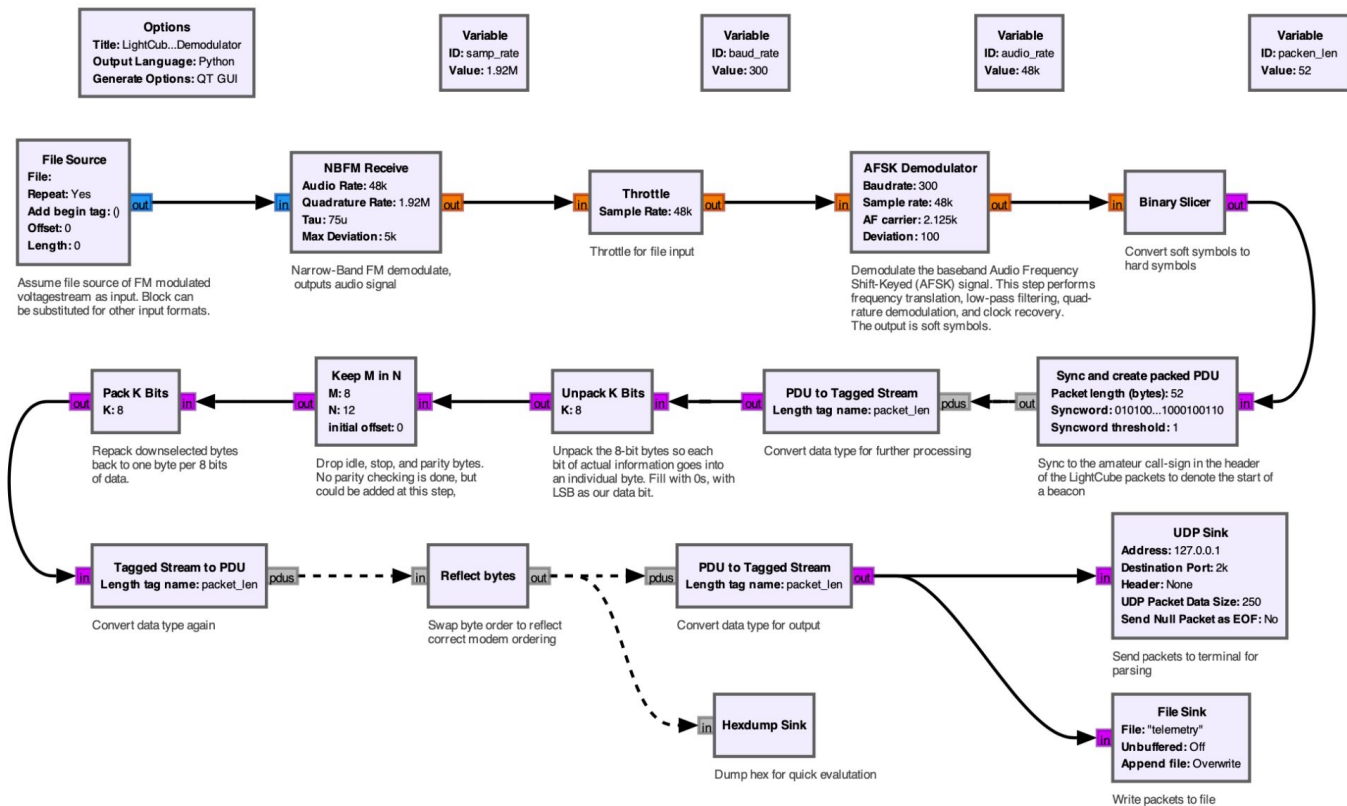
SatNOGS Links

[Network Observations ↗](#)

- Libre Space Foundation Satellite Networked Open Ground Stations project
- Network of amateur stations, essential to high duty-cycle Lightcube coverage!
- ASU Ground station connected to the network



Demodulating

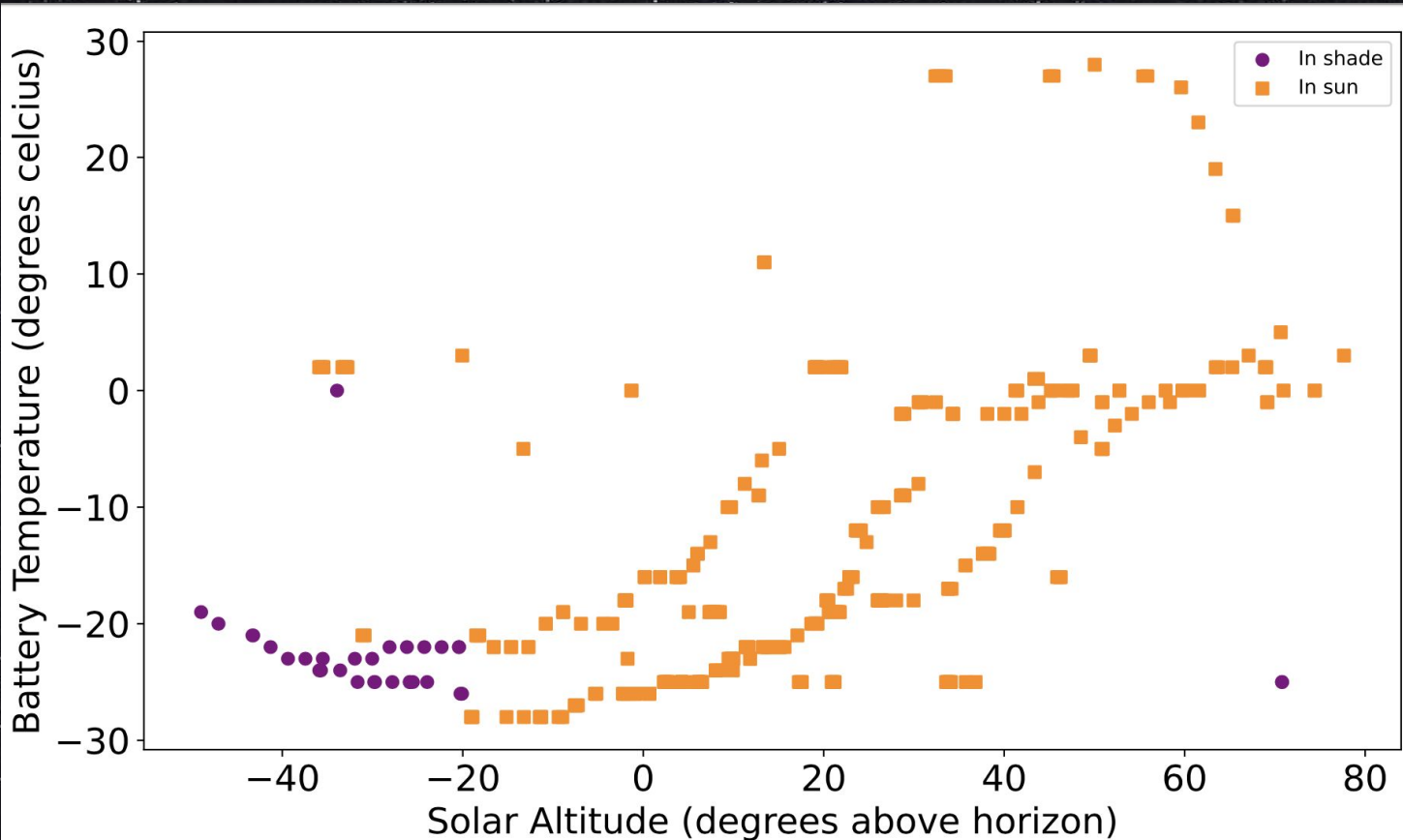


- Used by the LightCube team, as well as by a few SatNOGS enthusiasts
- Supported by gr-satellites package

Statistics

- Number of Packets Received: 531
- Number of Packets failed CRC: 112
- Percentage of usable packets: 79%
- Almost all packets had a reported battery temp of at or below 0C, which is the minimum recommended operating temp of the batteries

Solar Altitude vs Battery Temperature



- Battery heater left in pre-launch testing config
- High duty cycle observations enabled by SatNOGS critical to IDing battery failure

Conclusions

- Lessons learned from LightCube will be used for future missions
- Unlike to hear from the satellite again, but still looking out!
- Projects like SatNOGS and gr-satellites are great, consider contributing!



Thanks!

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Thanks to the SatNOGS and gr-satellites projects, and GNURadio collaboration for enabling observations

Funding provided by Arizona State University's Interplanetary Lab, Vega Space Systems, and ASU Alumni

More about LightCube: <https://lightcube.space/>