VIRGINIA CUBESAT CONSTELLATION FINAL REPORT

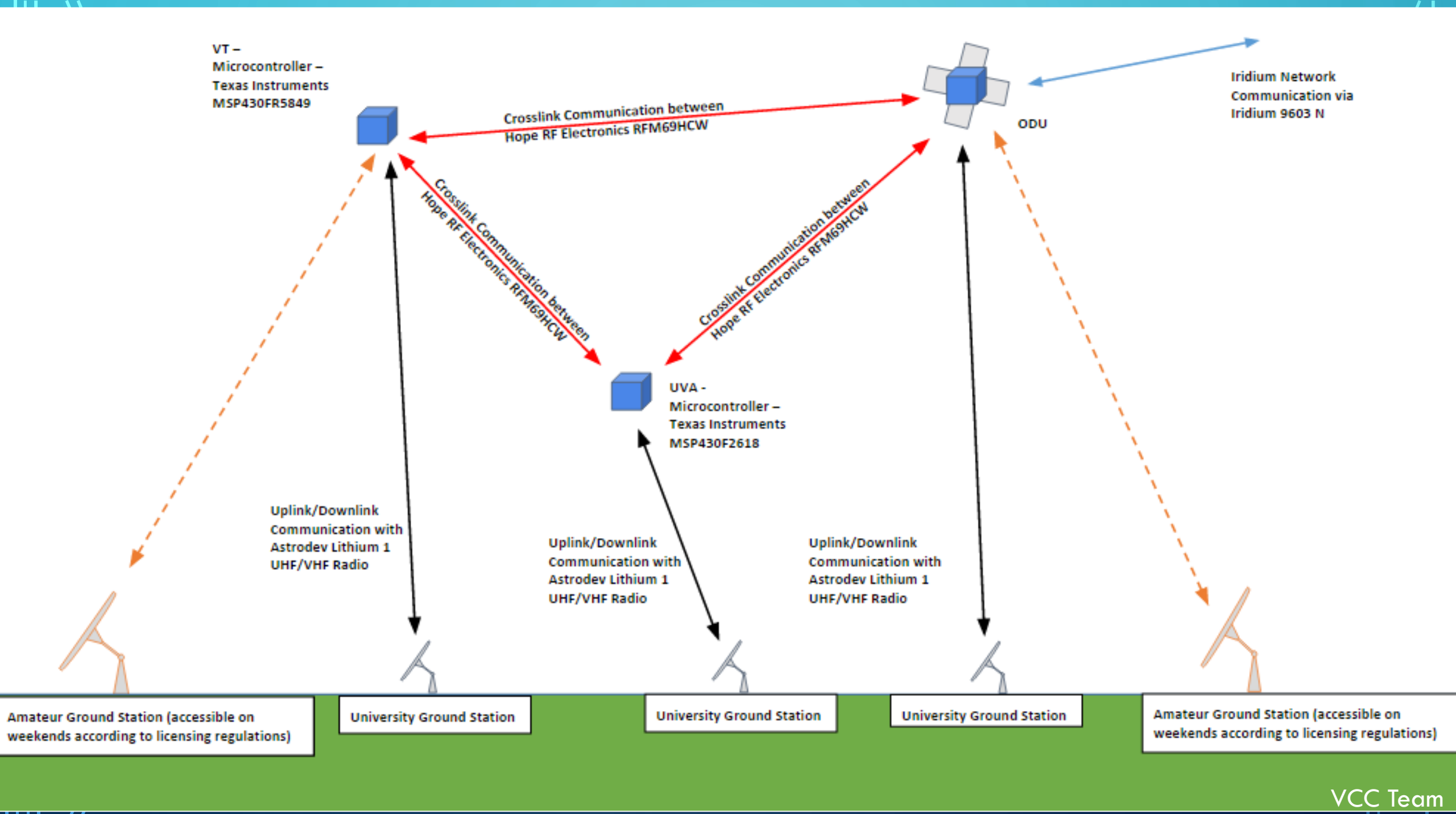
MIKE MCPHERSON, KQ9P

ALBEMARLE AMATEUR RADIO CLUB

10 MARCH 2020

MISSION OBJECTIVES

- Provide a hands-on, student-led flight project experience for undergraduate students by designing, developing, integrating, testing and flying an orbital constellation of three 1U CubeSats
- Obtain measurements of the orbital decay of a constellation of satellites to develop a database of atmospheric drag and the variability of atmospheric properties


VT –
Microcontroller –
Texas Instruments
MSP430FR5849
Crosslink Communication between
Hope RF Electronics RFM69HCW
ODU
Iridium Network
Communication via
Iridium 9603 N
Crosslink Communication between
Hope RF Electronics RFM69HCW
Crosslink Communication between
Hope RF Electronics RFM69HCW
UVA -
Microcontroller –
Texas Instruments
MSP430F2618
Uplink/Downlink
Communication with
Astrodev Lithium 1
UHF/VHF Radio
Uplink/Downlink
Communication with
Astrodev Lithium 1
UHF/VHF Radio
Uplink/Downlink
Communication with
Astrodev Lithium 1
UHF/VHF Radio
Amateur Ground Station (accessible on
weekends according to licensing regulations)
University Ground Station
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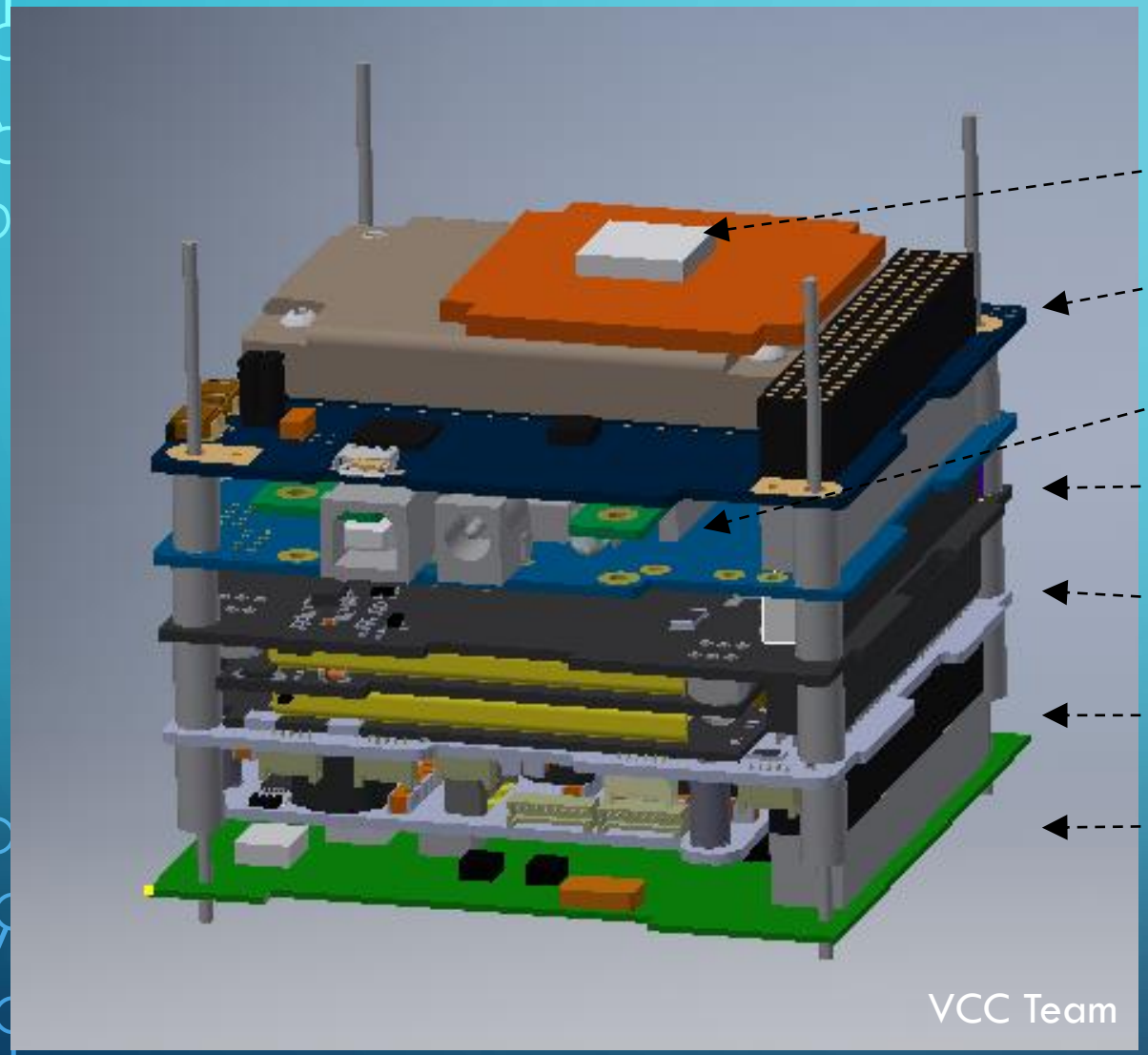
Amateur Ground Station (accessible on
weekends according to licensing regulations)



GPS Patch Antenna piPATCH-L1

Payload Module (GPS board, IMU)

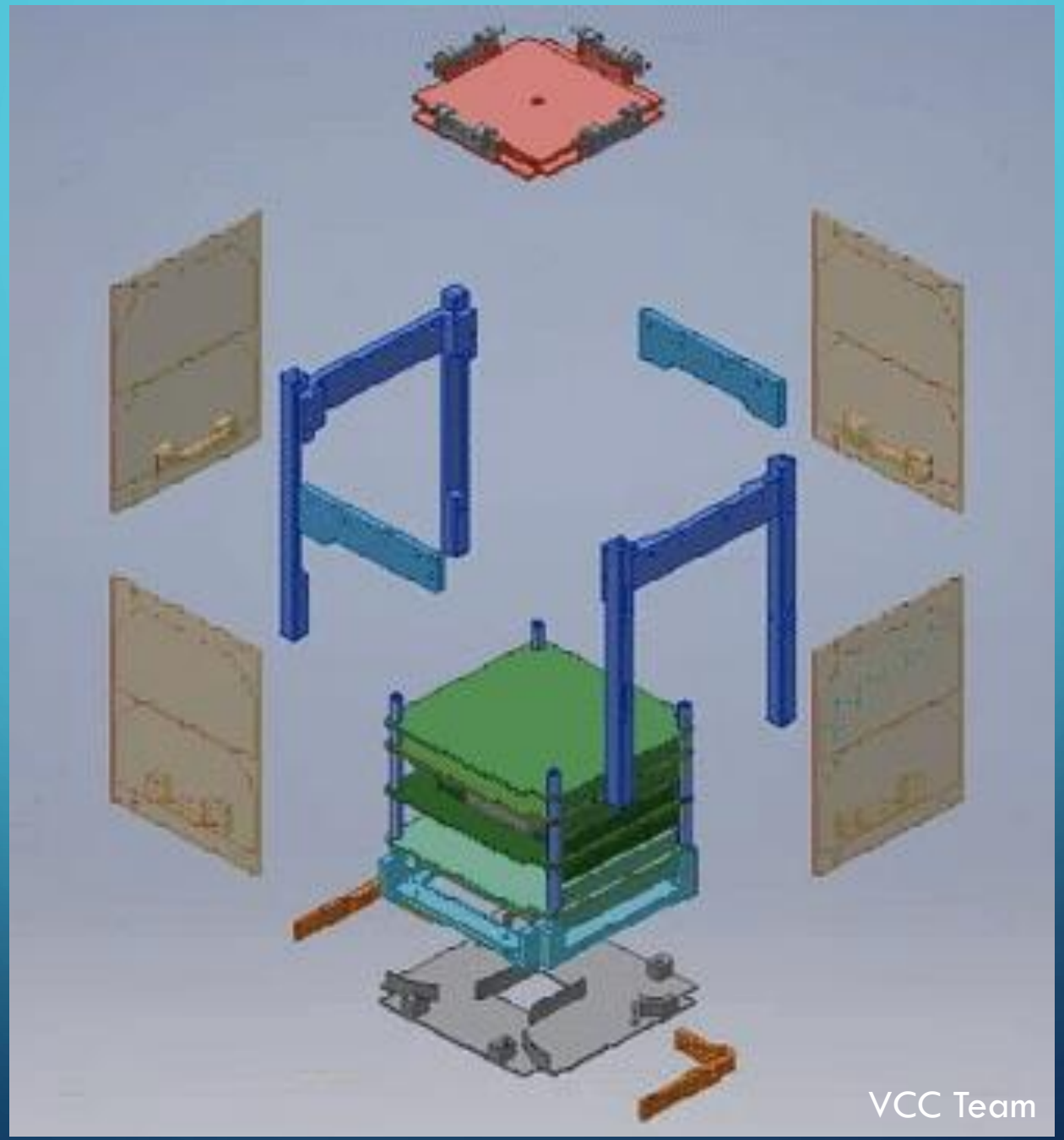
Flight Module, Processor

Flight Module, Motherboard

Clyde Space 20 Whr Battery

Clyde Space EPS

Radio Board (Lithium Li-1, RFM69HCW)


VCC Team

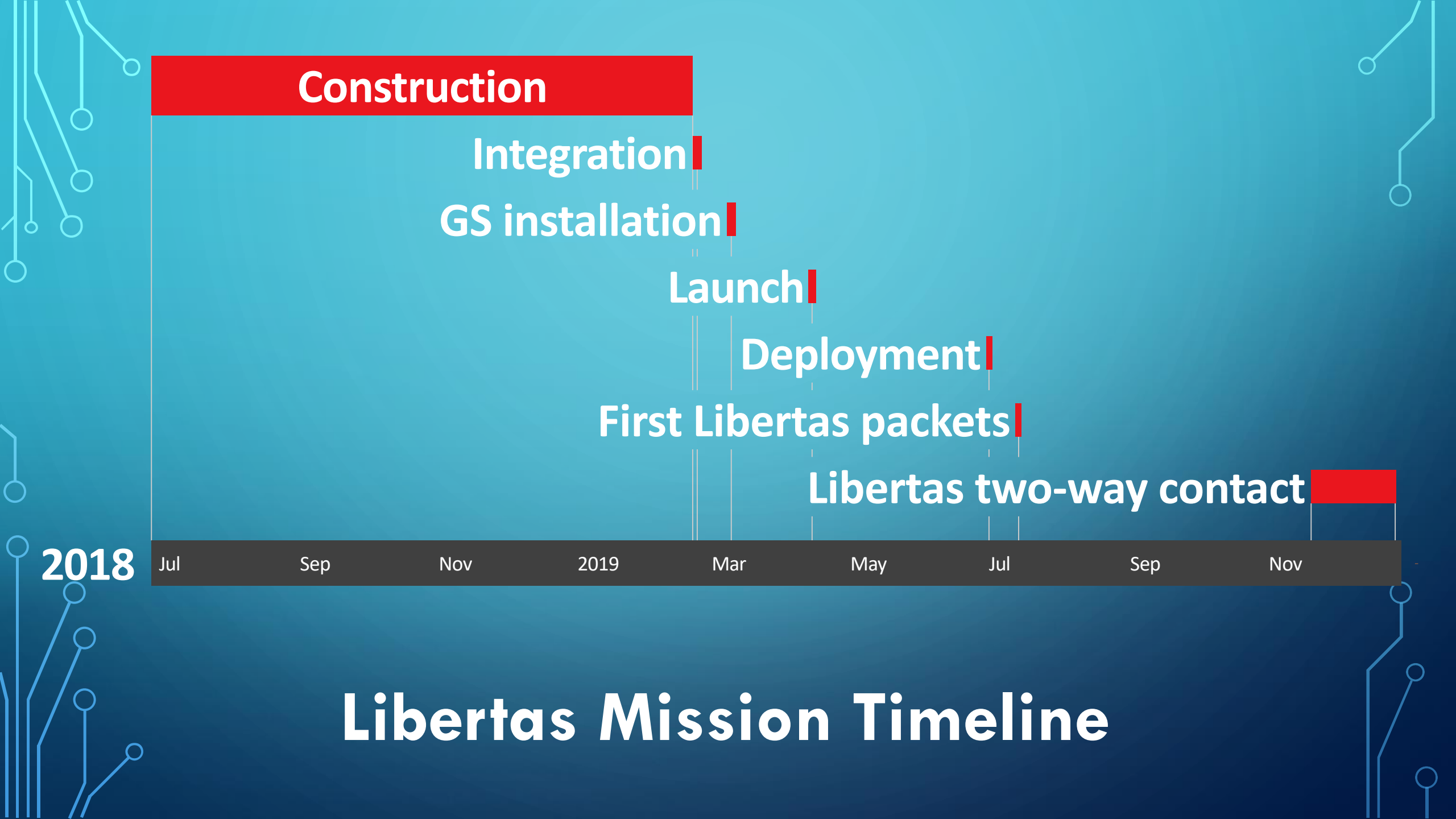
VCC Team

UVa students designed, built, and orbited a working cubesat…

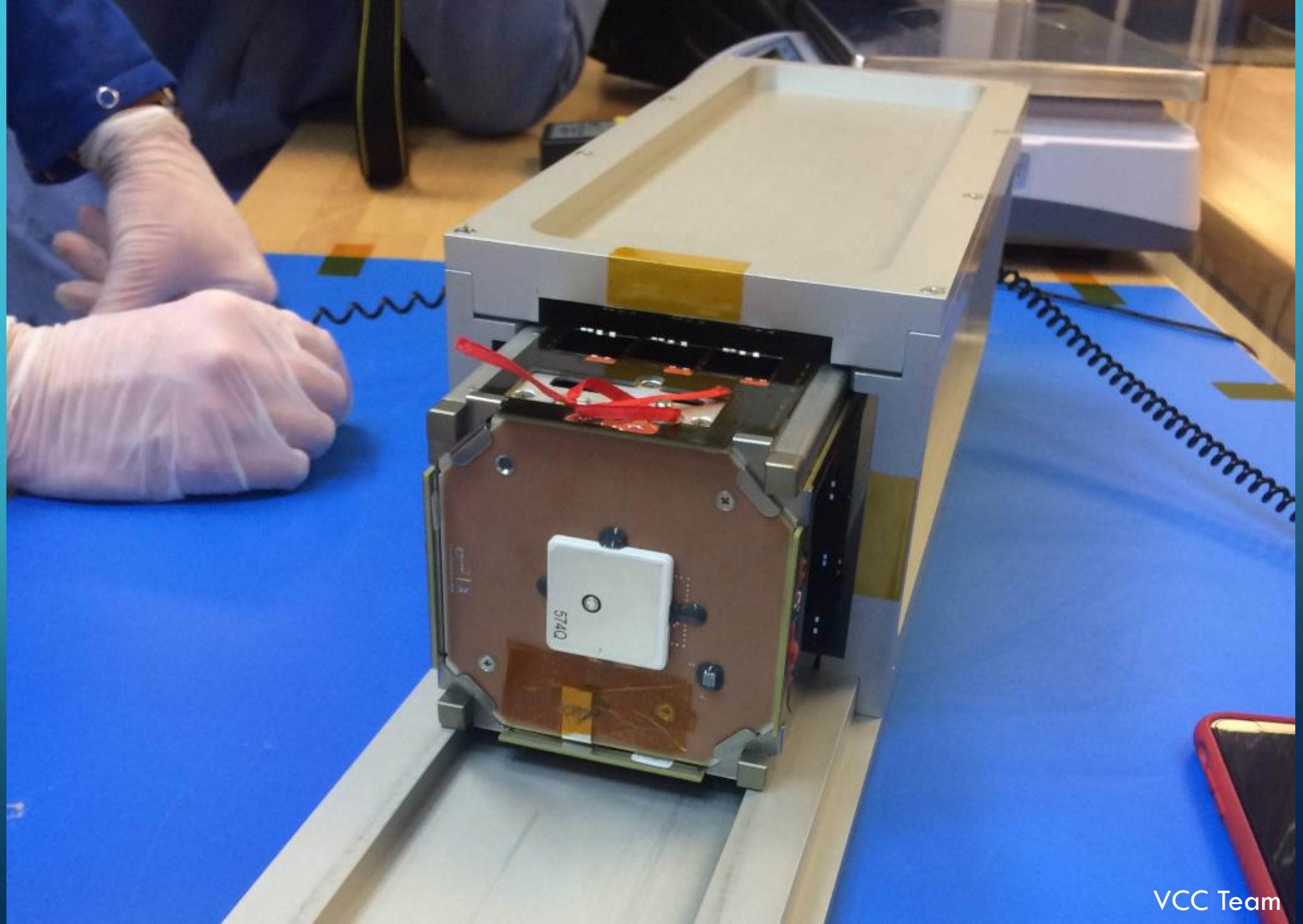
ON THE FIRST TRY!

UVA TEAMS

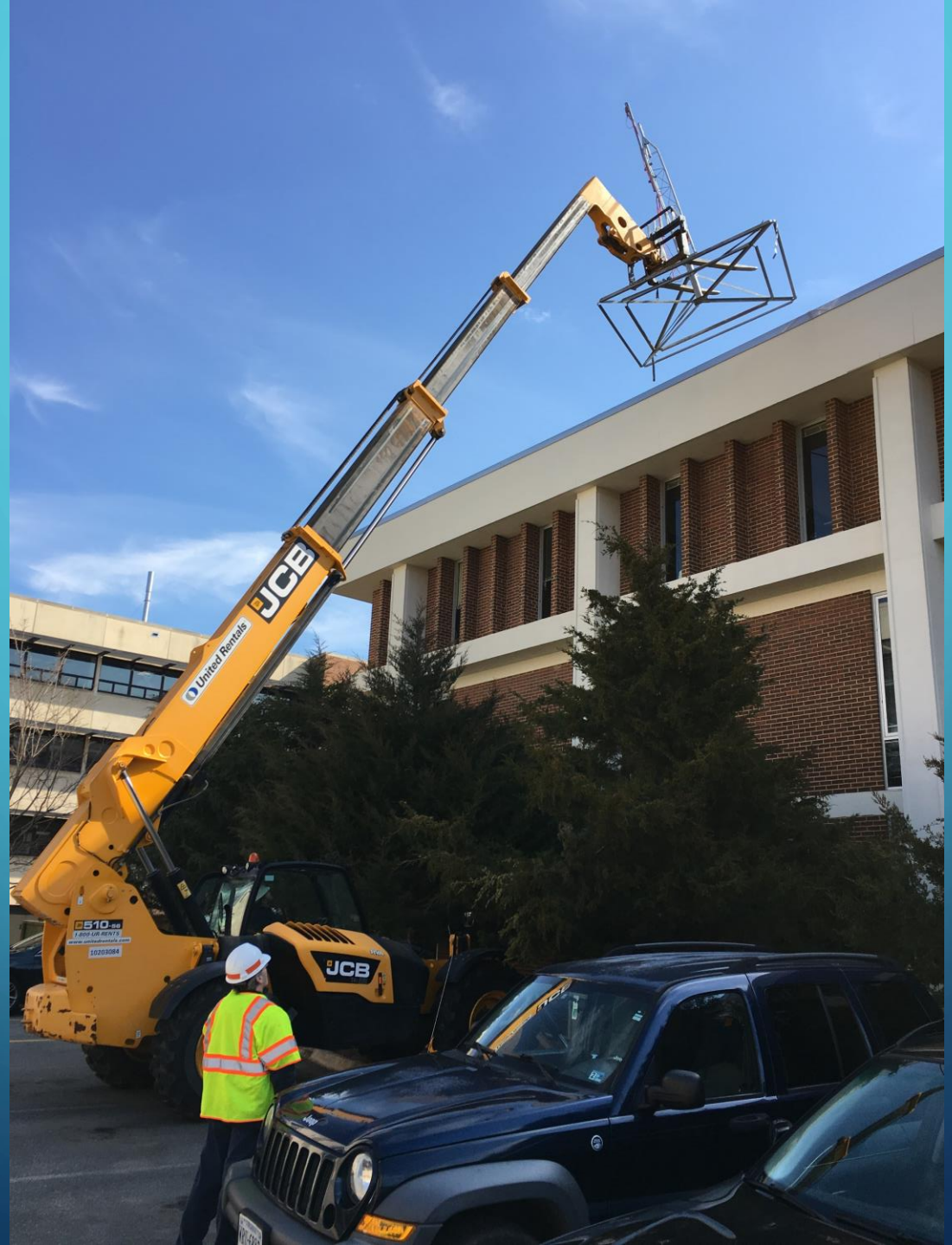
- Design Team
  - Nathan Gaul
  - Matt Anderson
  - Aaron Blaufox
  - Bruce Kay
  - David Khanan
- Build Team
  - Erin Puckette
  - Ken Dunne
  - Justin Javier
  - Trace LaCour
  - Wyatt Wilson
- Launch/Operations Team
  - Connor Segal
  - Hannah Umansky
  - Kathryn Wason



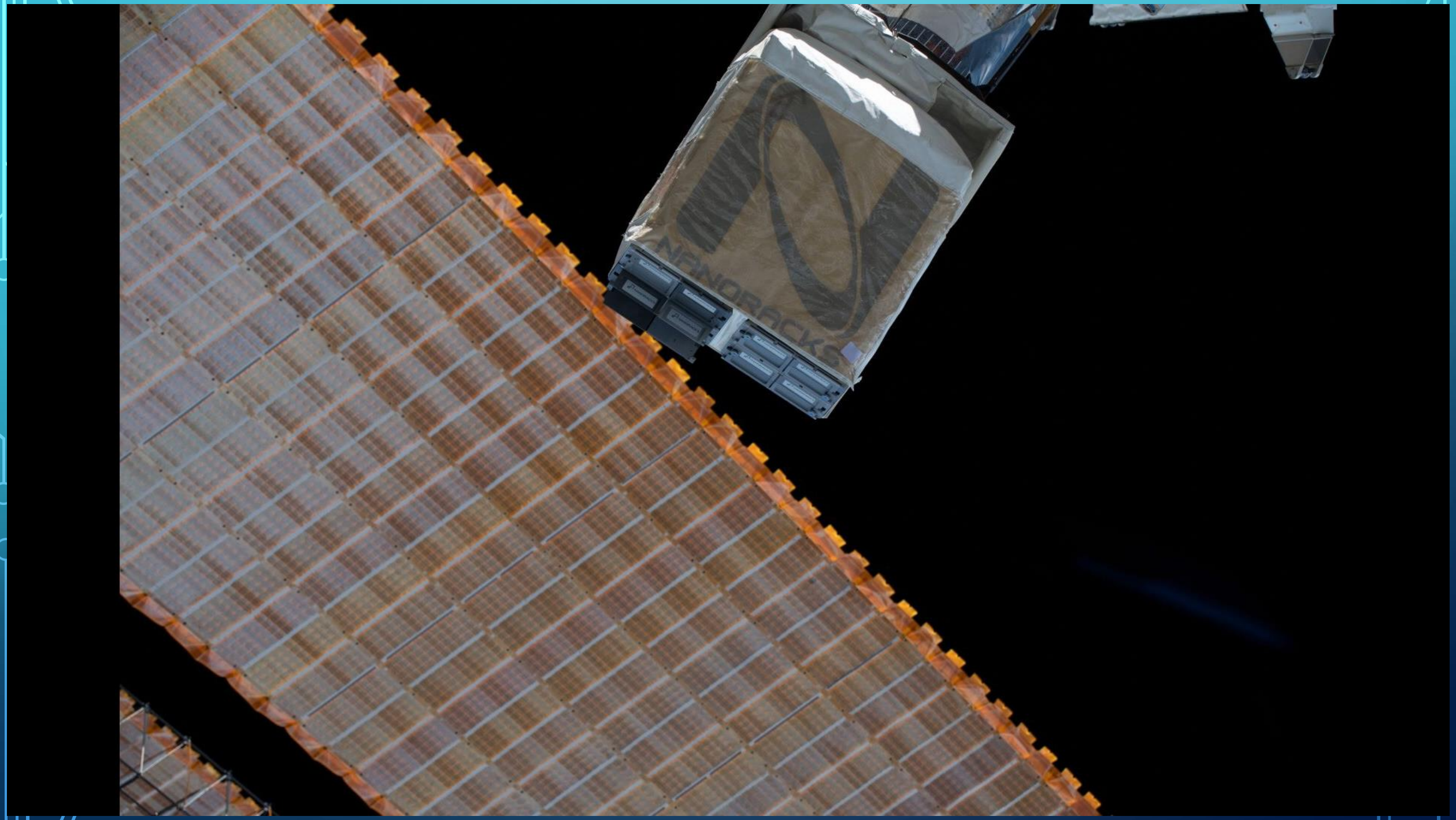
Libertas Mission Timeline



VCC Team

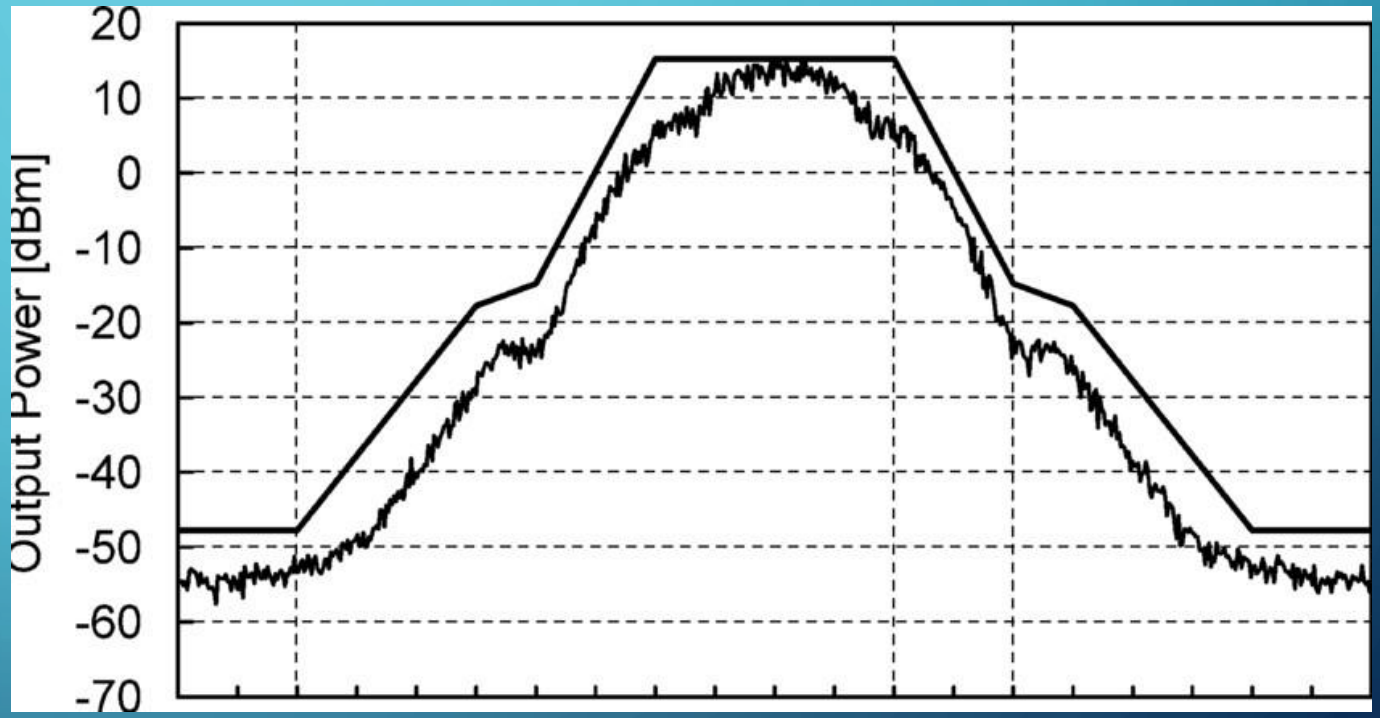

JCB
United Rentals
JCB


Video courtesy of
NASA TV


NANORACKS

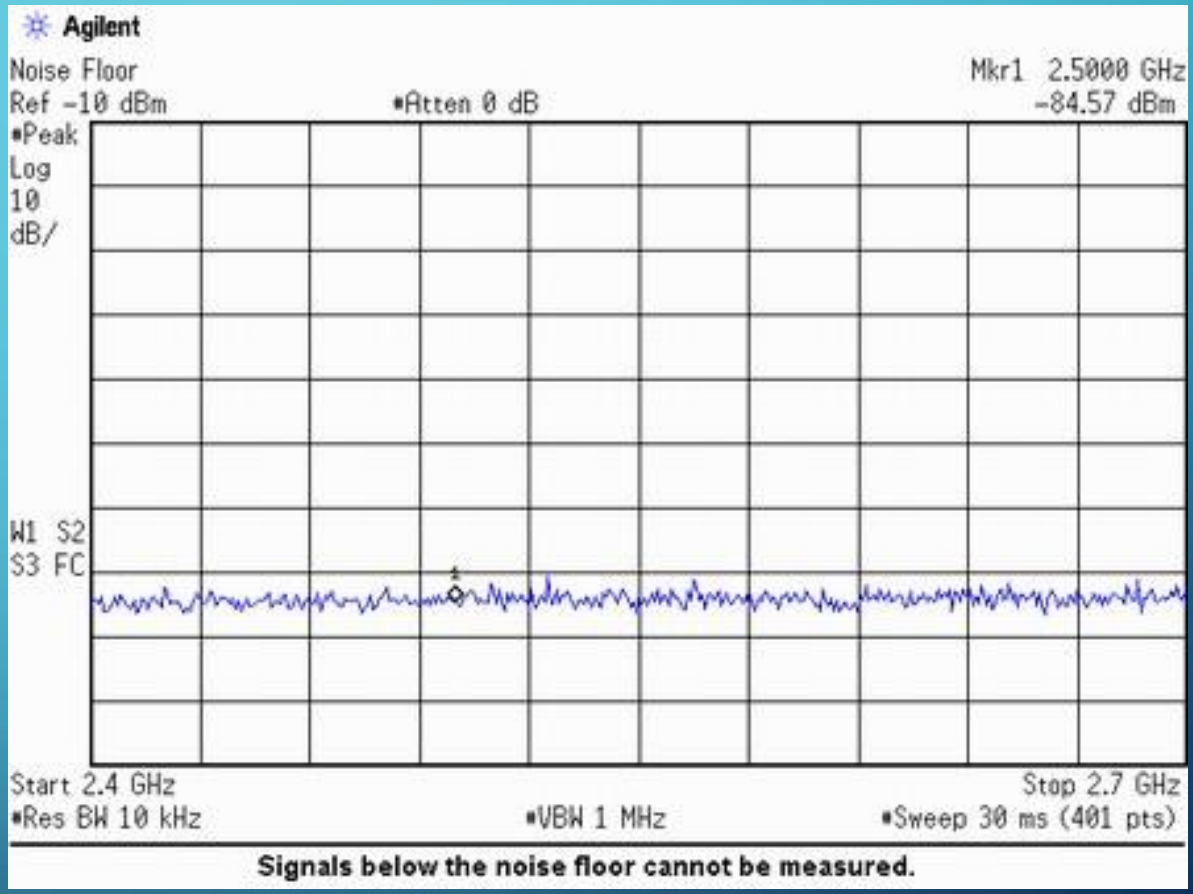
WHAT SHOULD HAVE HAPPENED?

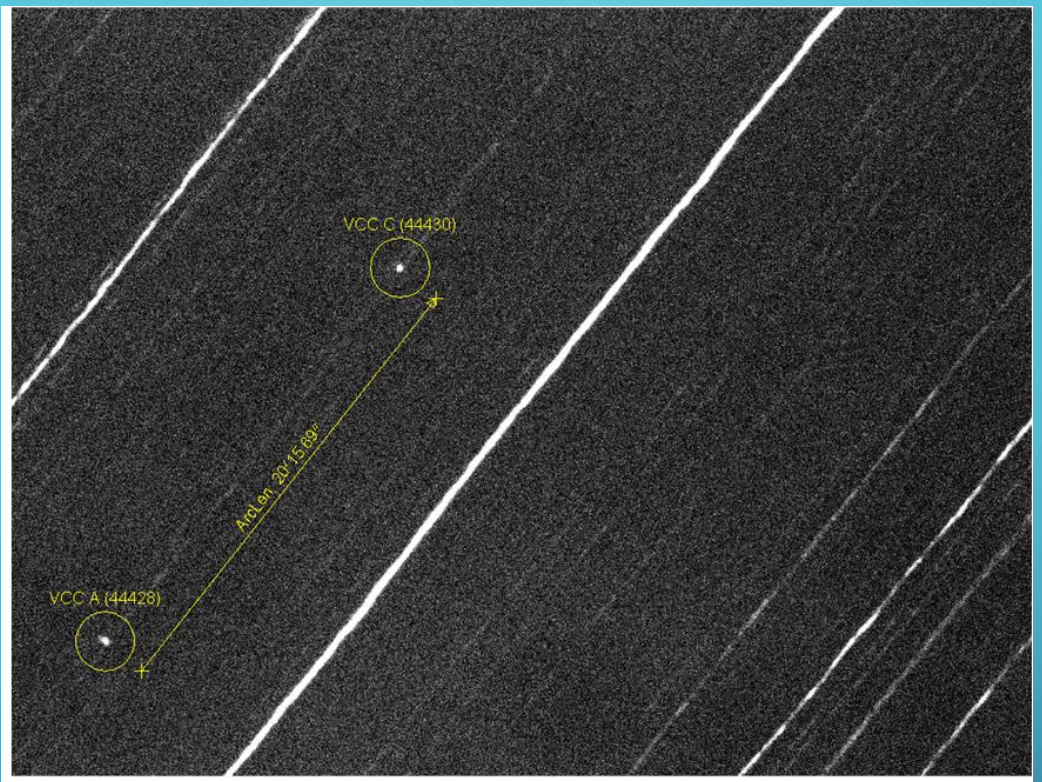
- Establish two-way communications within first week or so after deployment
- Operate spacecraft until re-entry, about 18 months for Libertas



WHAT DID HAPPEN?

- No contact with UVa Libertas
- No contact with ODU Aeternitas
- No contact with VT Veritas

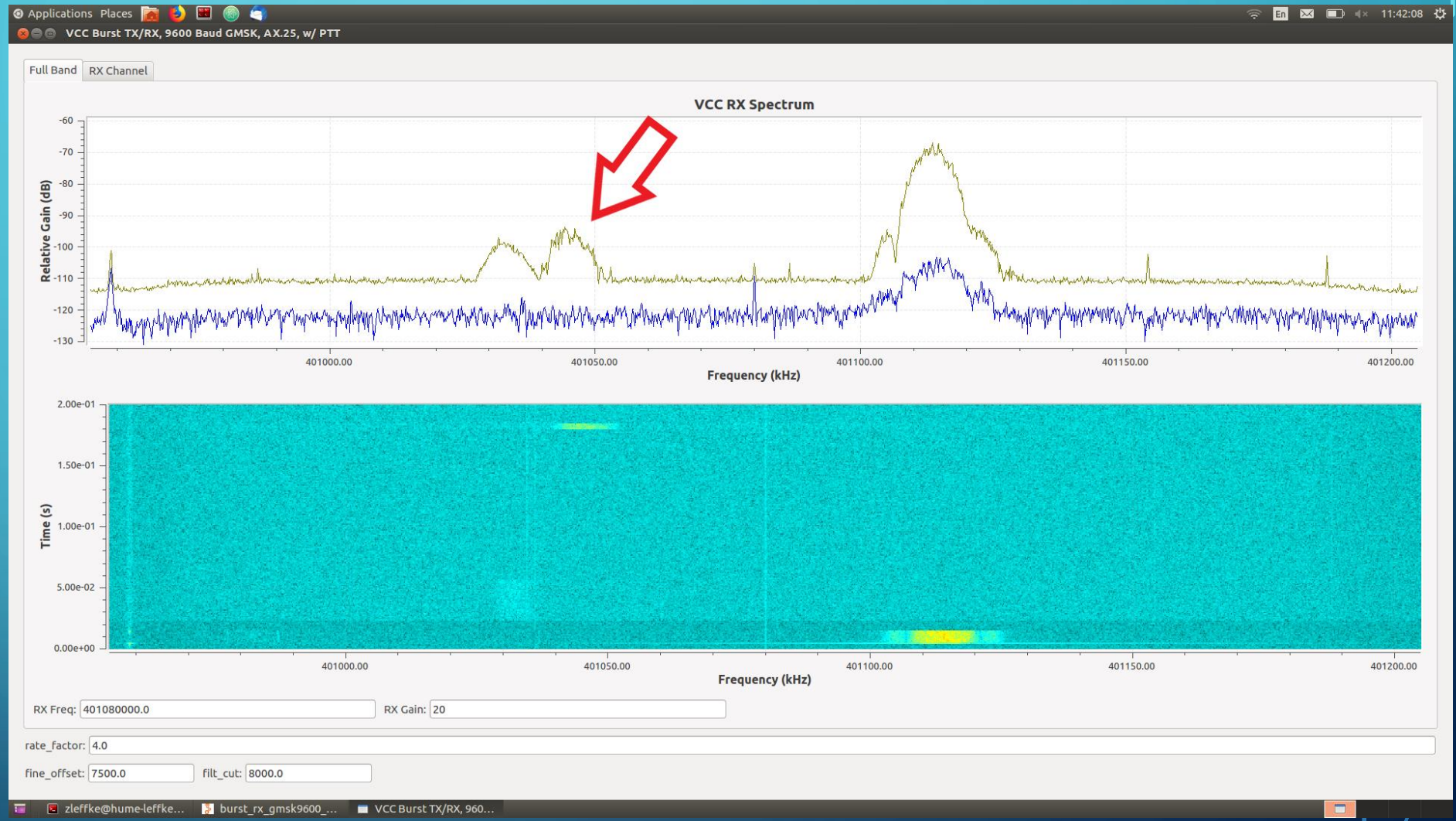


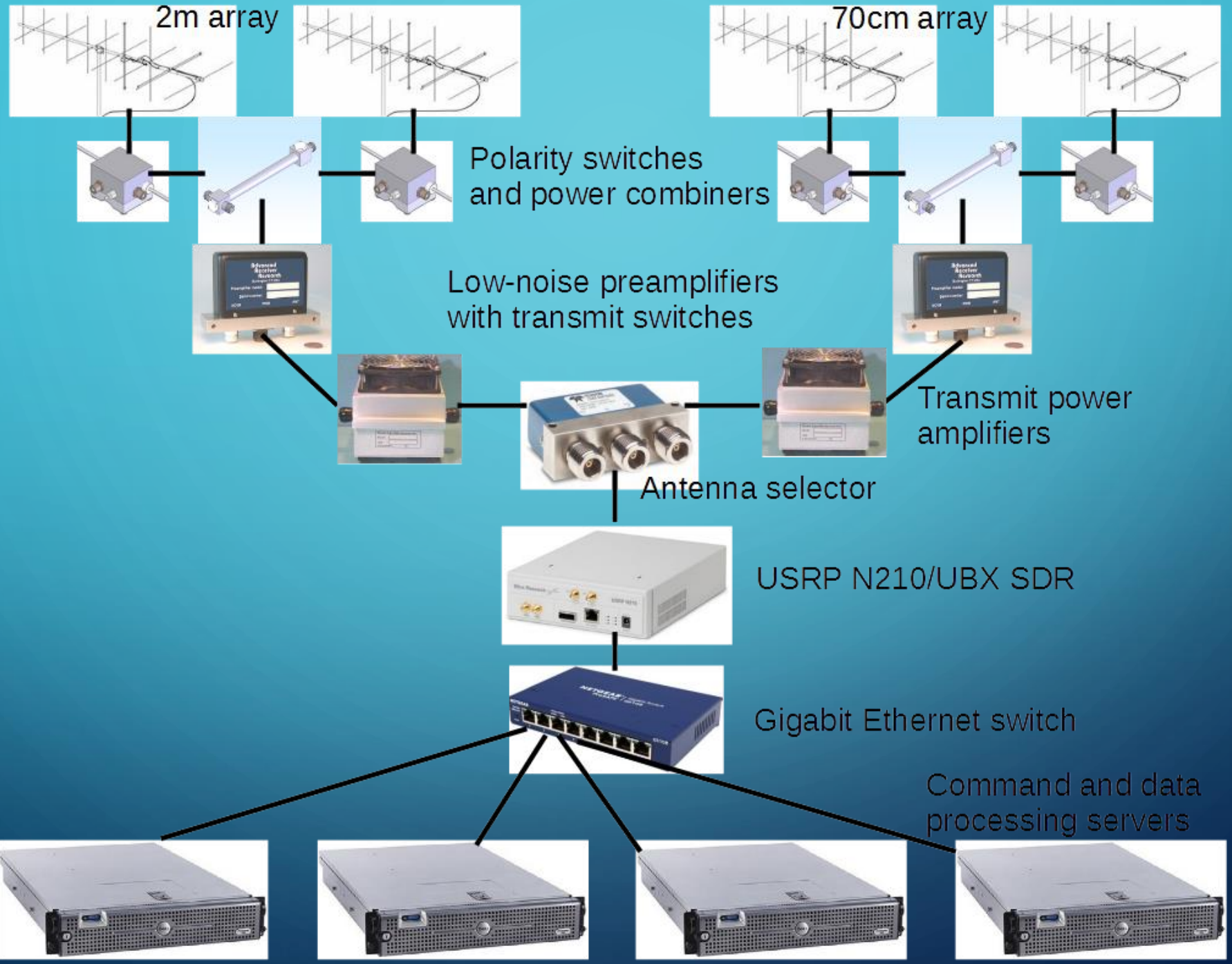


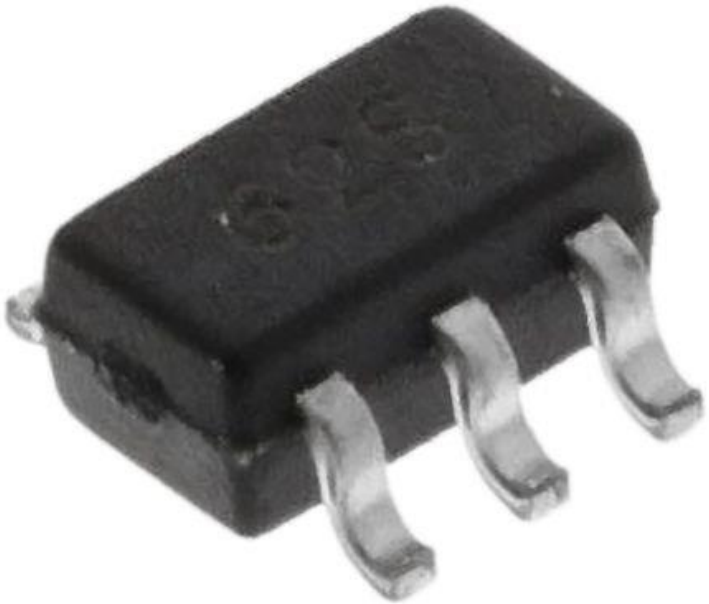
Telescope	Astro-Tech AT106
Camera	ATIK 414EX mono
Date	2019-07-23 19:00:46.53 UTC
Azimuth	42.89°
Altitude	13.96°
RA	04h 10' 44.81"
Dec	26° 06' 49.66"
Airmass	4.11
Exp. Time	15 sec
TLE	0 VCC C
	1 44430U 98067QQ 19204.17410399 .00003694 00000-0 68144-4 0 9994
	2 44430 51.6412 182.6130 0003103 177.0807 183.0201 15.51875583 1952
Earth Alt.	417.53 km (from TLE)
Range	1265.62 km (from TLE)
Ang. Sep	20' 15" (approx. 7.5 km)

Photo Courtesy of Manuel Polo

Finally, a packet!




2m array
70cm array
Polarity switches
and power combiners
Low-noise preamplifiers
with transmit switches
Transmit power
amplifiers
Antenna selector
USRP N210/UBX SDR
Gigabit Ethernet switch
Command and data
processing servers



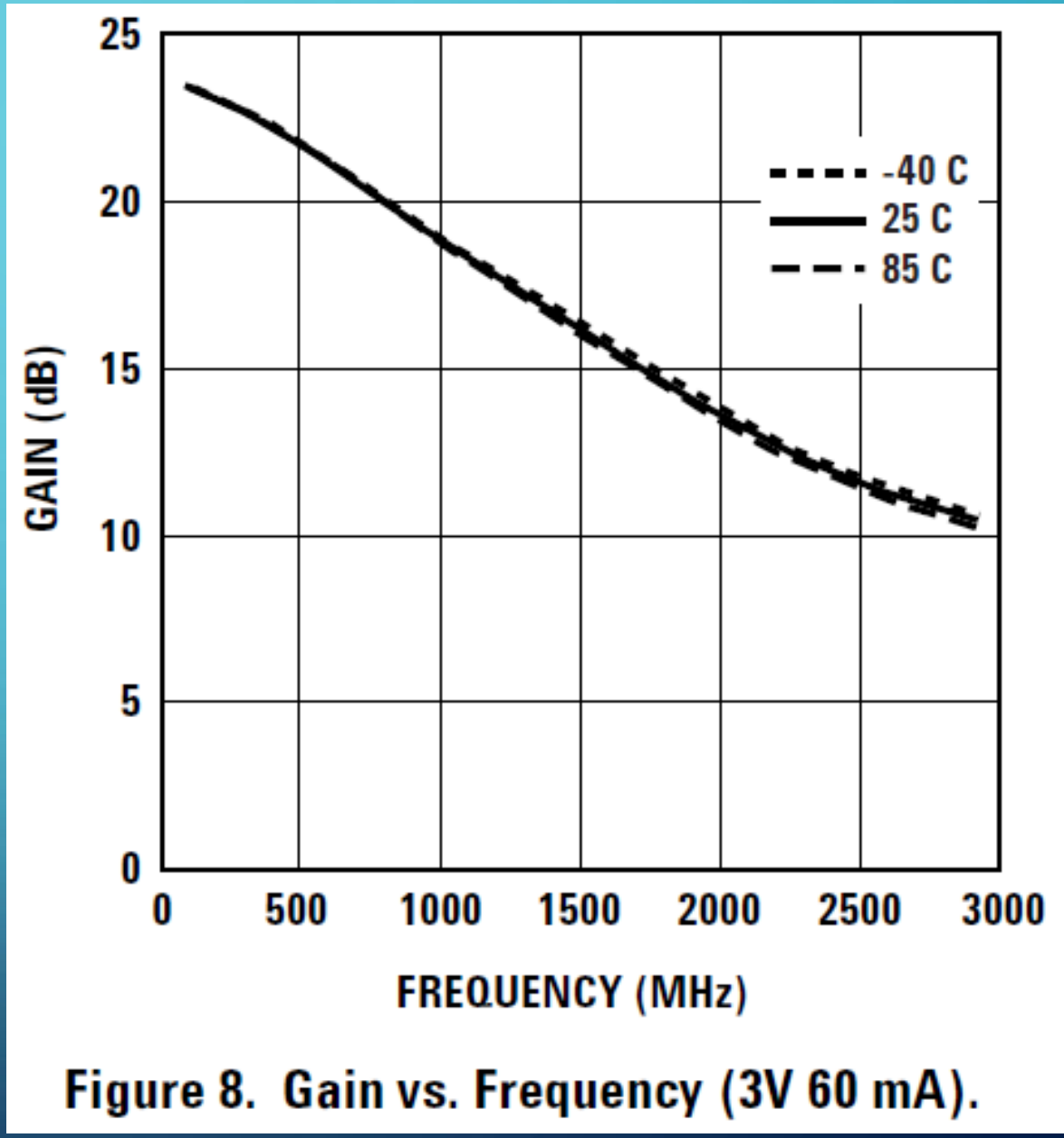


Figure 8. Gain vs. Frequency (3V 60 mA).

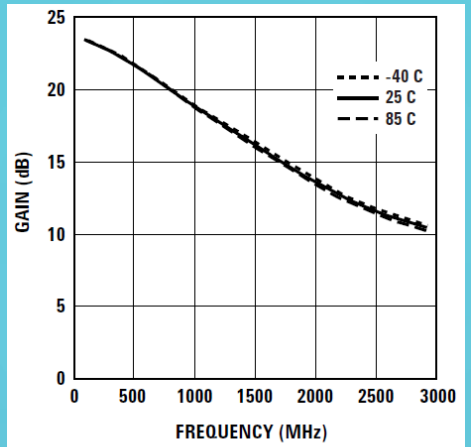
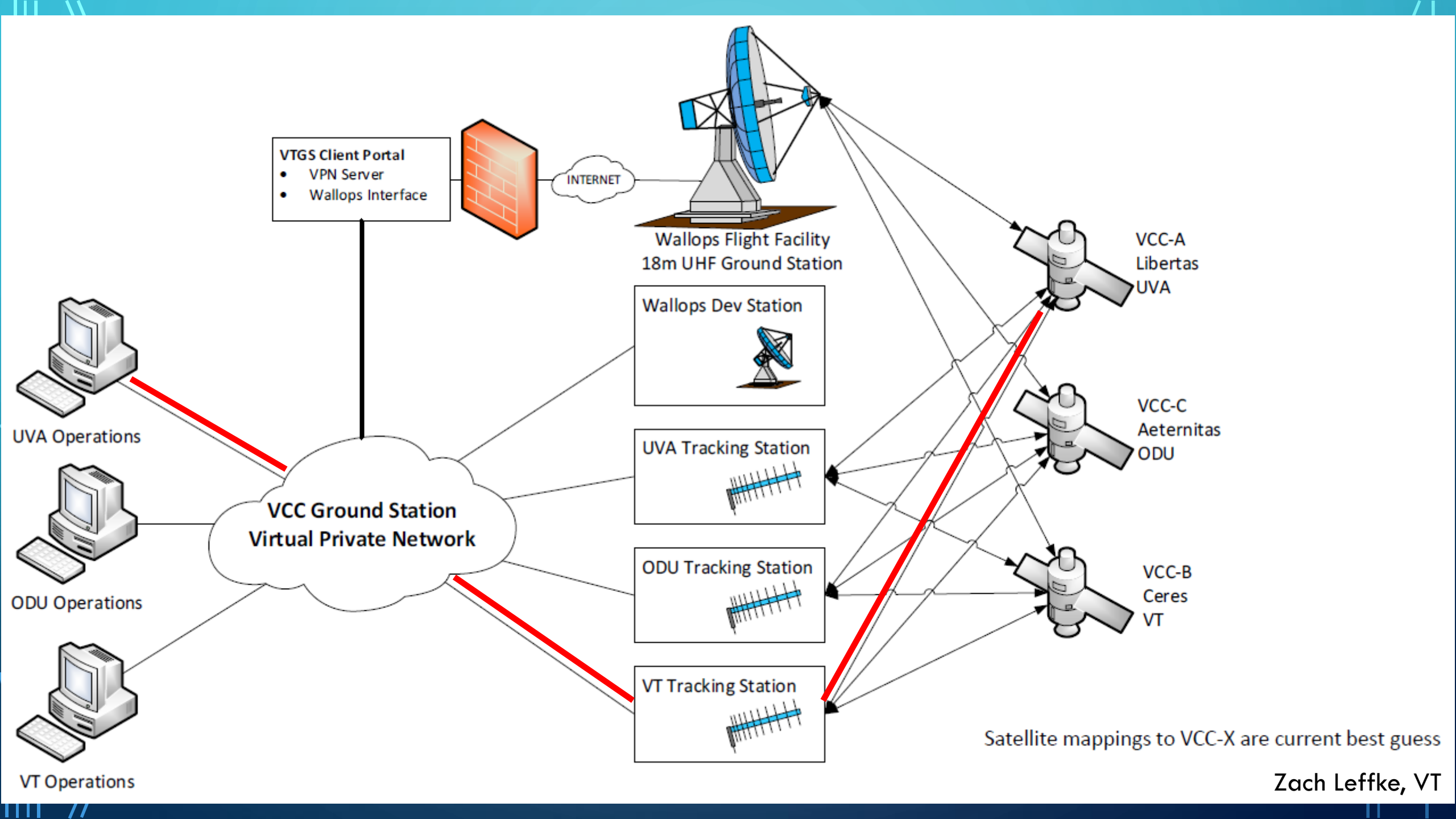


Figure 8. Gain vs. Frequency (3V 60 mA).

-58dB!


RETURN
TO
SENDER



Zach Leffke, VT

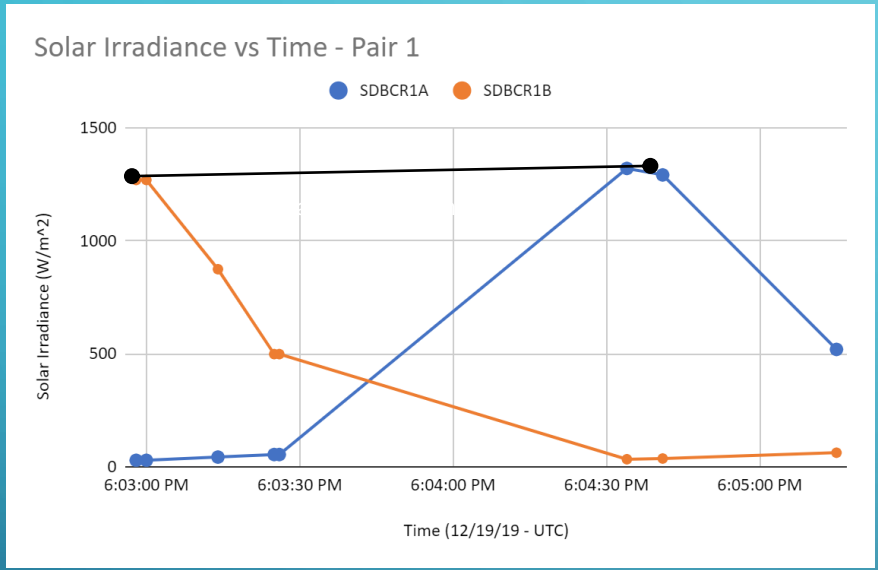
CONTACT!

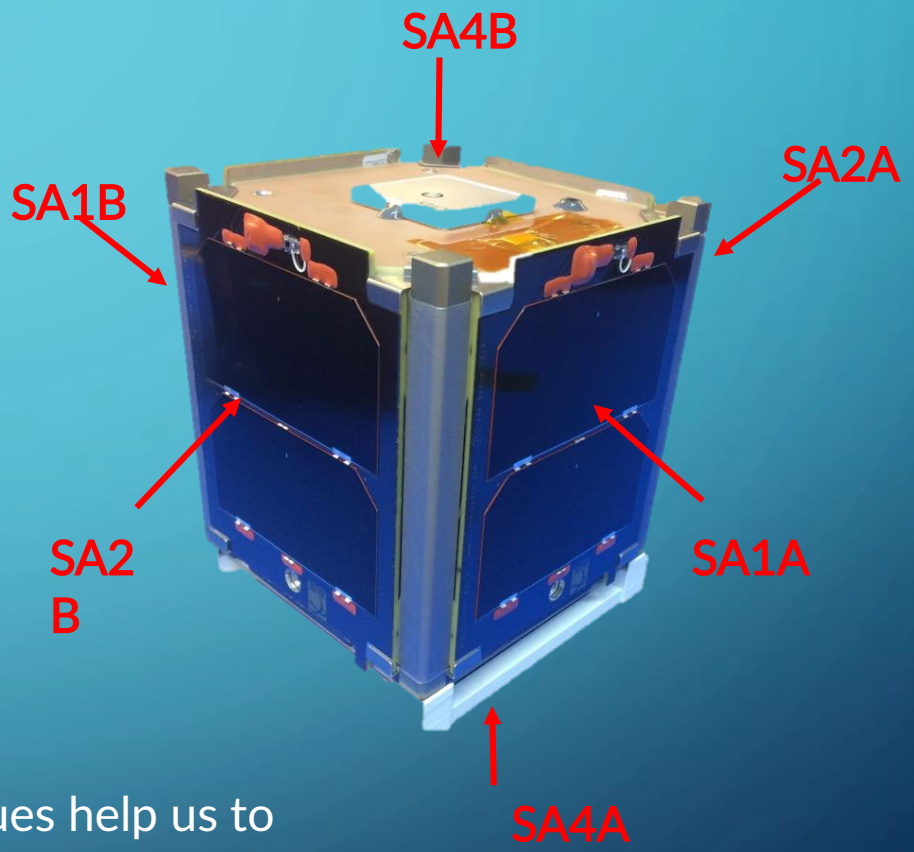
SUCCESSFUL TWO-WAY COMMS WITH LIBERTAS

- 23 Nov 2019 through 29 Dec 2019
- Eleven passes worked
- 244 packets downlinked
- Unfortunately, GPS receiver appears to be non-functional, so no position/velocity/acceleration data is being collected

	Definition of Variable	Data	Units
IPCM12V	Output current of 12V bus	0.02898	Amps
VPCM12V	Output voltage of 12V bus	12.0466	Voltage
TBRD	Motherboard temperature	27.7767	°C
VBCR1	Voltage feeding BCR1	4.61657	Voltage
IBCR1A	Current BCR1, Connector SA1A	0.001955	Amps
TBCR1A	Array temp., Connector SA1A	18.1781	°C
SDBCR1A	Sun Detector, Connector SA1A	28.7505	W/m^2
ANTENNA_STATUS	Is Antenna Deployed	1	

INTERPRETATION OF THE DATA

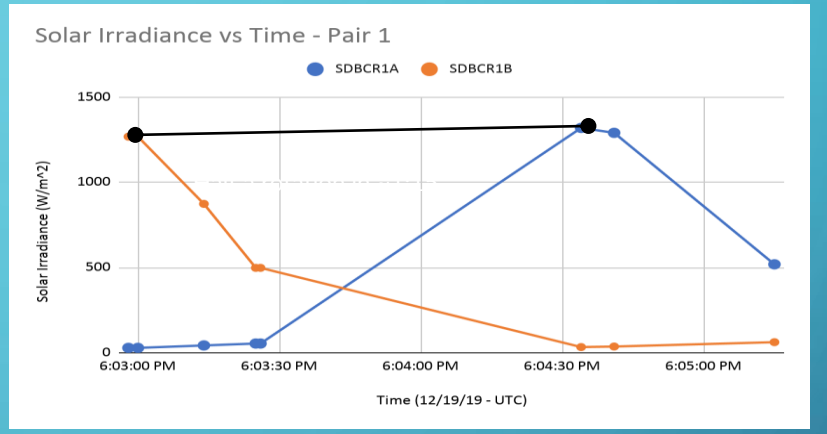


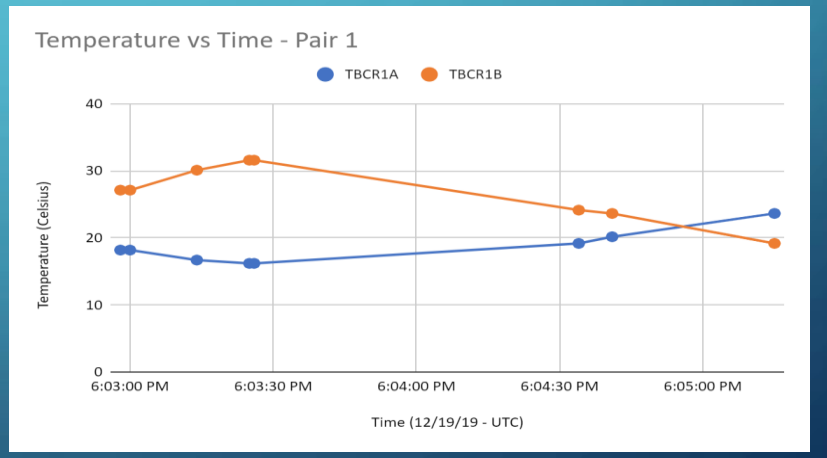


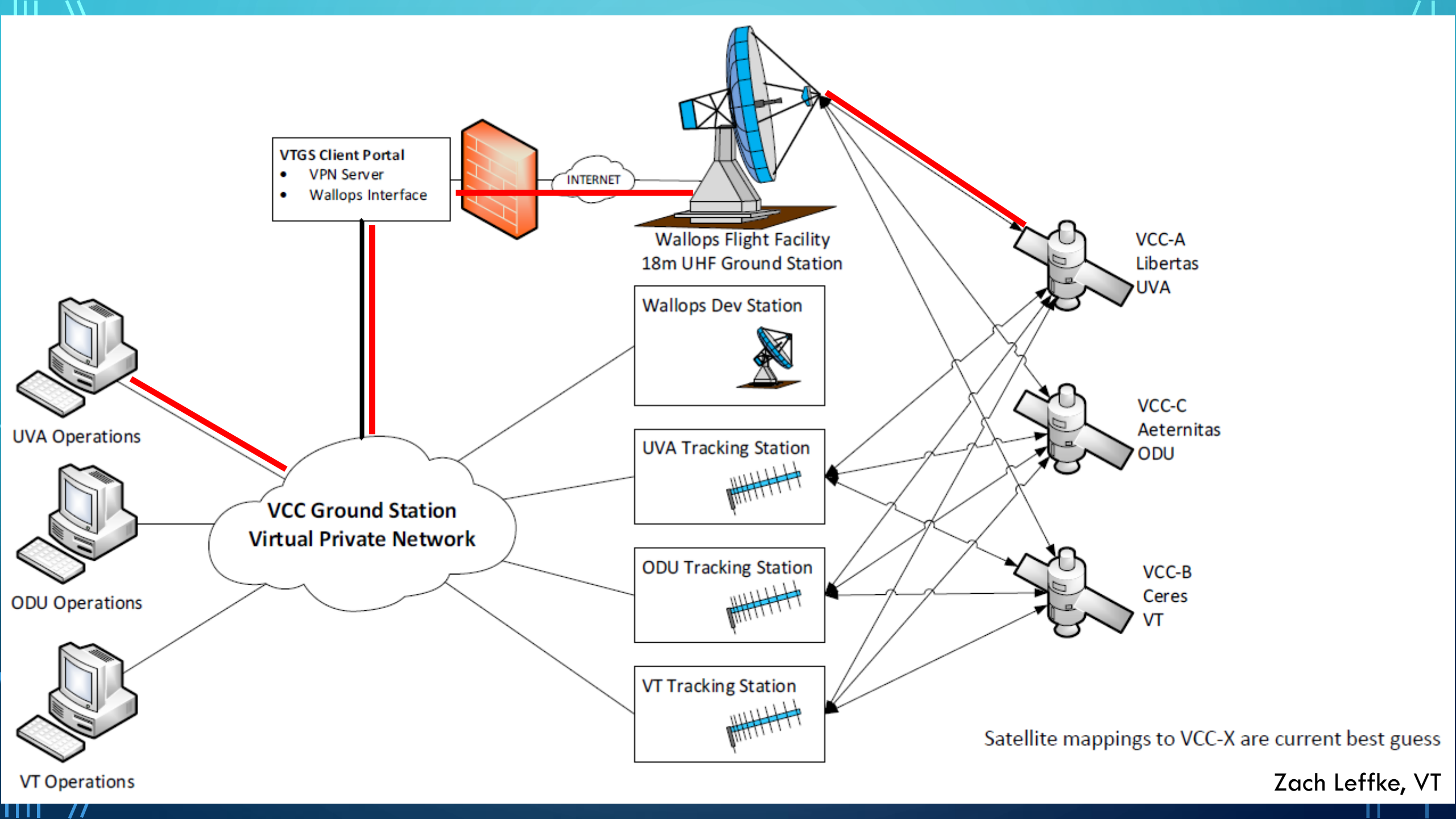
- We can determine a rotation rate!
- Changes in different Sun sensor values help us to determine this rate

ROTATION RATE COMPARISON

Predicted	1 rotation in 4 minutes
Solar Irradiance	1 rotation in 2 and a half minutes
Telescope Images	< 1 rotation per minute
Temperature	Not currently discernable - Future work







Zach Leffke, VT

And that's the last we've heard…

WHAT'S NEXT?

- Work with cubesat radio manufacturer to see if there is a way to "unbrick" the radio remotely
- Continue to attempt communications occasionally in case the radio power-cycles for some reason
- Declare victory and move on to the next mission!

FUTURE MISSION PLANS

- 1U cubesat in collaboration with AMSAT flying the latest version of the FOX payload, providing amateur radio service as the primary mission
- 3U cubesat with an imaging spectrometer designed by UVa Astronomy for high-resolution study of automobile NO^2 emissions by UVa Environmental Science

THANK YOU FOR YOUR ATTENTION!

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MIKE@KQ9P.US