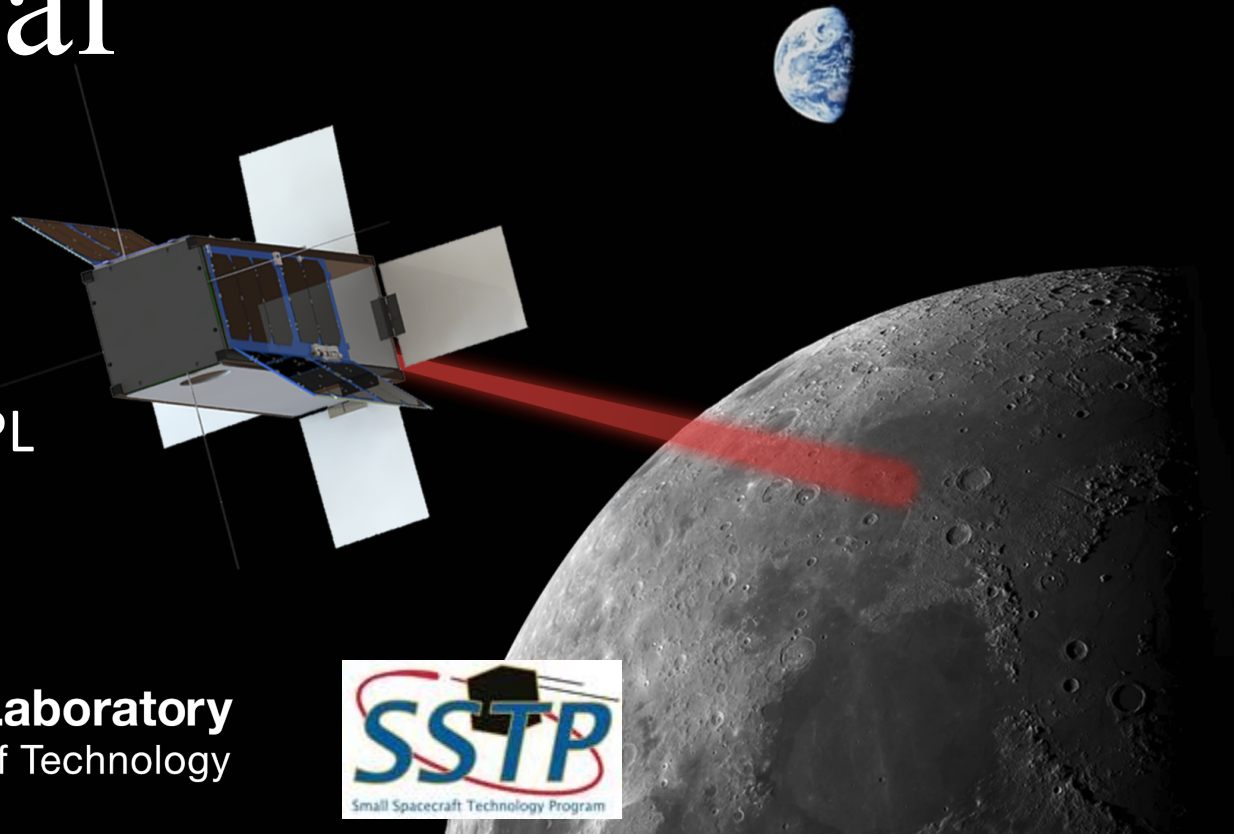
Deployable Optical Receiver Array

Cubesat demonstration

NASA Smallsat Technology Program, ASU, JPL

D. Jacobs – 30 Nov 2020



Arizona State University

Jet Propulsion Laboratory
California Institute of Technology

SSTP
Small Spacecraft Technology Program

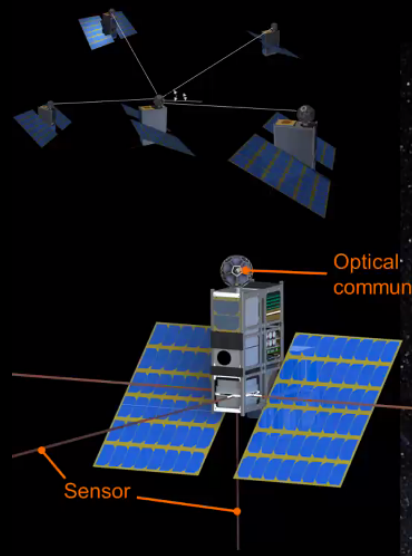
Dora Team

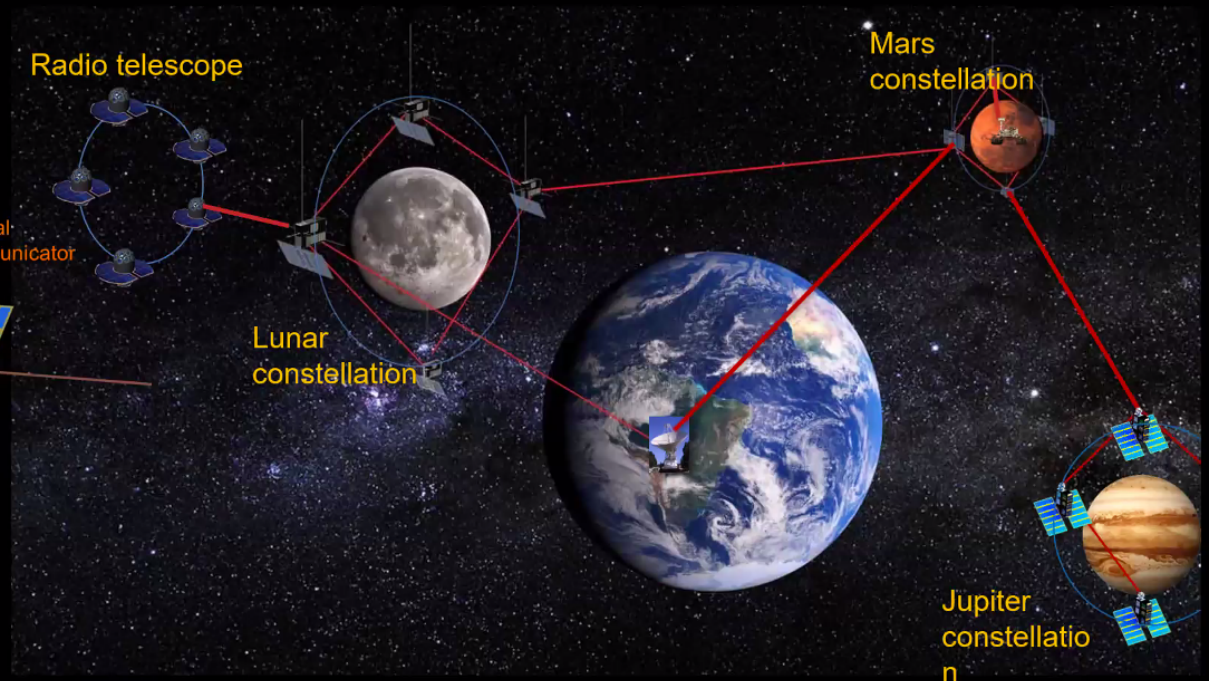
- Jose Velazco (333M)
- Andy Klaib
- Uriel Escobar (UC Irvine)
- Sean Cornish (USC)
- Sarah Spector (Umilwaukee, 2020 Intern)
- Charles Lindsey (MIT, 2020 Intern)

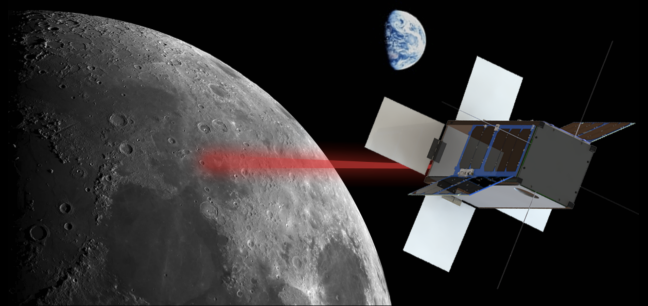
- Danny Jacobs (PI)
- Judd Bowman
- Mickey Horn
- Christopher McCormick (II Lab)
  - Katrina Lewis
  - Isabella All
- CSE Capstone Group
  - Zachary Hoffman (CS/Robotics)
  - Jah Markabowski (CS/Robotics)
  - Justin Colyar
- Jaime Sanchez de La Vega (Vega Space Systems

Need for high bandwidth interconnect

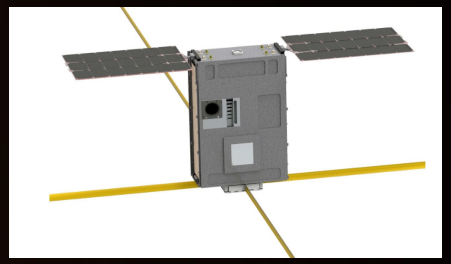
- Crosslink between spacecraft
- Swarm instruments
- Reduce DSN load in planetary networking





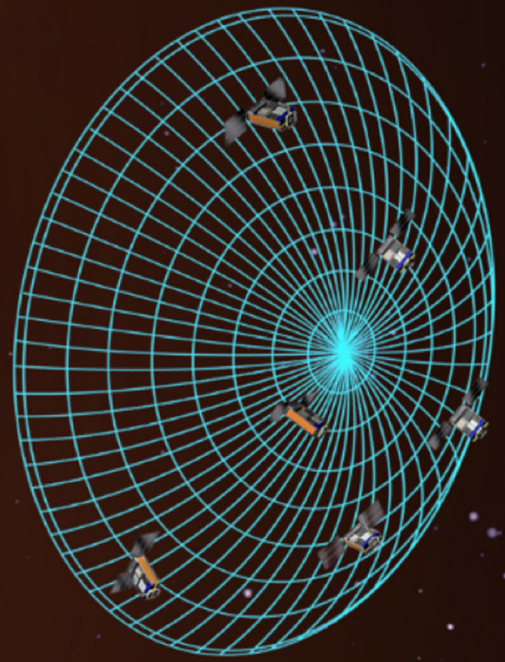


SunRISE

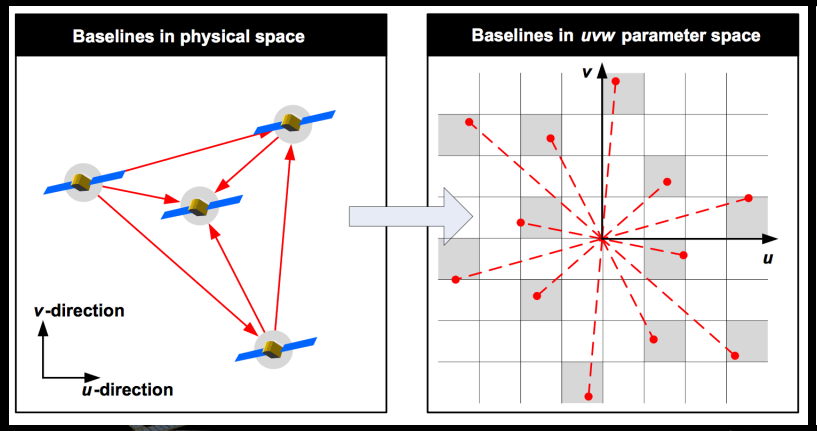


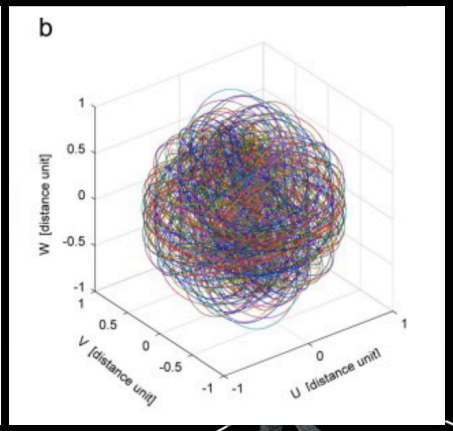
3U Cubesat

6 element radio interferometer
0.1 to 30MHz



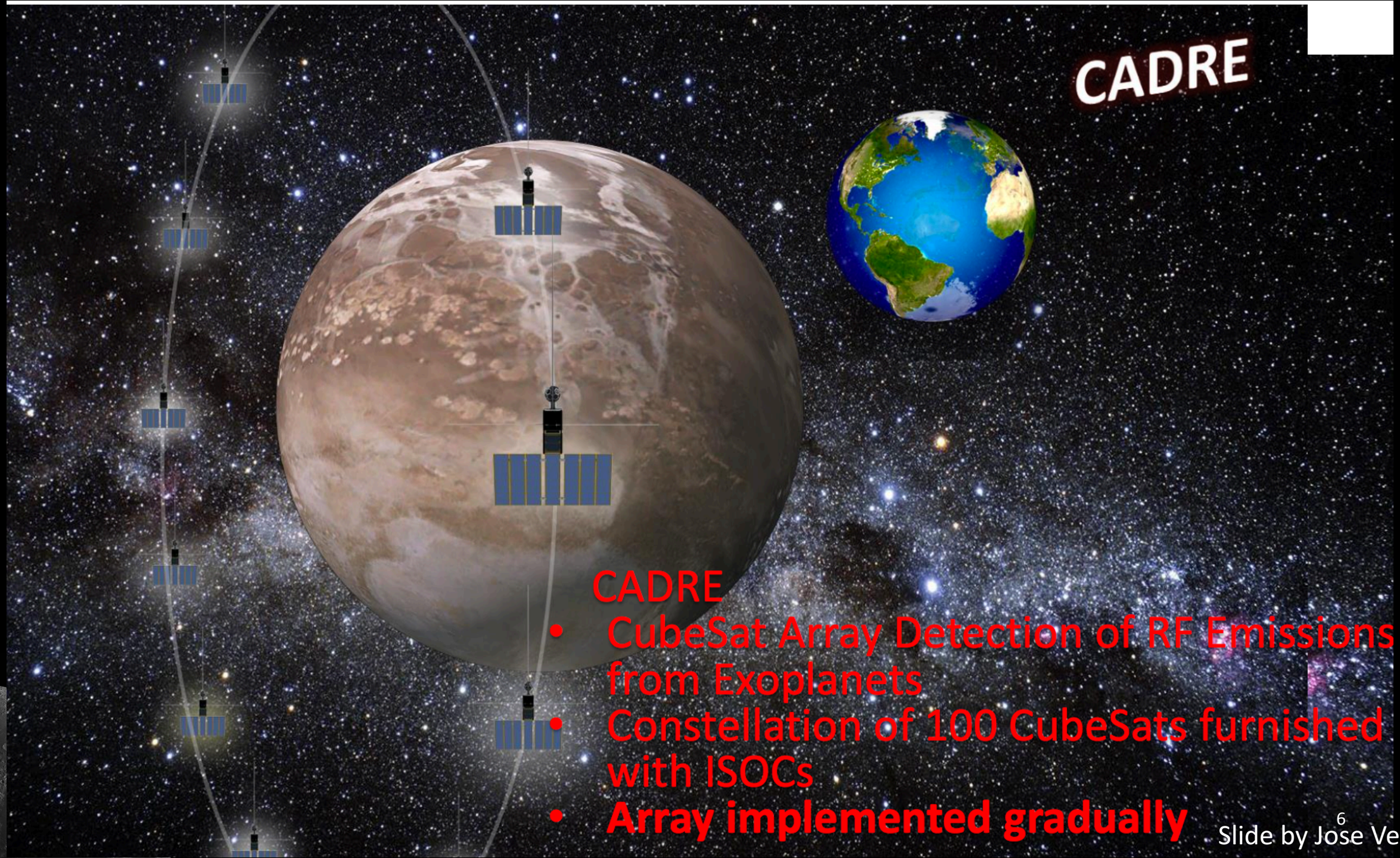
Downlink via DSN and
correlates on the ground





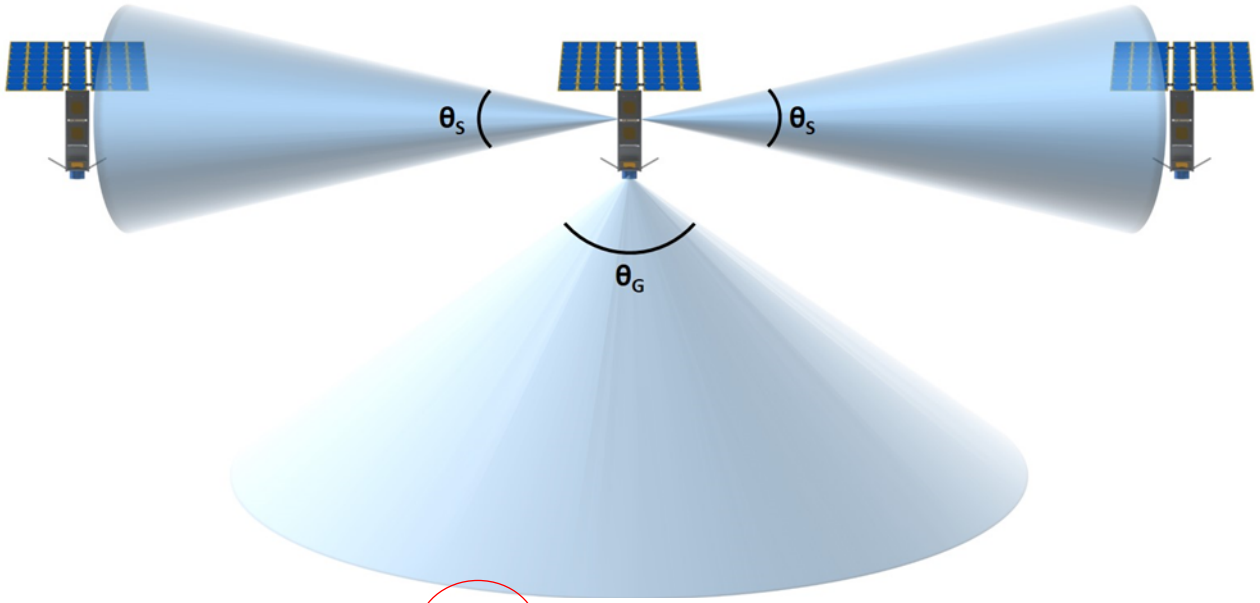
OLFAR, Deckans et al 2010

LOWPASS, Manchester and Jacobs Concept 2017



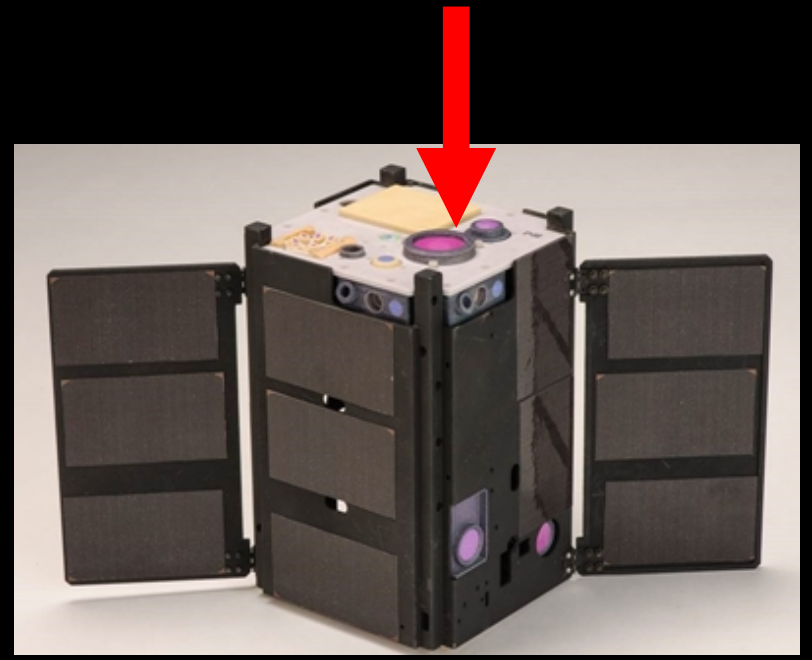
Slide by Jose Velazco

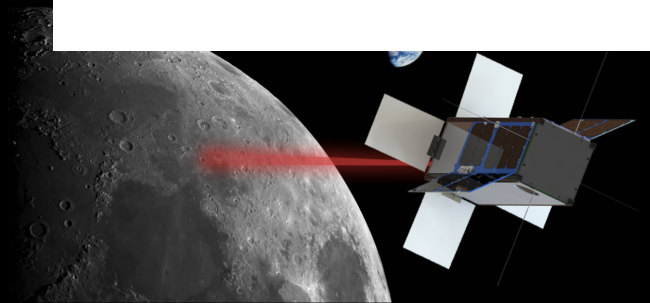
Limitations of Traditional Apertures



$$P_s = \frac{P_T A_T A_R}{(z\lambda_T)^2}(\eta_T \eta_A \eta_R) L_{TP} L_{atm} L_{pol} L_{RP}$$

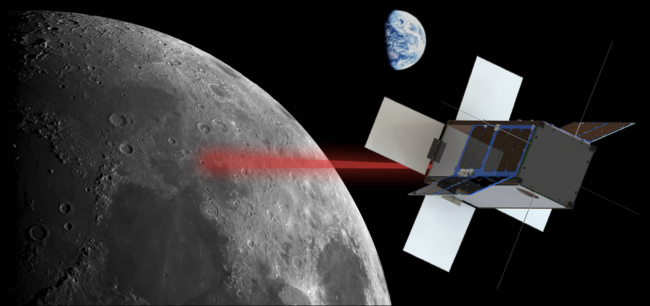
- One of the limitation for high data rate optical communications is the Tx/Rx **aperture size**
- Tx/Rx apertures are typically **compact** and **conformal** to the spacecraft body
- This also limits pointing freedom

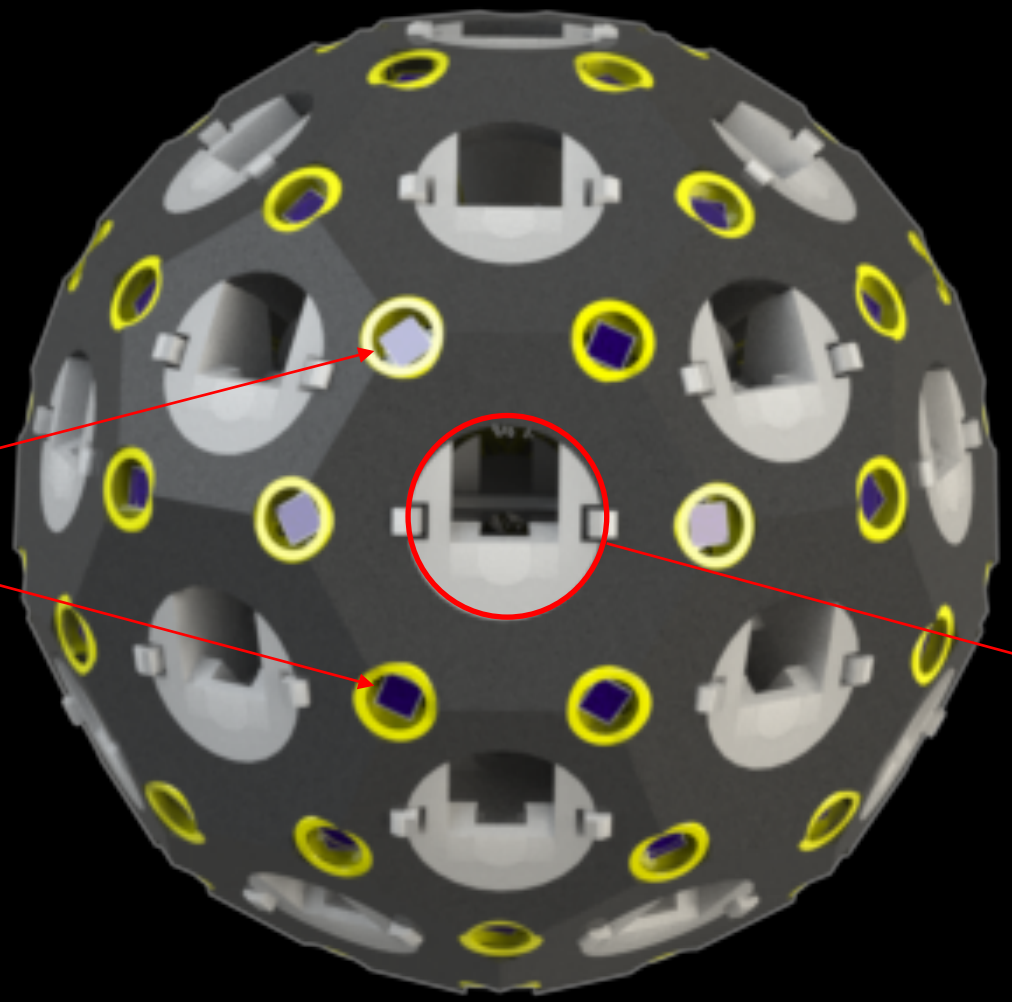




Omnidirectional Laser Terminal

Basic Operating Principles
- Distributed Aperture
- Requires no pointing
- Receiver Diodes arrival angle
- Transmission Mirror Steered to close link





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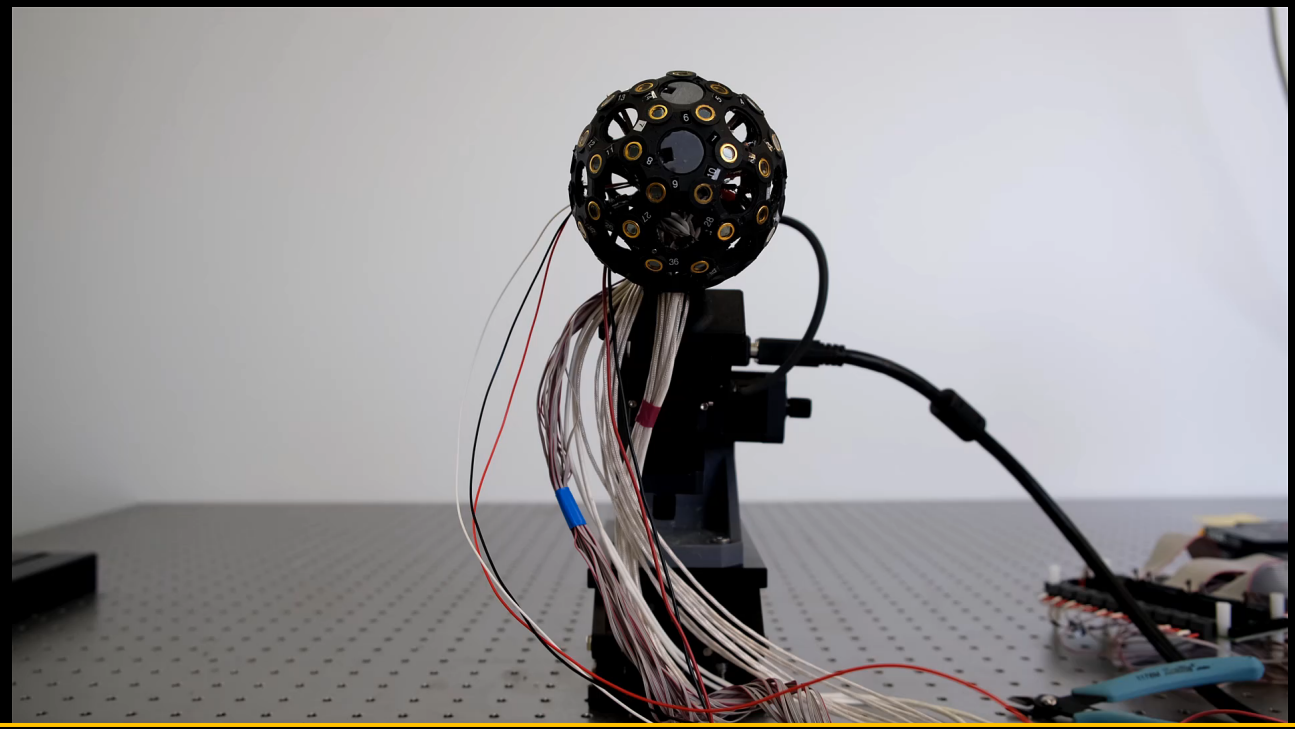
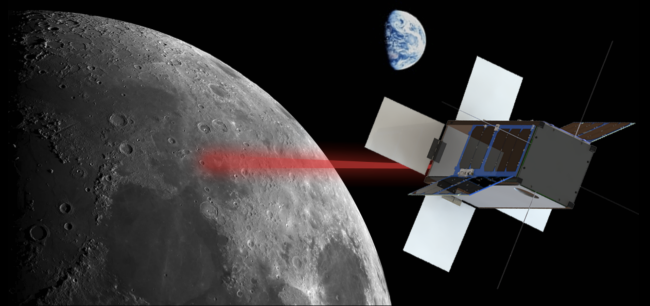
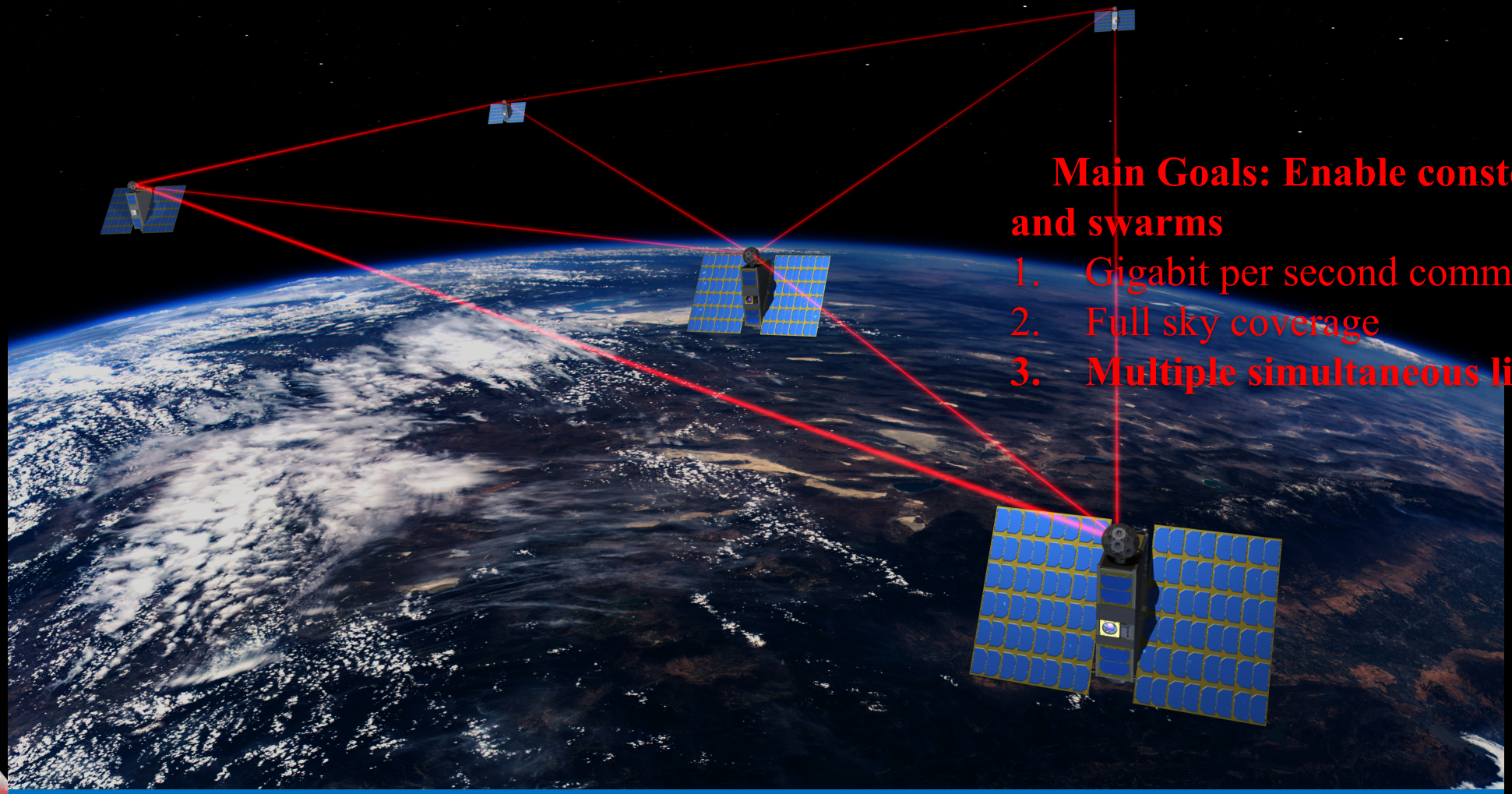


Omnidirectional Optical Communicator - Prototype



ISOC



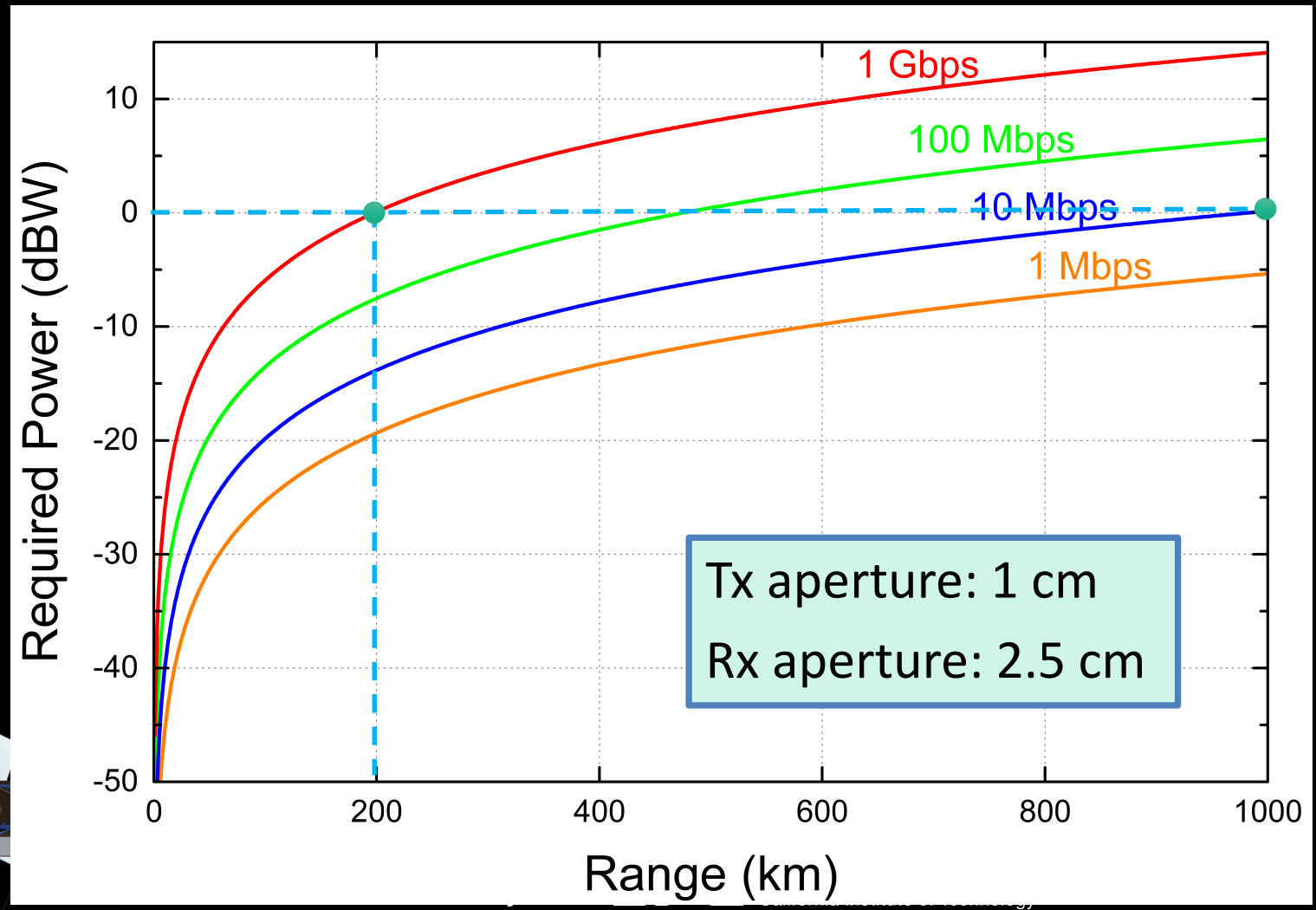
Main Goals: Enable constellations and swarms

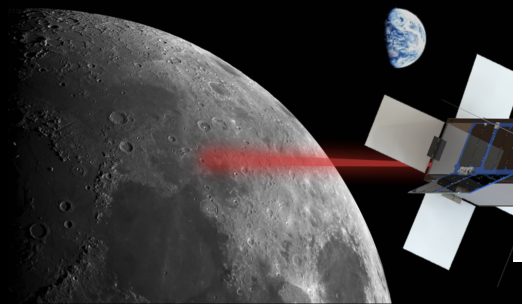
1. Gigabit per second communications
2. Full sky coverage
3. **Multiple simultaneous links**

ISOC enabled Swarm

Slide by Jose Velazco

ISOC Link Budget





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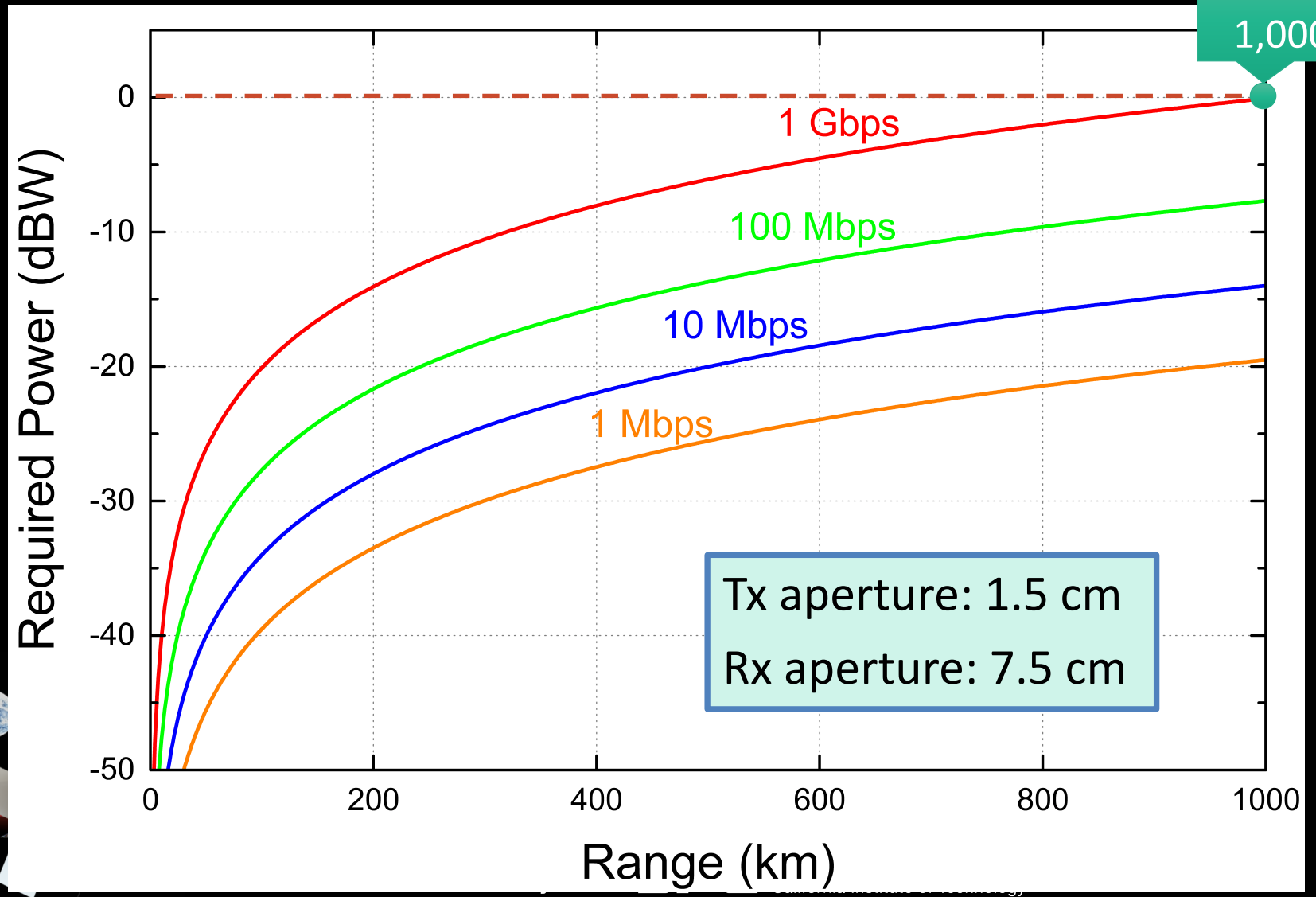
Dora link budget



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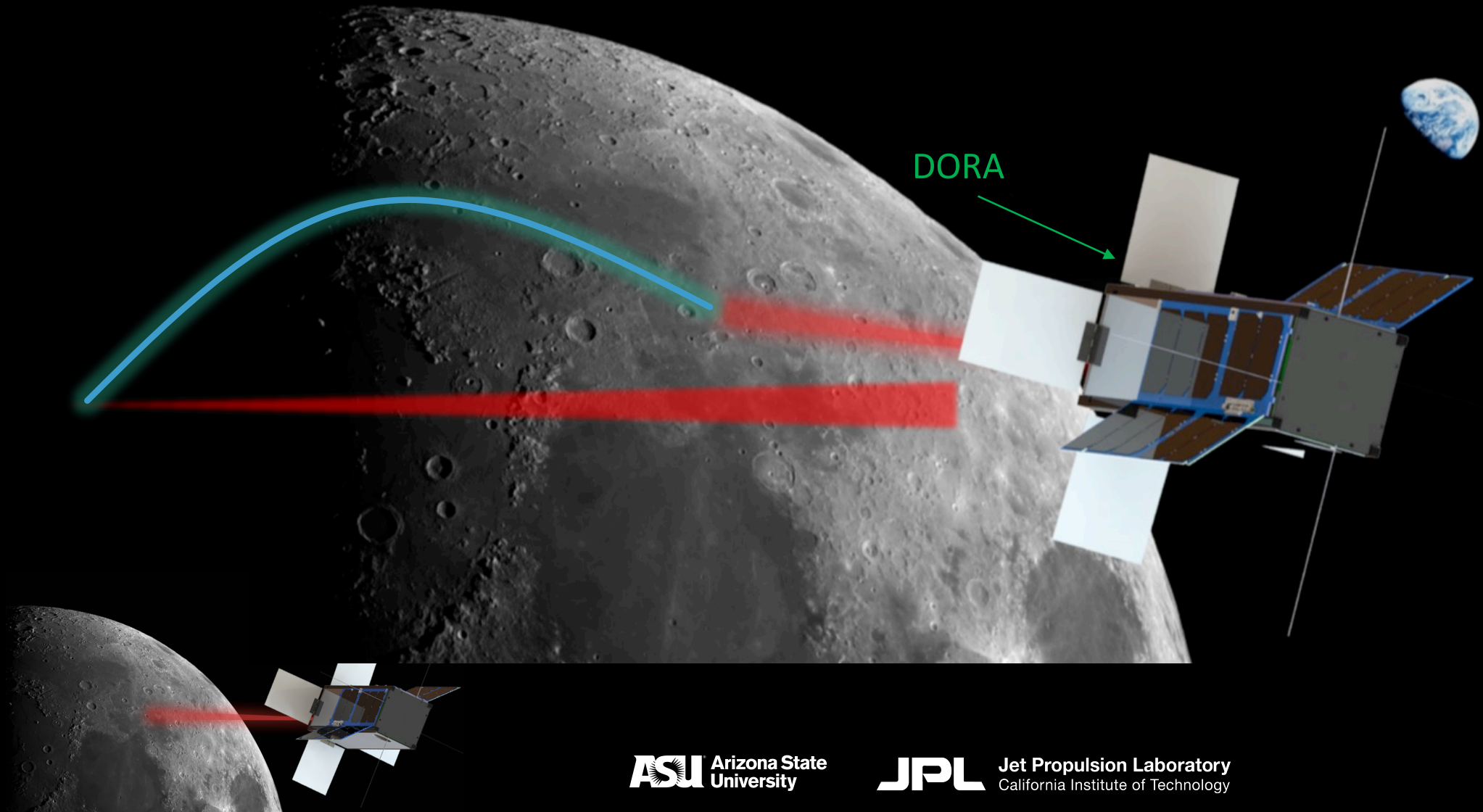
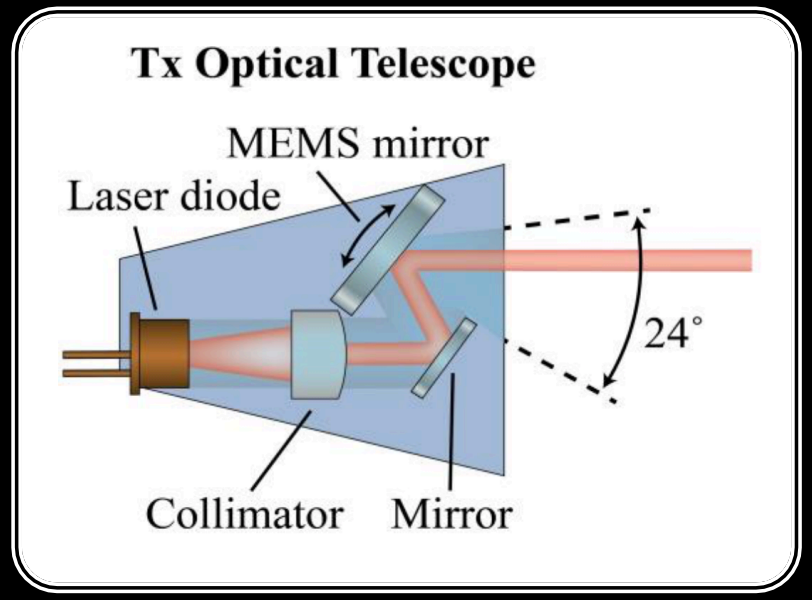
DORA Supporting LUNAR NET

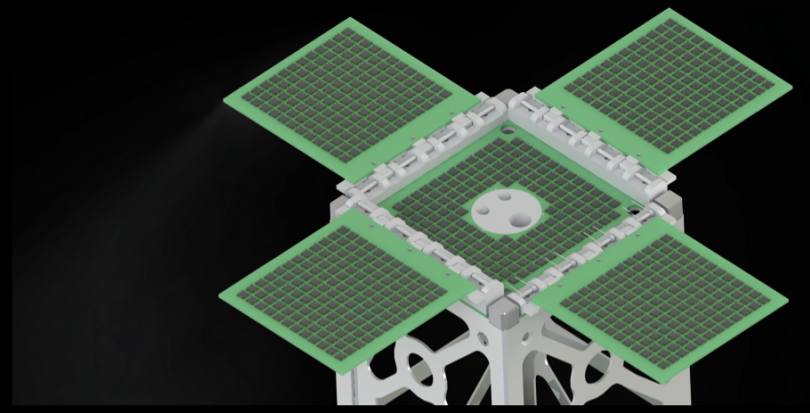
Rendering by Jaime Sanchez de La Vega

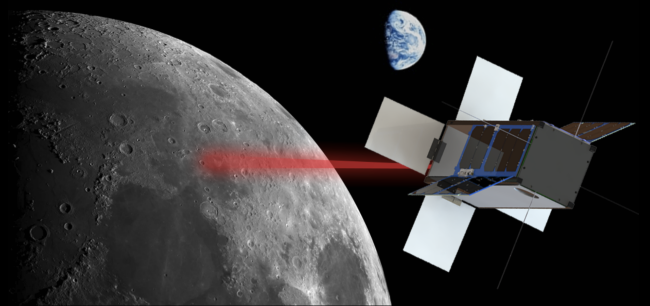


DORA Transceiver Operation

- Silicon Photomultiplier detectors
- Order 100 detectors combined per panel
- MEMS mirror steers +/-10deg

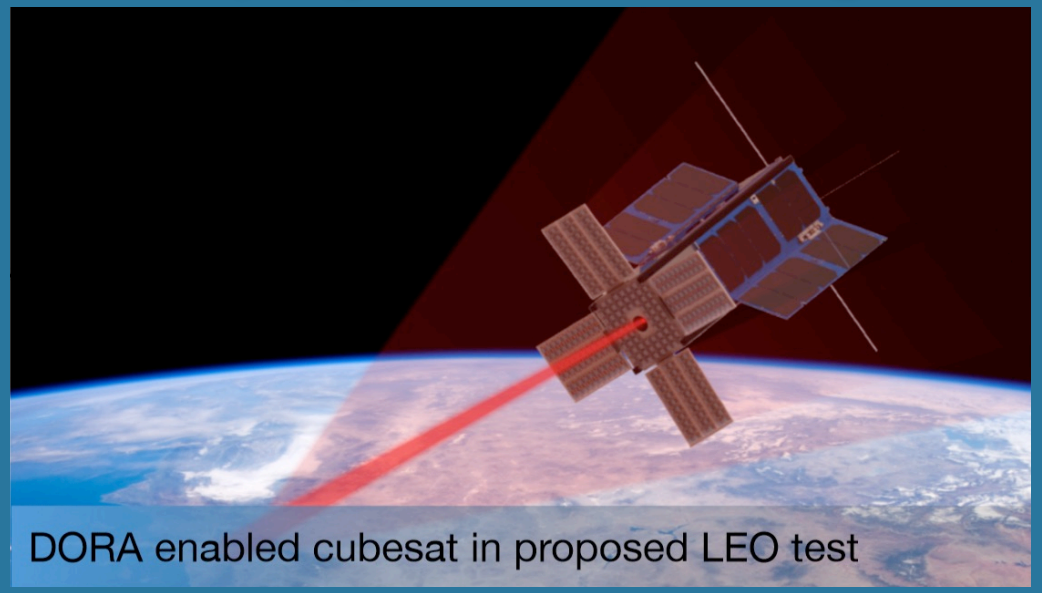






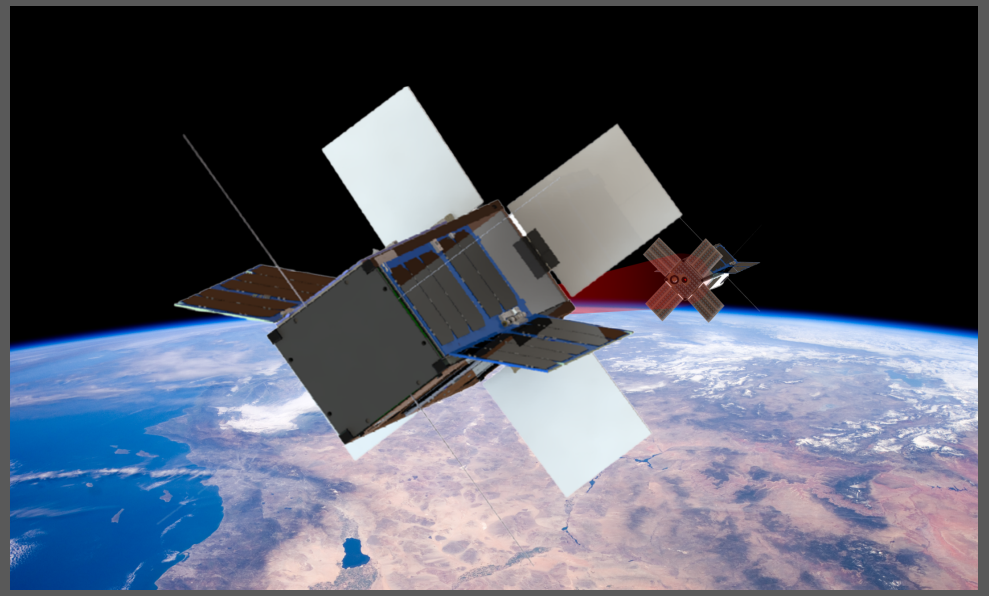
DORA Roadmap

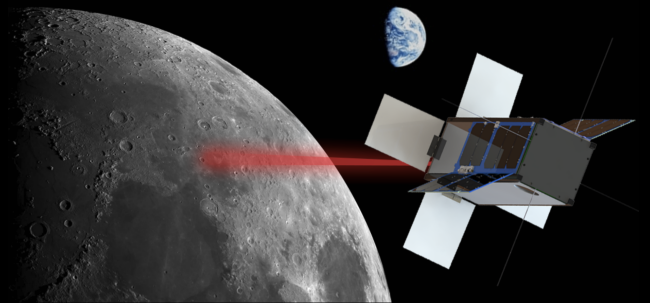
This project: Lab to Flight



ASU – Cubesat, Ground Station, Attitude Testing
JPL – DORA Payload

Next: Cross-link



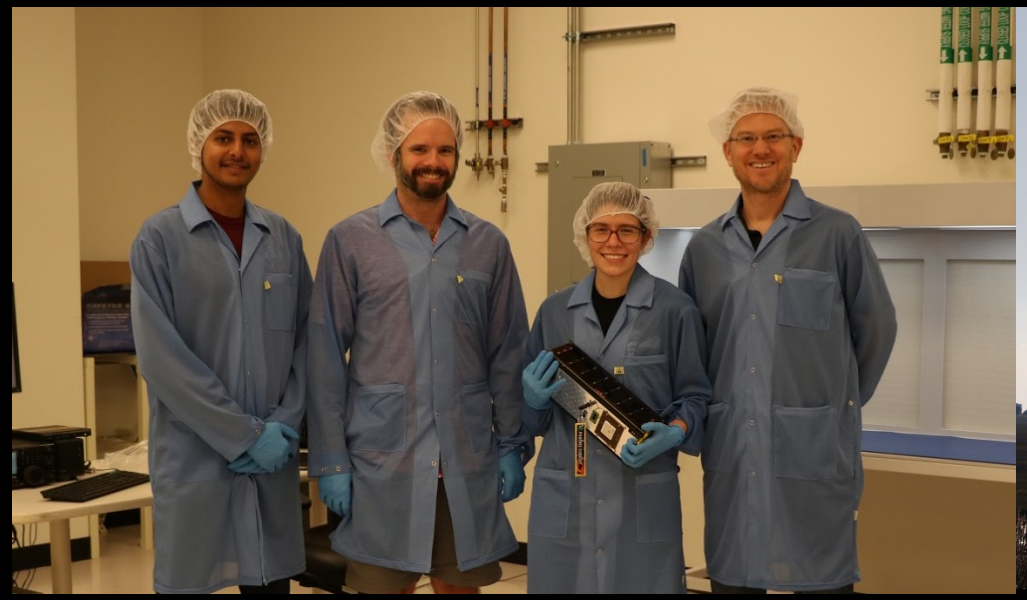


Renderings by Jaime Sanchez de La Vega

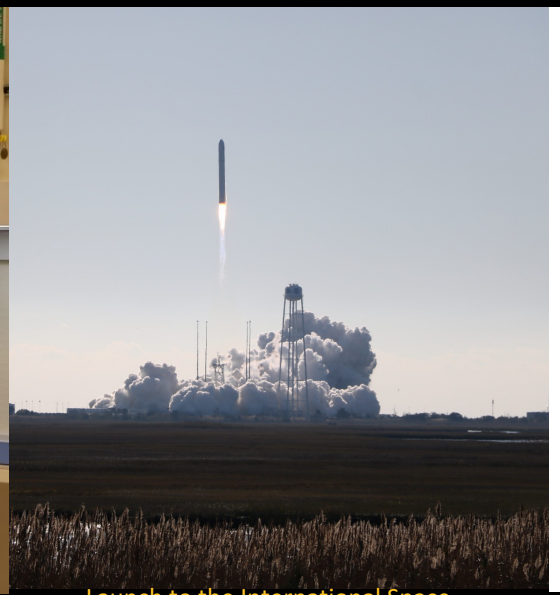
PHEONIX

Student cubesat thermal imager targeting the urban heat island effect.

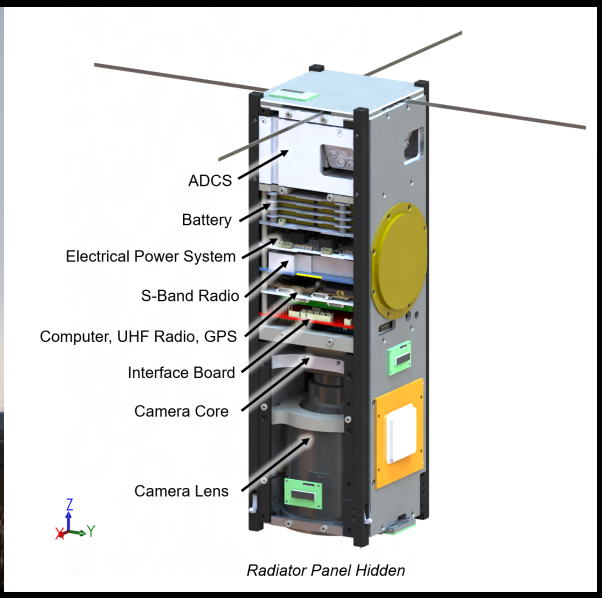
Advisors: Judd Bowman, Danny Jacobs



Software engineer Vivek Chacko, Project Advisor Danny Jacobs, Project Manager Sarah Roger, and Project Advisor Judd Bowman at completion of integration August 2019



Launch to the International Space Station aboard the Cygnus NG12 resupply mission 2 Nov 2019

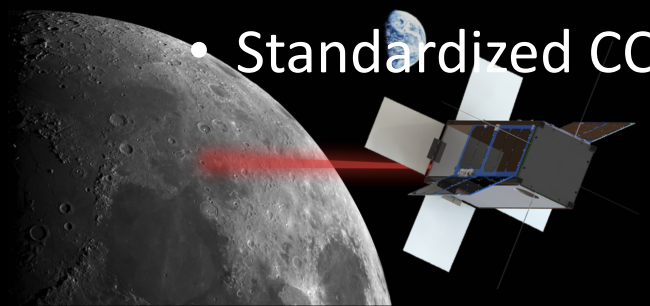


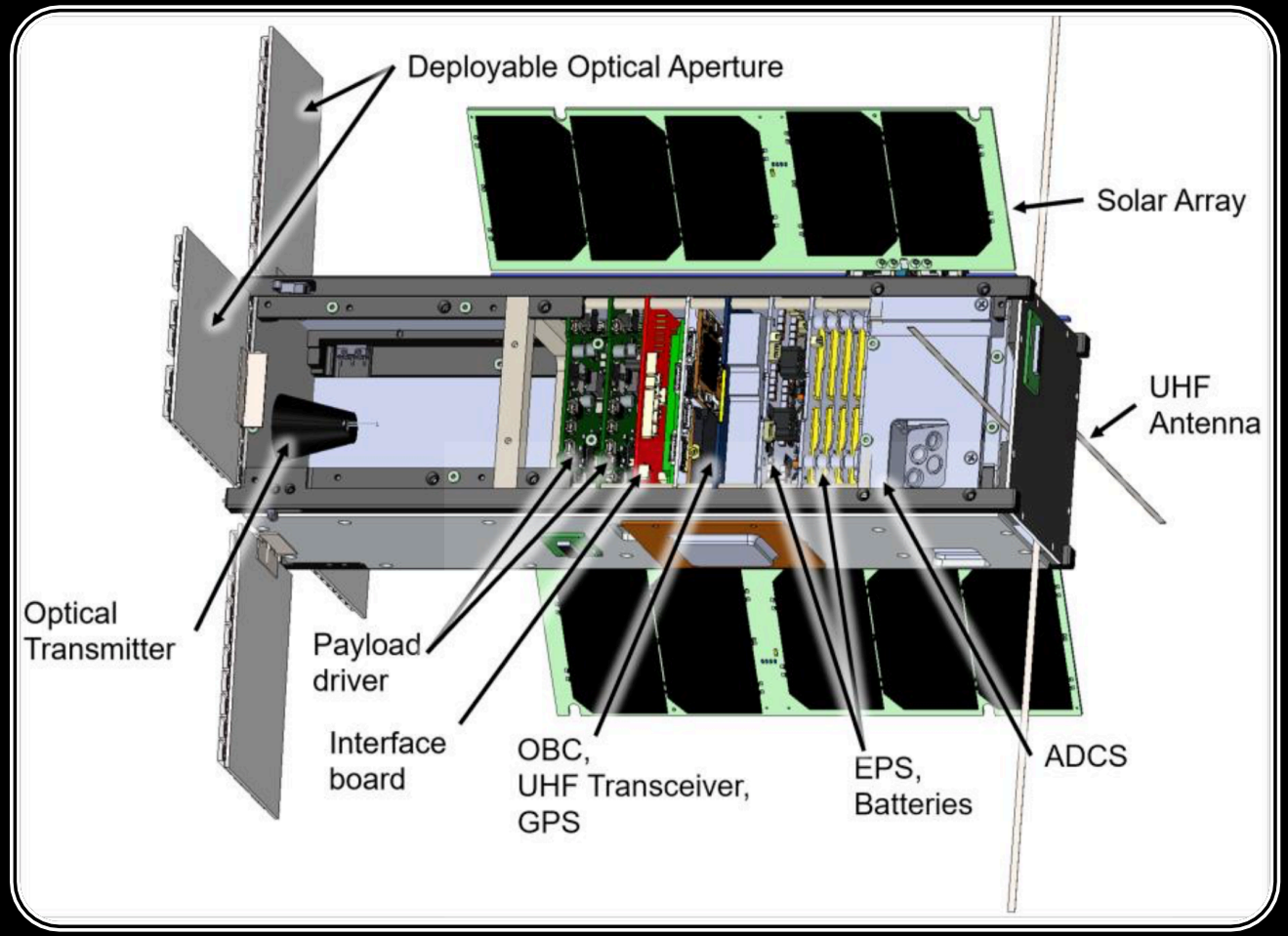
Phoenix is an earth observing thermal camera with a ground resolution of 60m.

Sponsored by NASA USIP and the ASU Low frequency Cosmology Lab

DORA Cubesat Design

- Phoenix Heritage with updates
  - Beagle bone computer
  - MAI attitude controller
  - Planet openLST radio
  - 6x2U panels. 2 deployable, 4 fixed
  - GPS
  - More Batteries
- KubeOS Linux-based OS
- Standardized CCSDS protocol





DORA Schedule

2020-2021

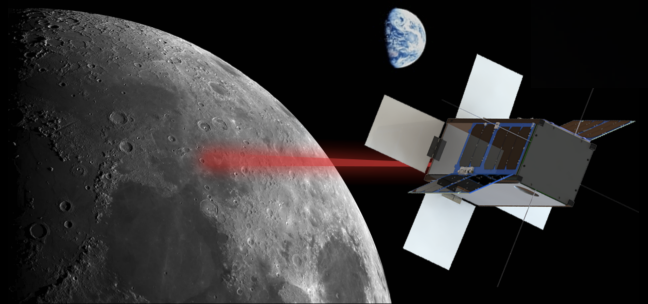
Panel Design and Lab Testing
Cubesat Mission Engineering

2021-2022

Flight laser terminal testing and integration
Spacecraft Integration and Testing
Ground Station Deployment

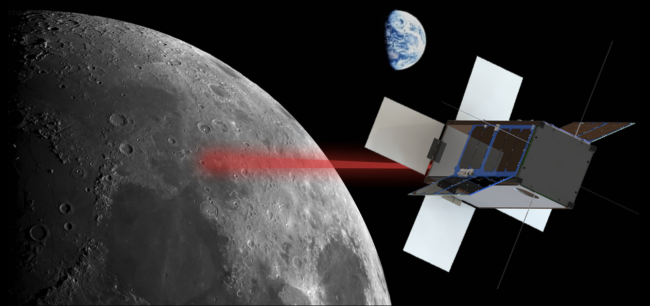
2022-2023

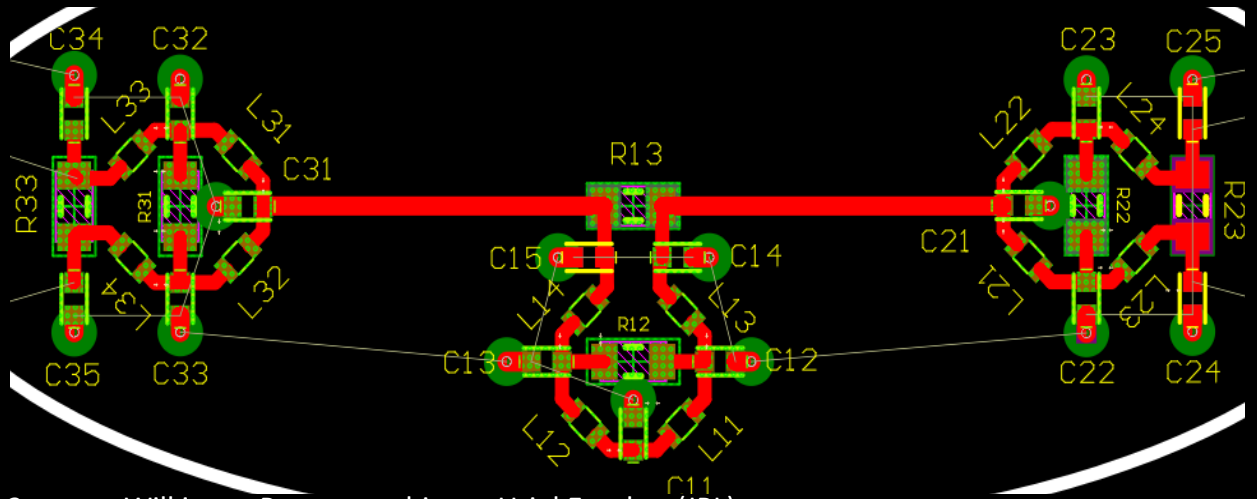
Flight updates
Delivery and Operation



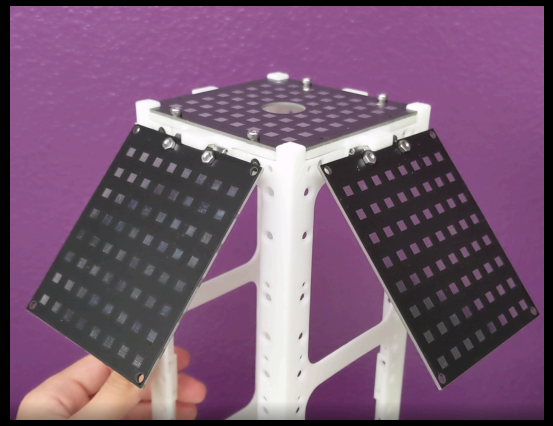
DORA Status

- Currently in month 5 out of 24.
- DORA payload design nearing prototype stage
  - Building on ISOC
  - Deployment design prototyped
- Stray light and sensitivity study suggests limitation to night operations
- Cubesat concept of operation and design study
- Part order under way
- Significant software development and demos by capstone team

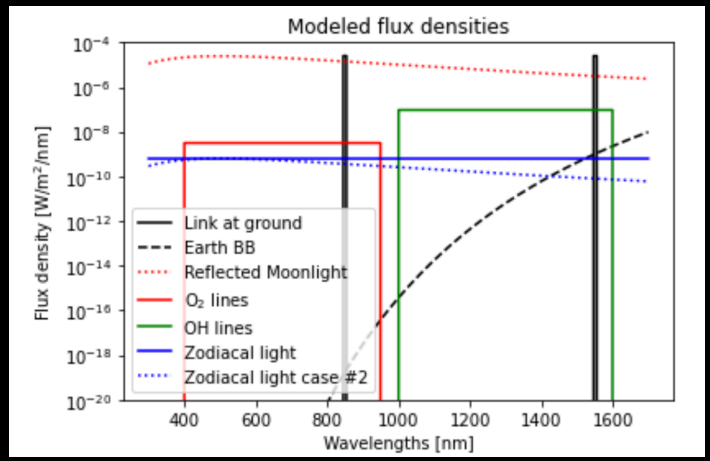




3 sensor Wilkinson Power combiner - Uriel Escobar (JPL)



Deployable panel hinge testing (J. Sanchez de la Vega)



Background light study (J. Bowman, LoCo Memo #46)

Thanks!