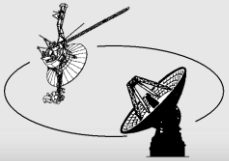
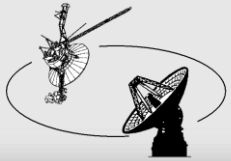


Inter-satellite Omnidirectional Optical Communicator for CubeSat Swarms

Dr. Jose Velazco

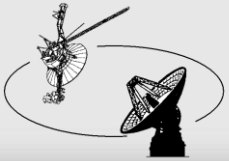
Jet Propulsion Laboratory

Inter-Spacecraft Omnidirectional Optical Communicator (ISOC)



Outline

1. Description of ISOC
2. ISOC Design and Testing
3. Technology Demonstration Mission Concept
4. Swarm Testbed
5. Examples of Science Missions
6. Conclusions



Acknowledgements

- Collaborators:

  JPL

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  University California - Irvine

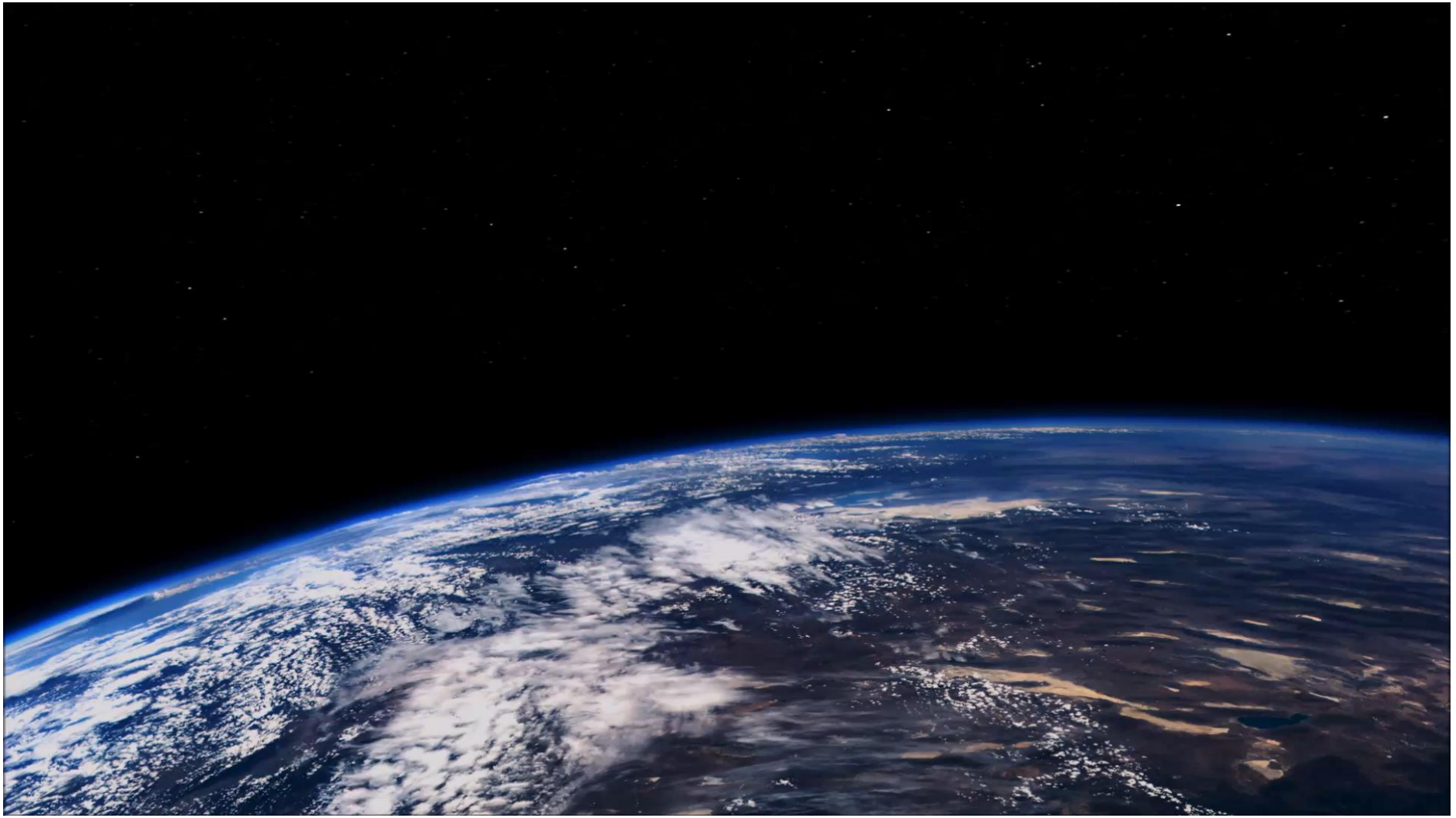
  Ozdal Boyraz, Imam-Uz Zaman

  California State University – Northridge (CSUN)

  James Flynn and student team

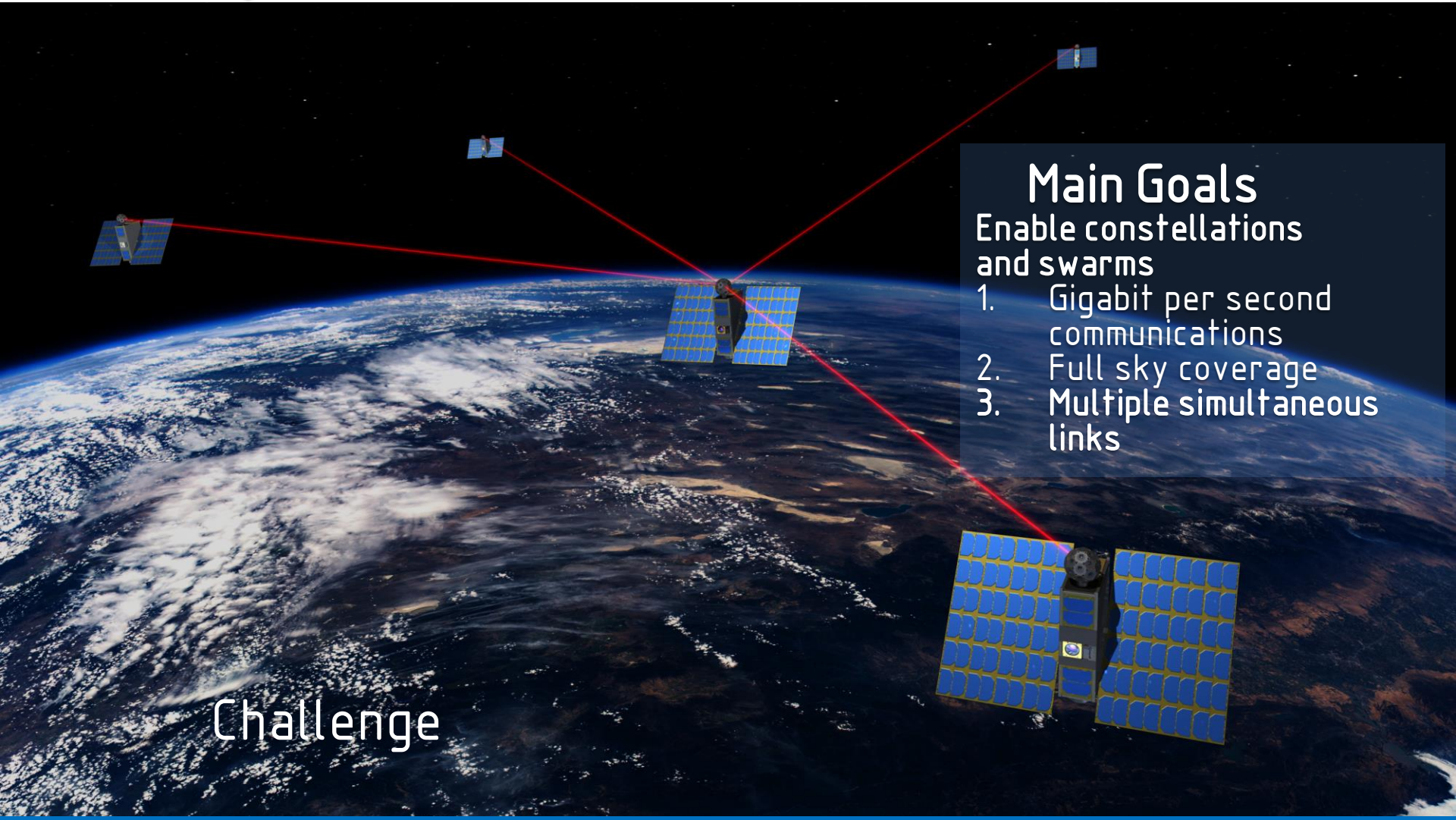
- This work is being carried out with funding from NASA's Small Spacecraft Technology Program

1. Description of ISOC



Description of ISOC: Inspiration

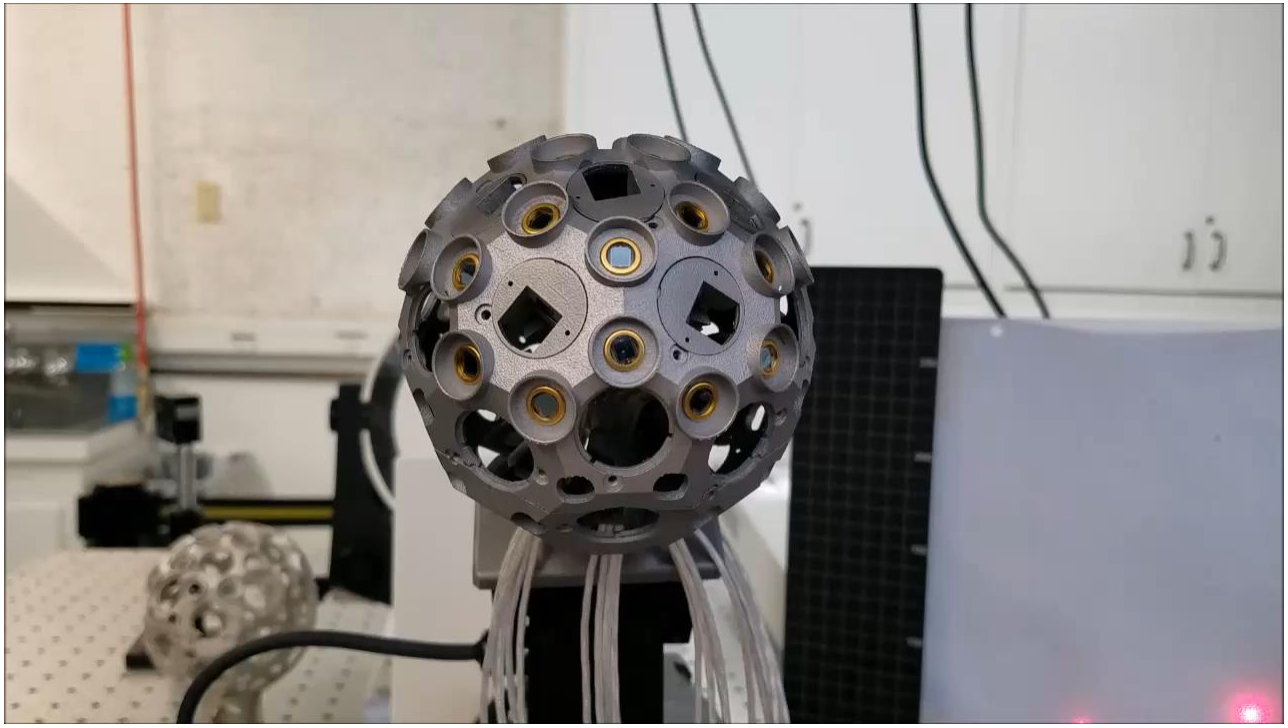
1. Description of ISOC



Description of ISOC: Challenge

1. Description of ISOC

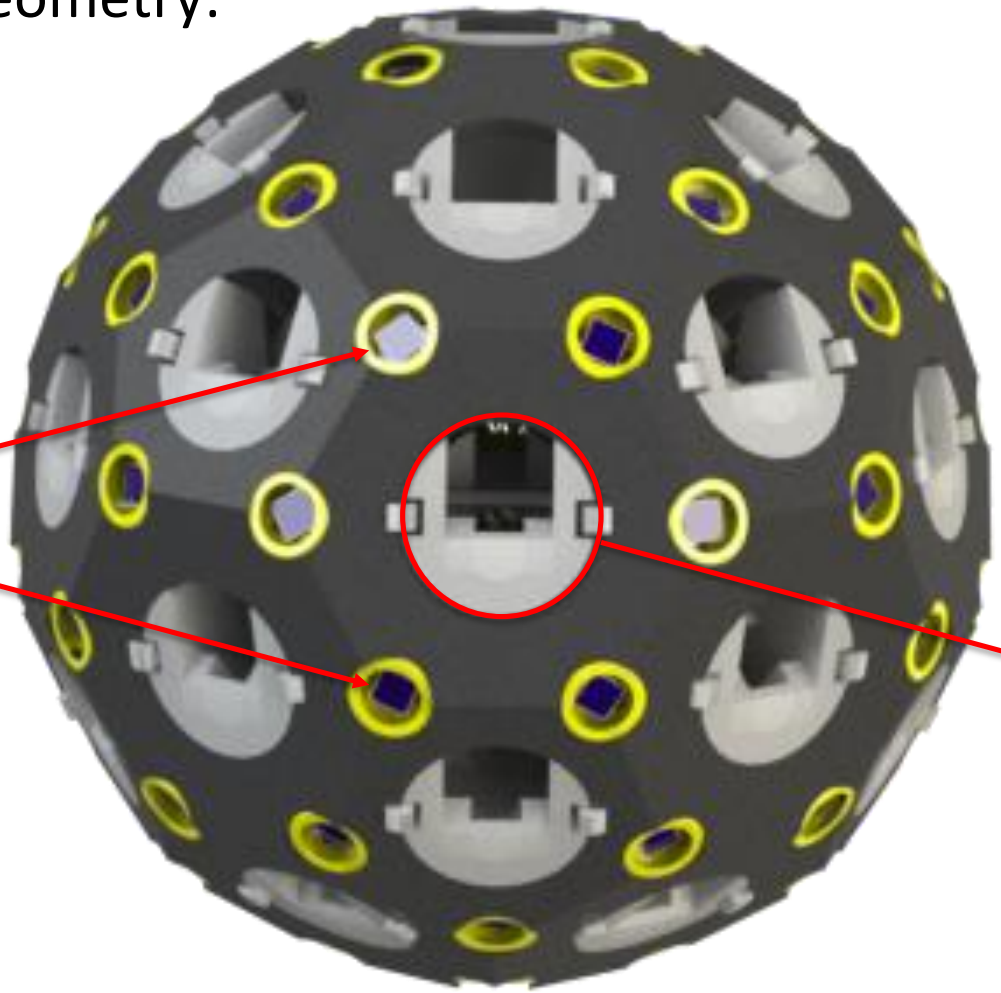
Let me introduce to you the ISOC:



Description of ISOC: ISOC Introduction

1. Description of ISOC

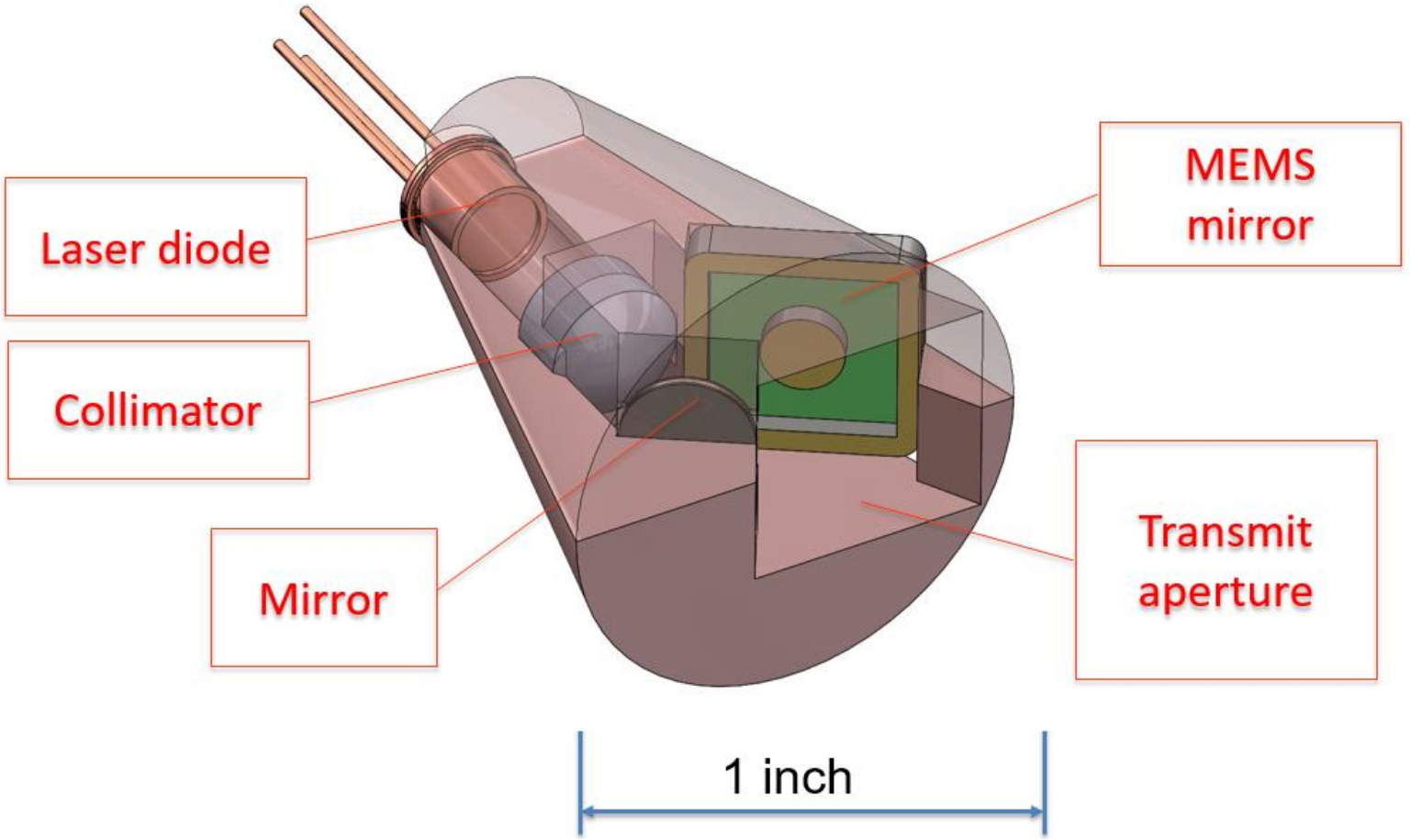
Basic ISOC geometry:



Description of ISOC: Basic ISOC geometry

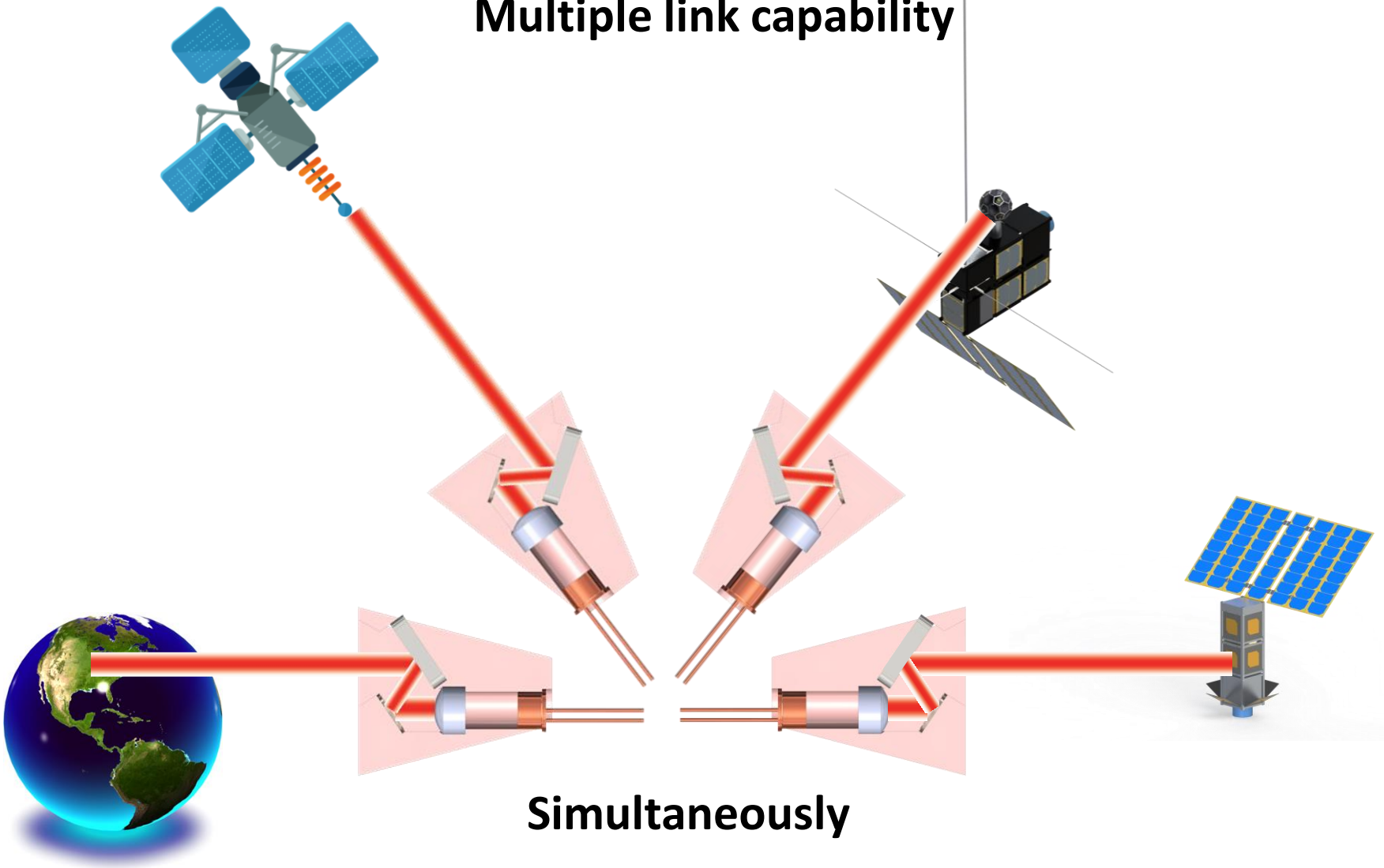
1. Description of ISOC

ISOC Transmit Telescope



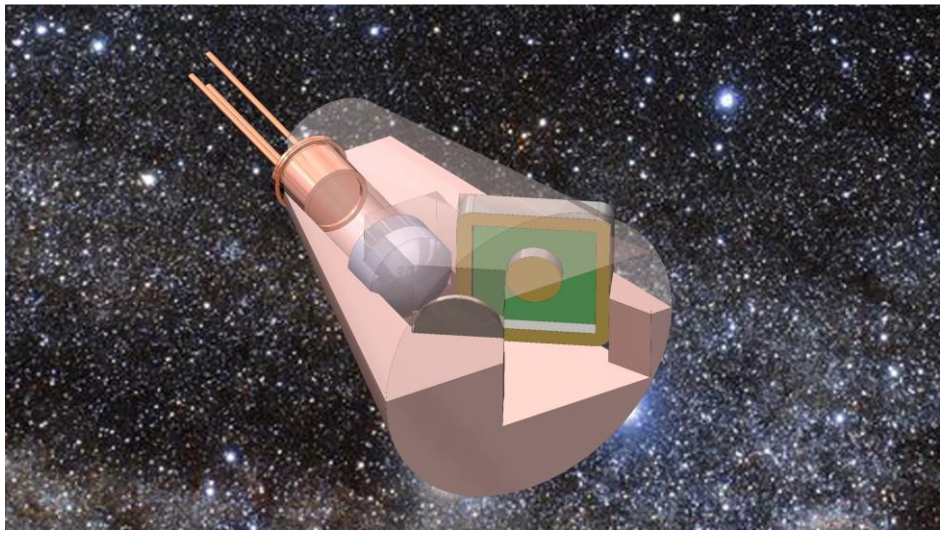
Description of ISOC: Transmit Telescope

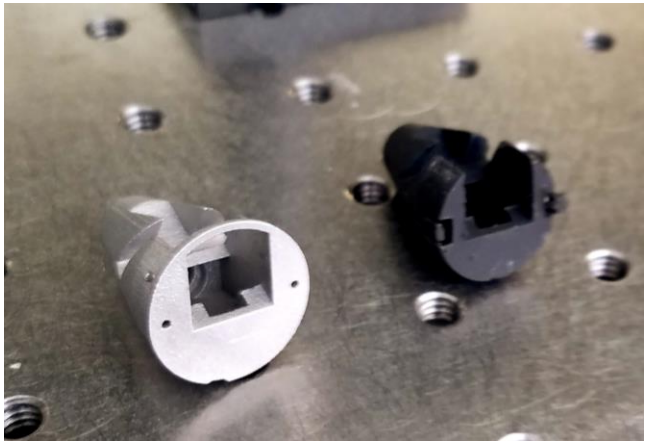
1. Description of ISOC

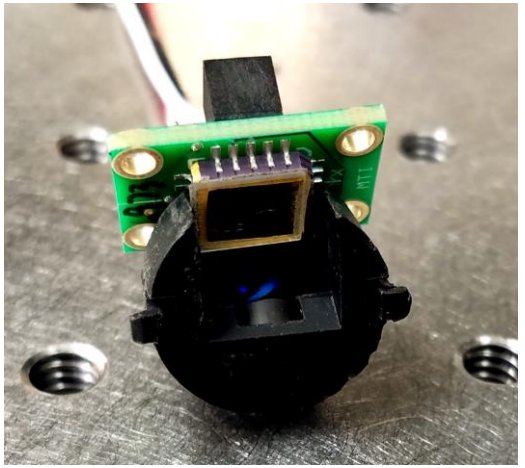


1. Description of ISOC

ISOC Transmit Telescope





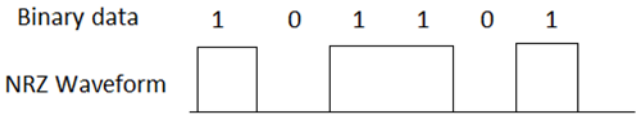


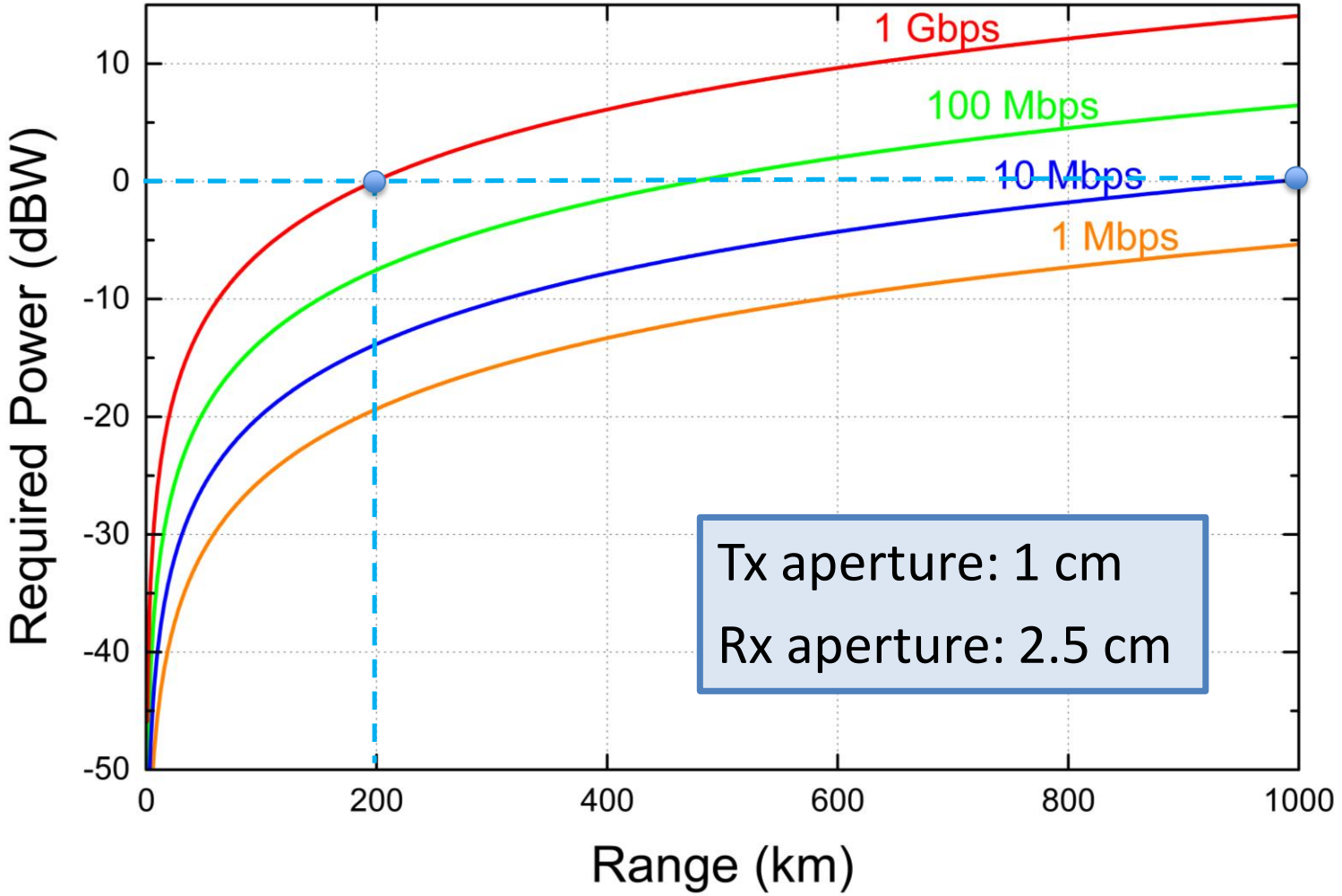
Omnidirectional Optical Communicator

1. Description of ISOC

NRZ - OOK (On-Off Keying)

- Bandwidth (BW) = Bitrate (R_b)

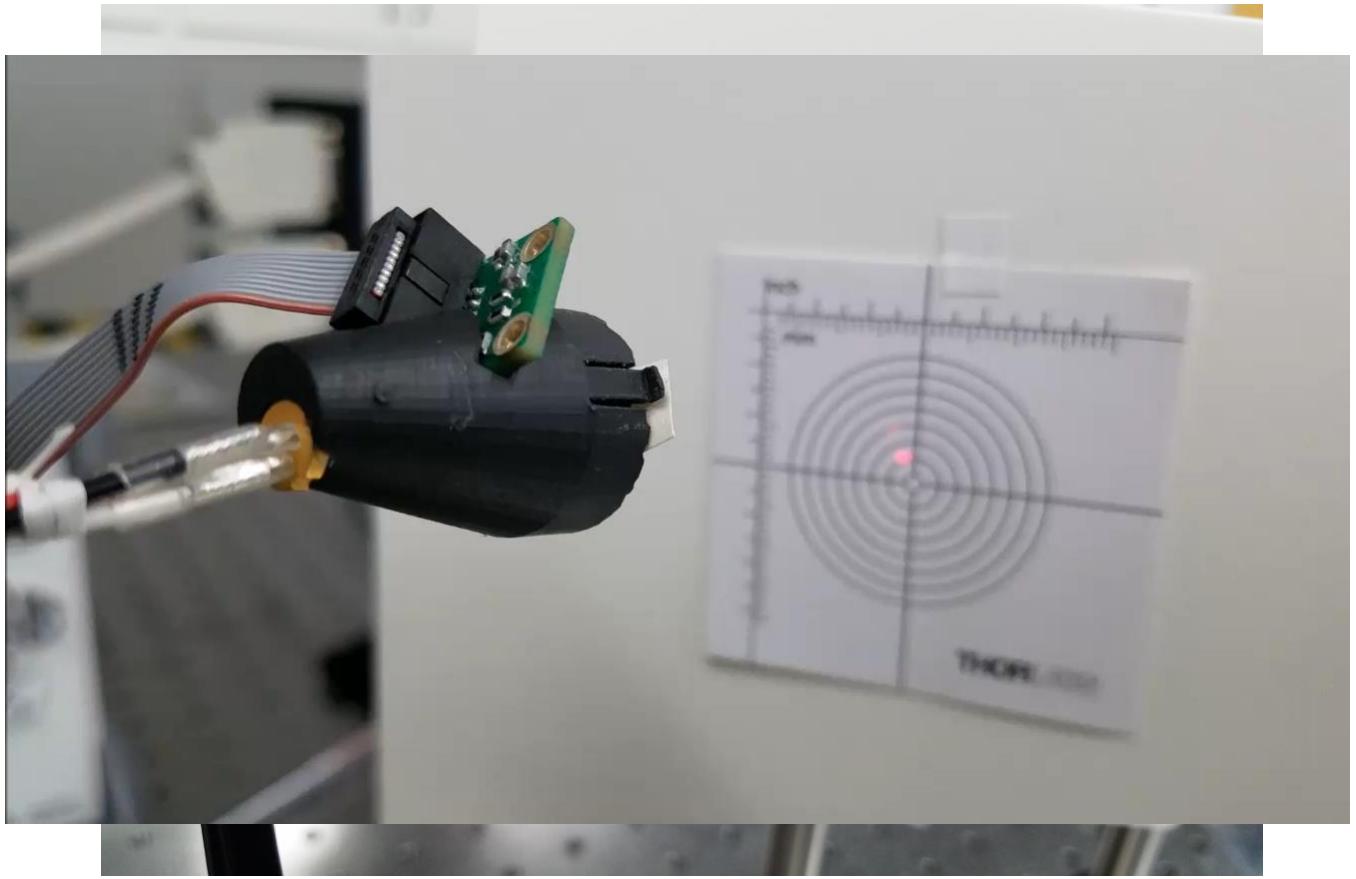




Omnidirectional Optical Communicator

2. ISOC Testing

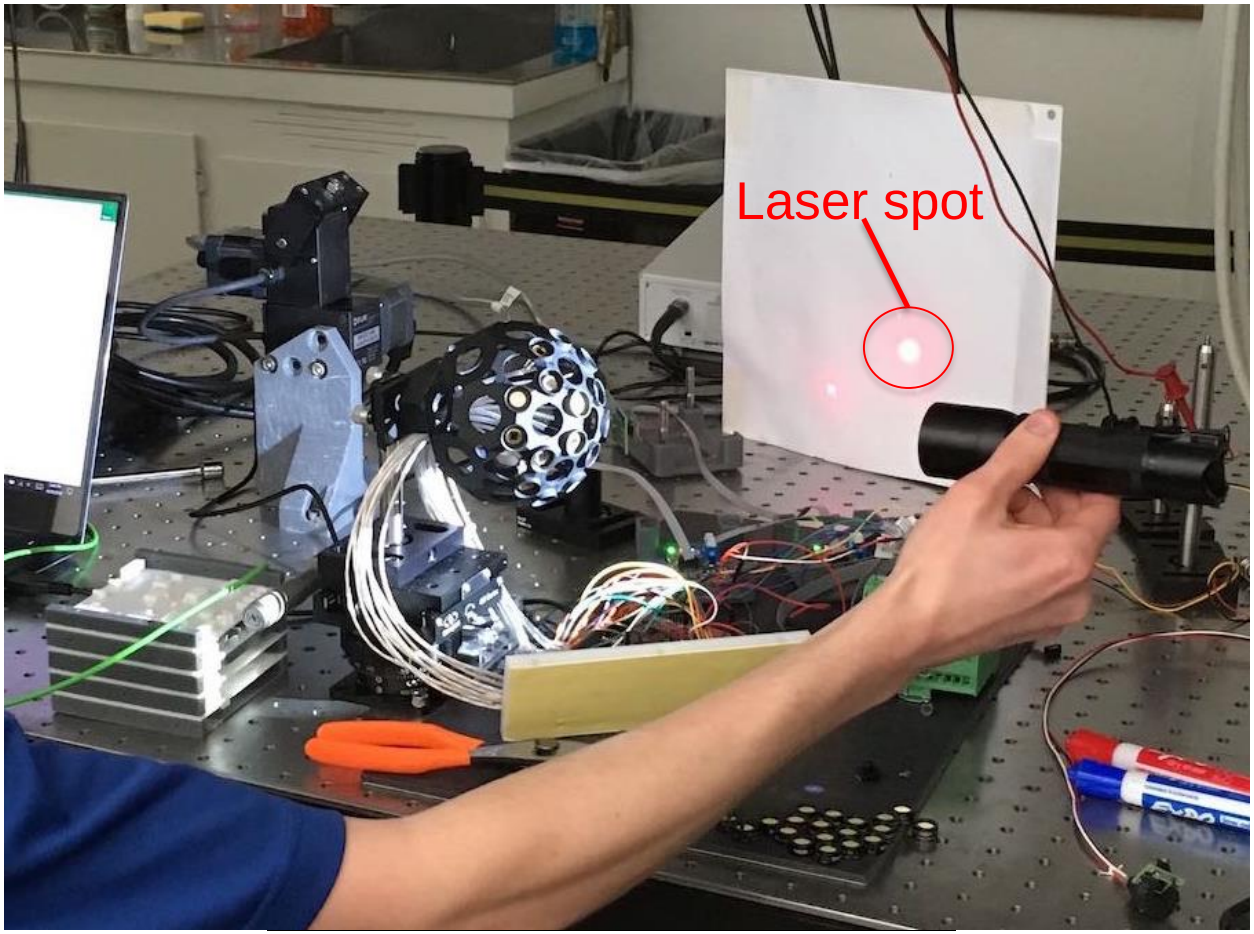
Preliminary results of miniature telescope testing



ISOC Telescope: Tx Telescope Testing

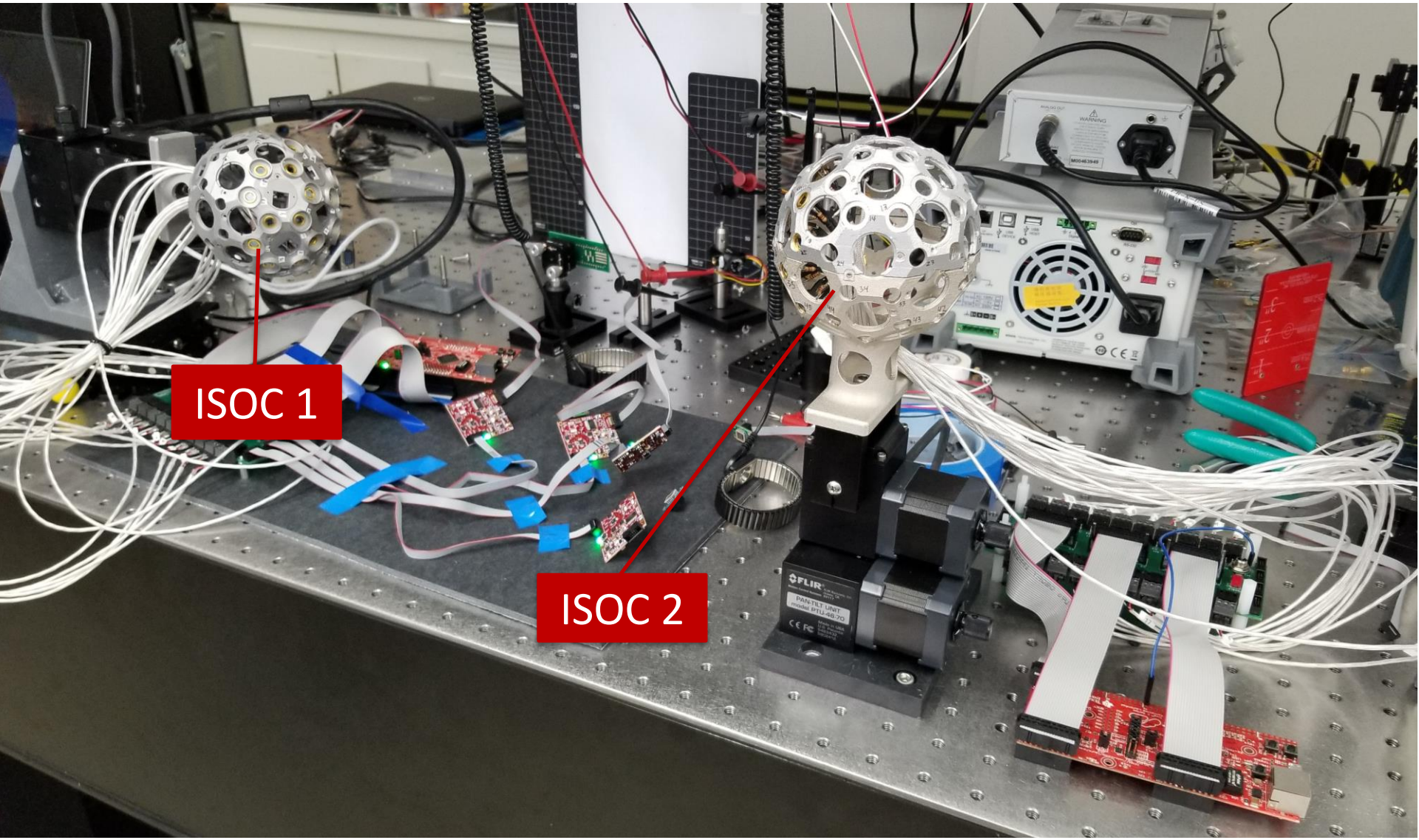
2. ISOC Testing

Preliminary results of miniature telescope testing

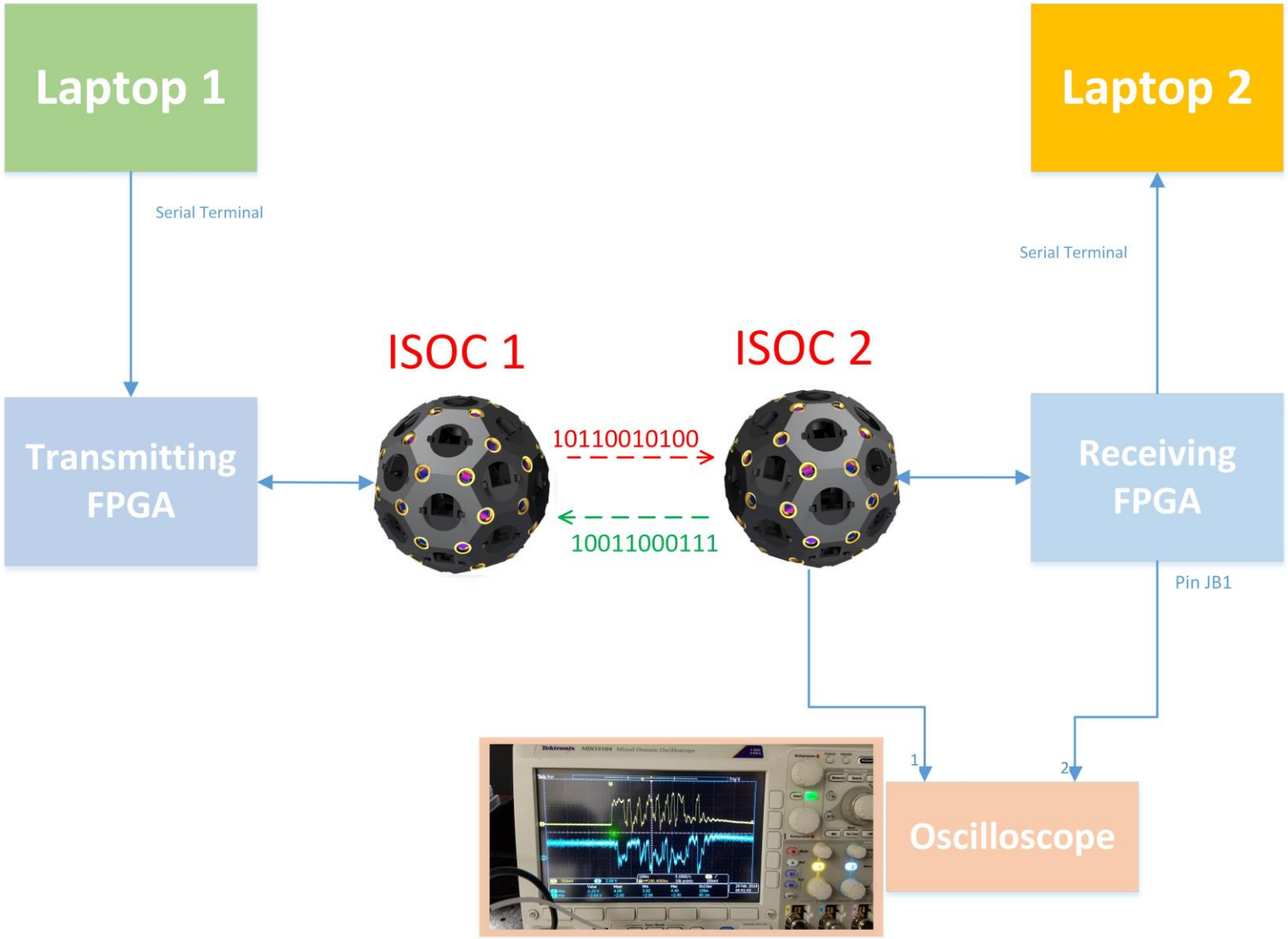


ISOC Telescope: Telescope Testing

ISOC Testing



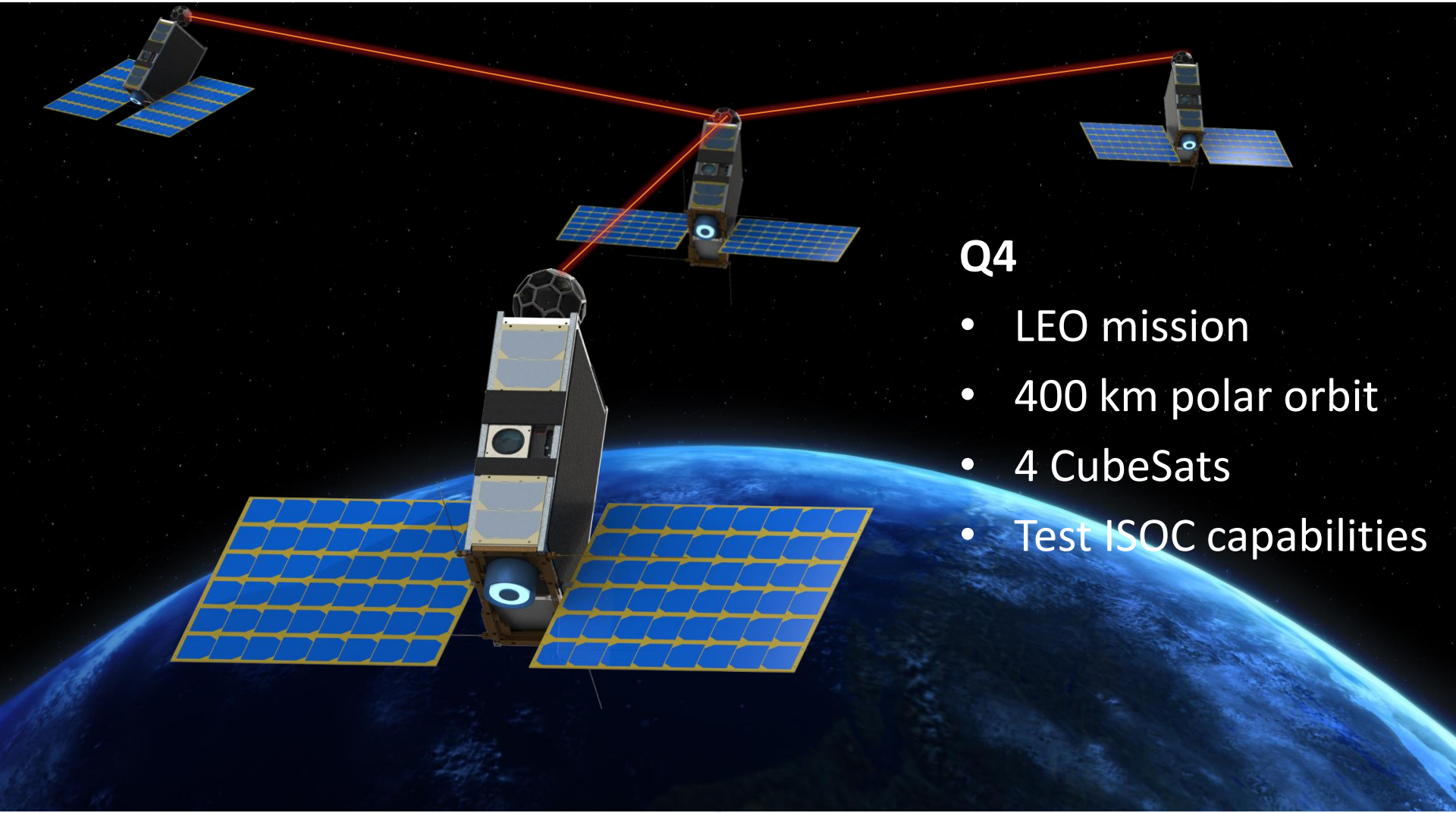
ISOC Testing



Omnidirectional Optical Communicator

3. Technology Demonstration Mission

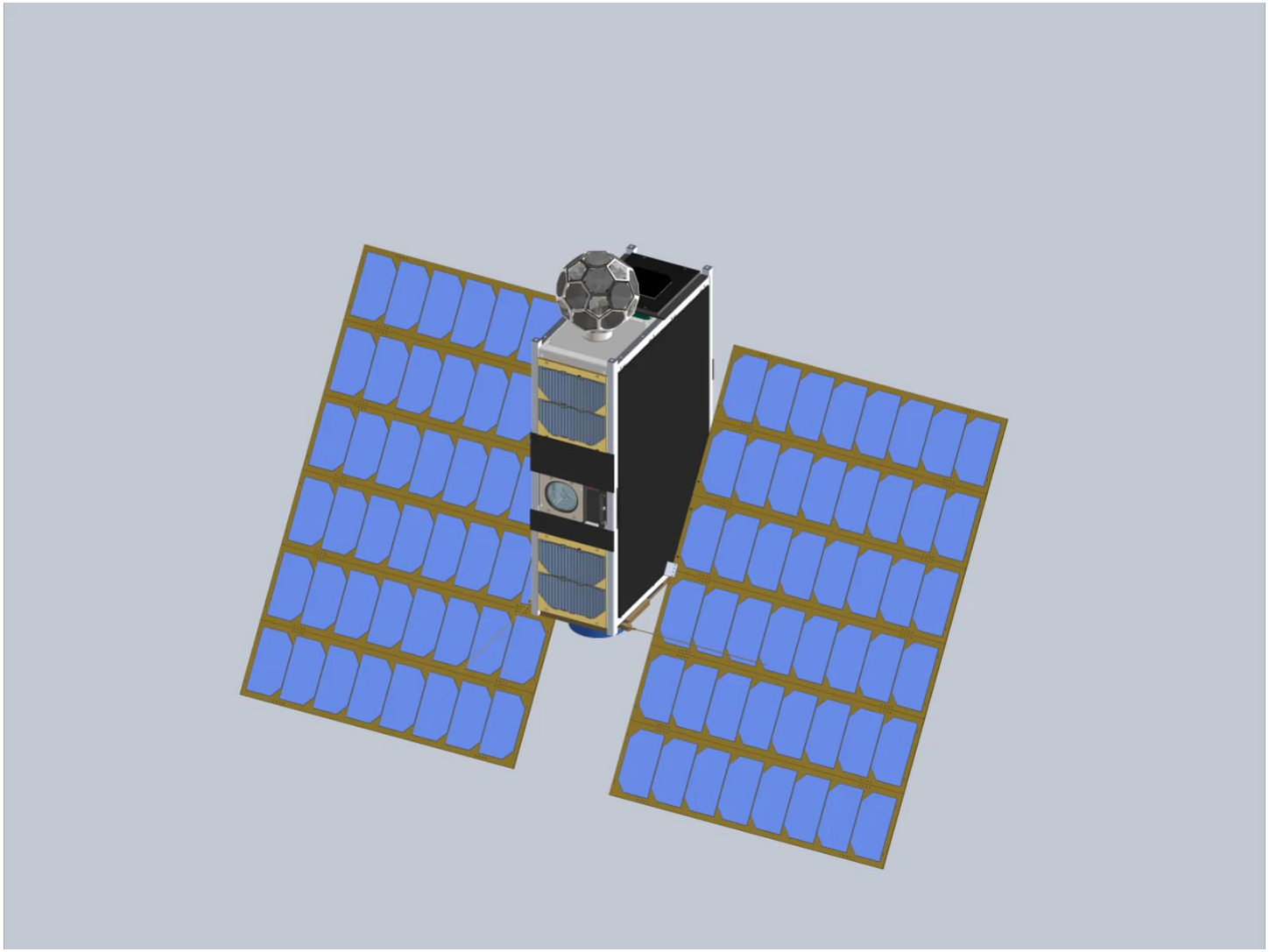
Q4



Q4

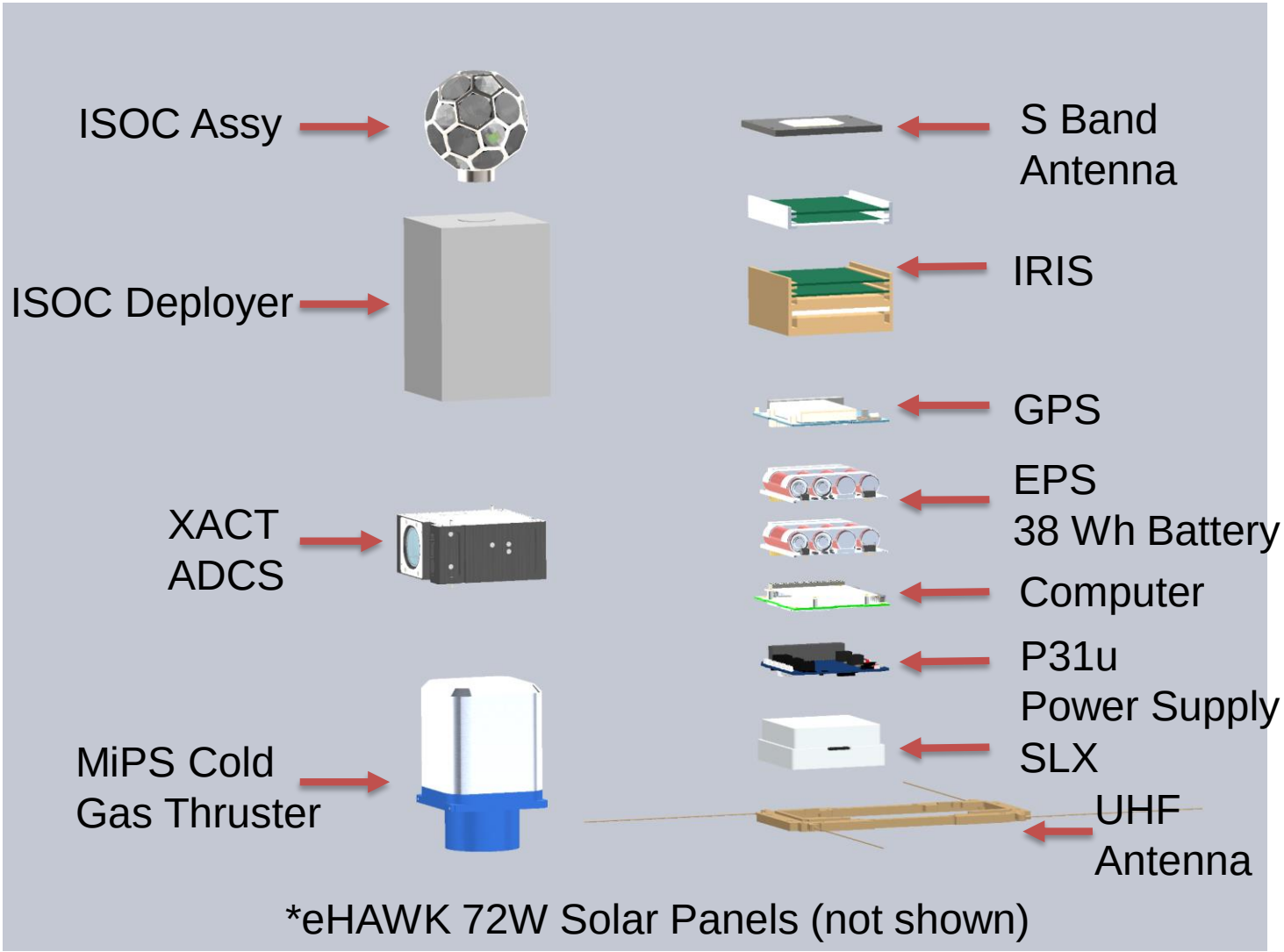
- LEO mission
- 400 km polar orbit
- 4 CubeSats
- Test ISOC capabilities

3. Technology Demonstration Mission

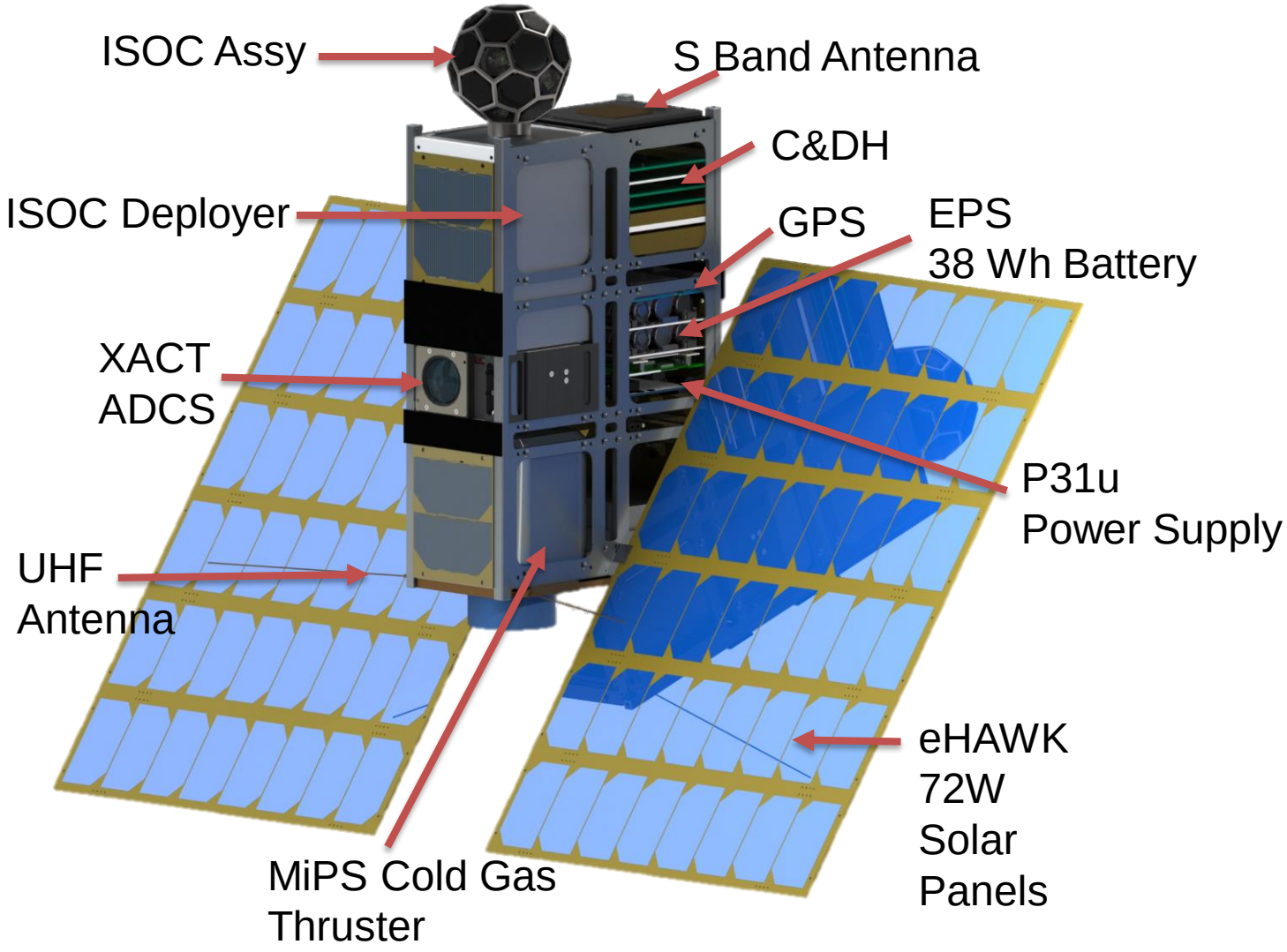


Omnidirectional Optical Communicator

3. Technology Demonstration Mission

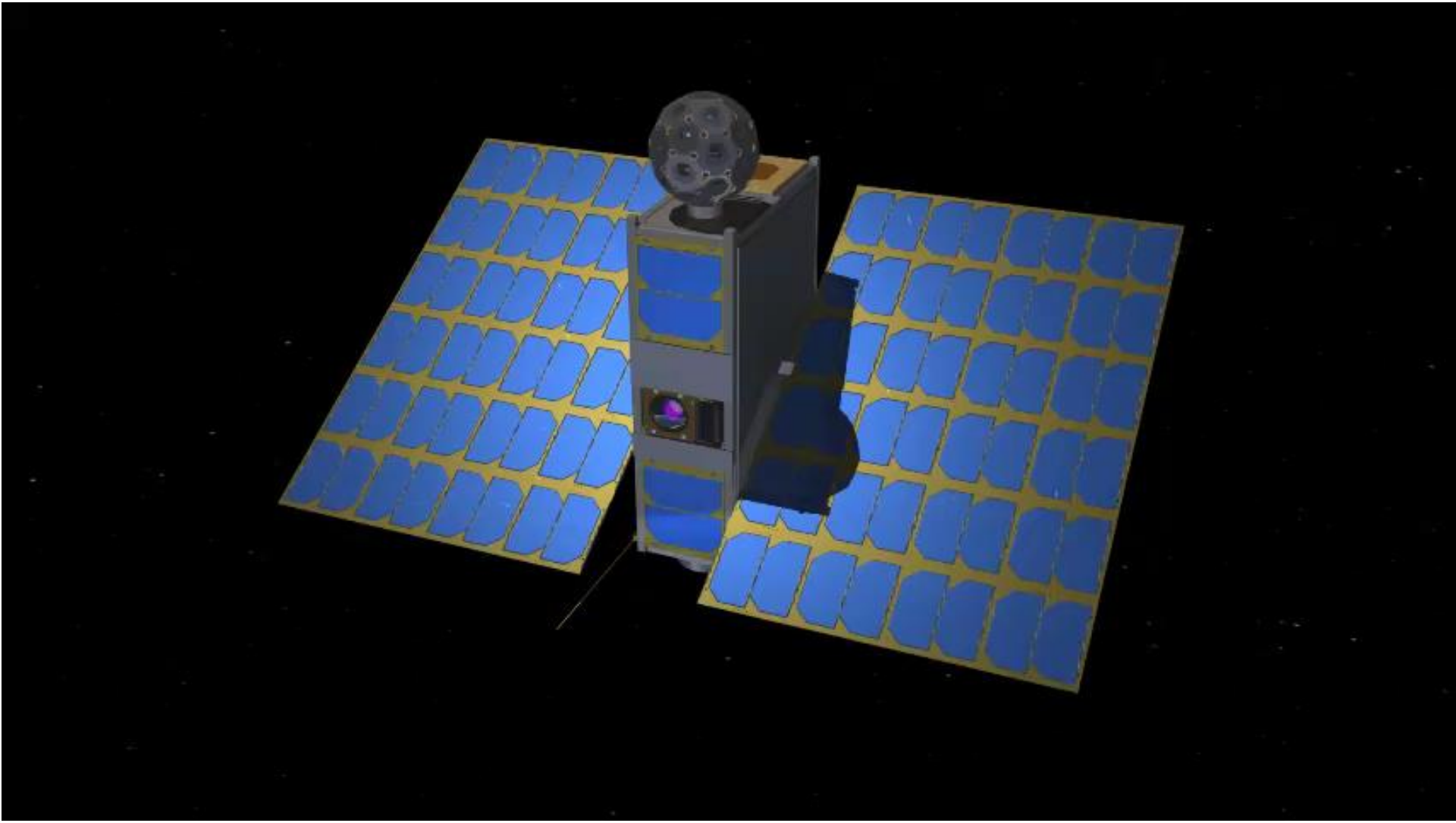


3. Technology Demonstration Mission



Omnidirectional Optical Communicator

3. Technology Demonstration Mission



Omnidirectional Optical Communicator

3. Technology Demonstration Mission

Orbital Dynamics

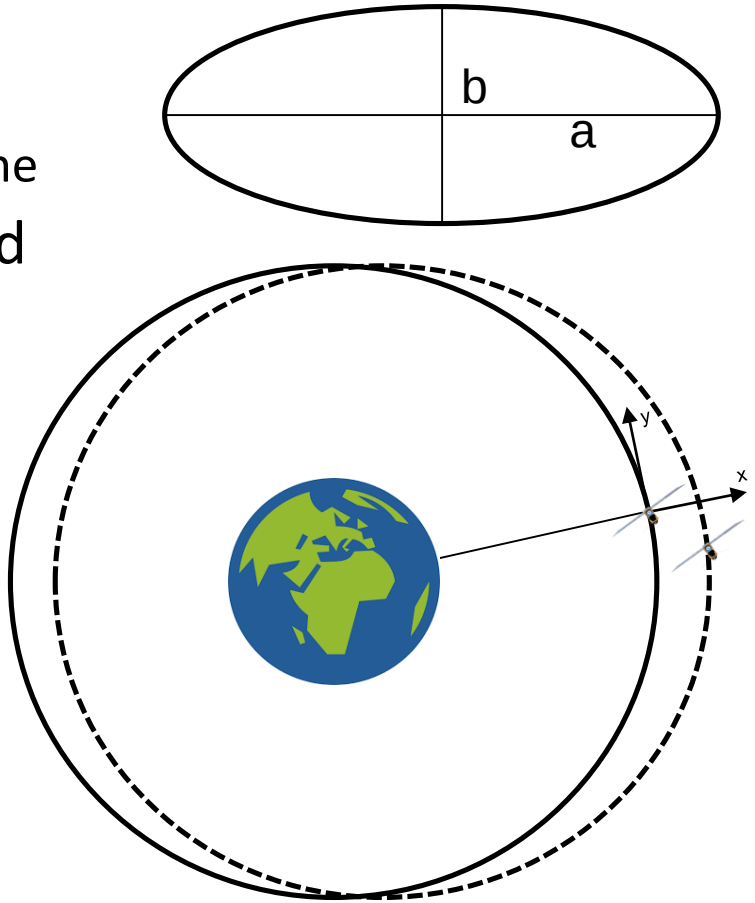
- Clohessey-Wiltshire Equations
  - Describe chaser motion in target frame
- Same semi-major axis, same period
  - Relative motion is repetitive

$$\ddot{x} - 2n\dot{y} - 3n^2x = f_x$$

$$\ddot{y} + 2n\dot{x} = f_y$$

$$\ddot{z} + n^2z = f_z$$

$$n = \sqrt{\frac{\mu}{a^3}}$$



3. Technology Demonstration Mission

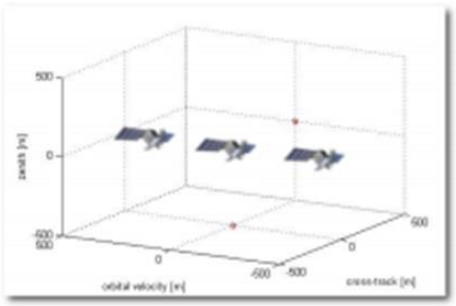
Orbital Dynamics

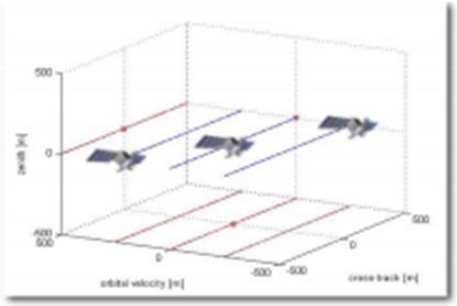
Possible Configurations

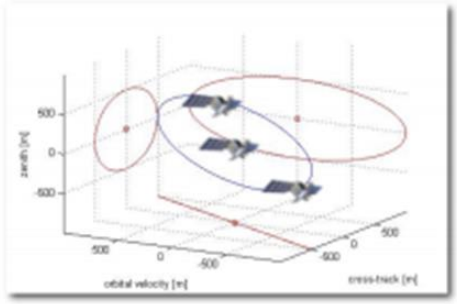
- Homogenous Analytical Solution

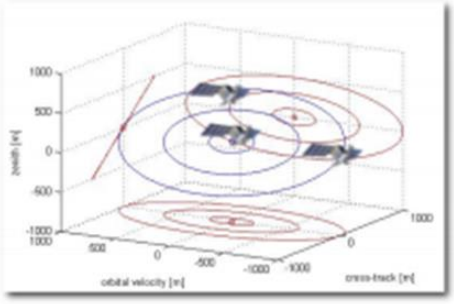
$$x = A_x cos(nt + \alpha)$$
$$y = -2A_x sin(nt + \alpha) + y_{off}$$
$$z = A_z cos(nt + \beta)$$

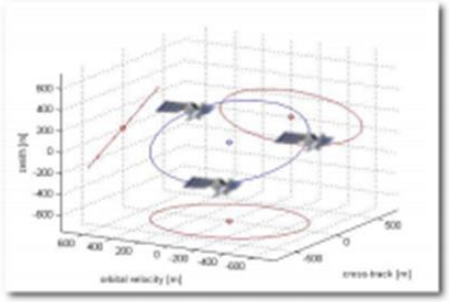
  - X,Y motion coupled
  - Z motion free

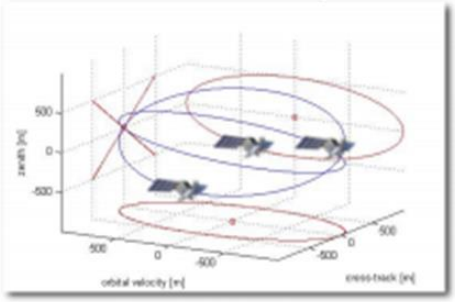

String of Pearls


Cross-track Scan


Azimuth Scan


Multi Free Orbit Ellipse

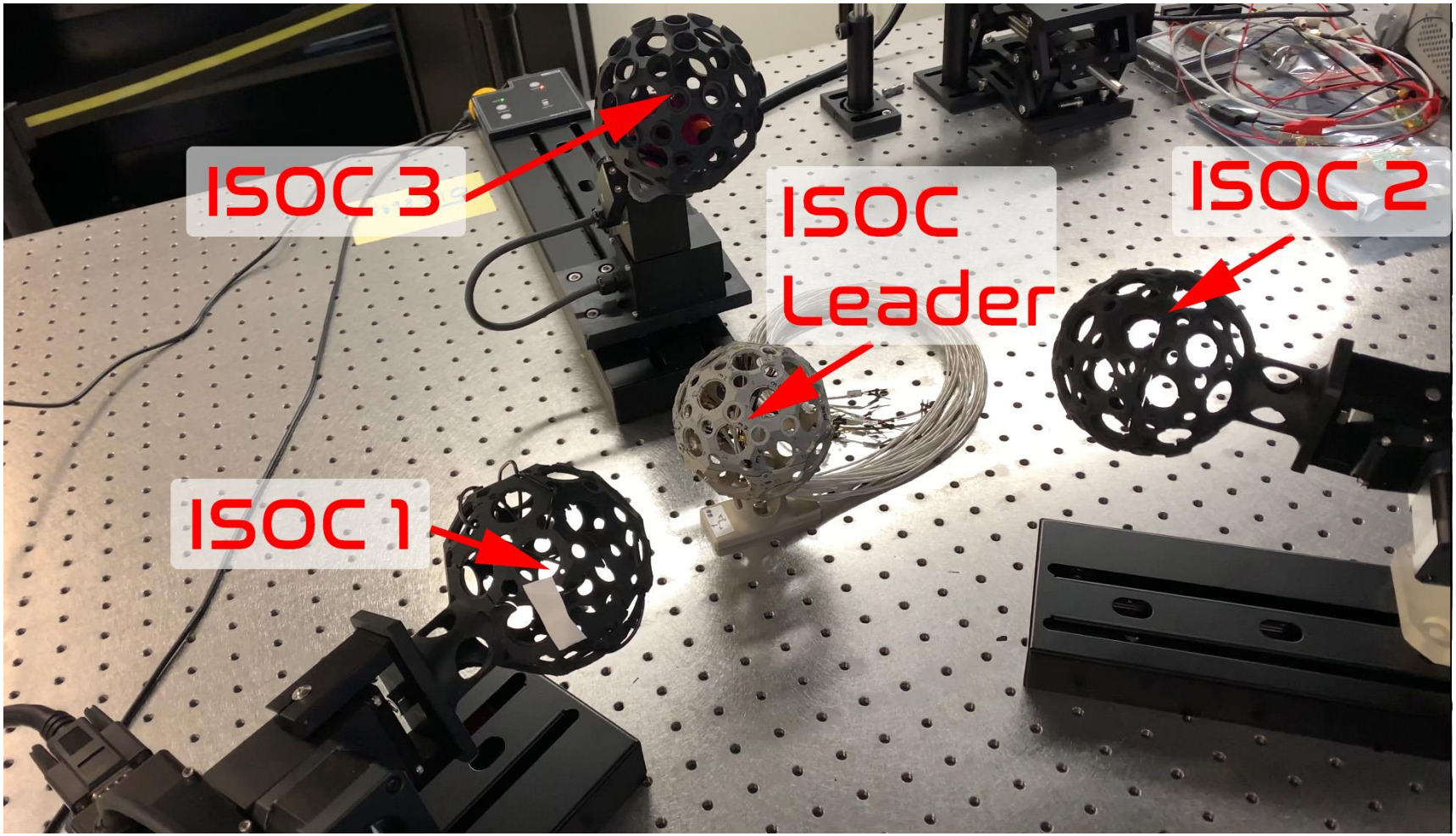

Nadir Circle


Dual Side Scan

3. Technology Demonstration Mission

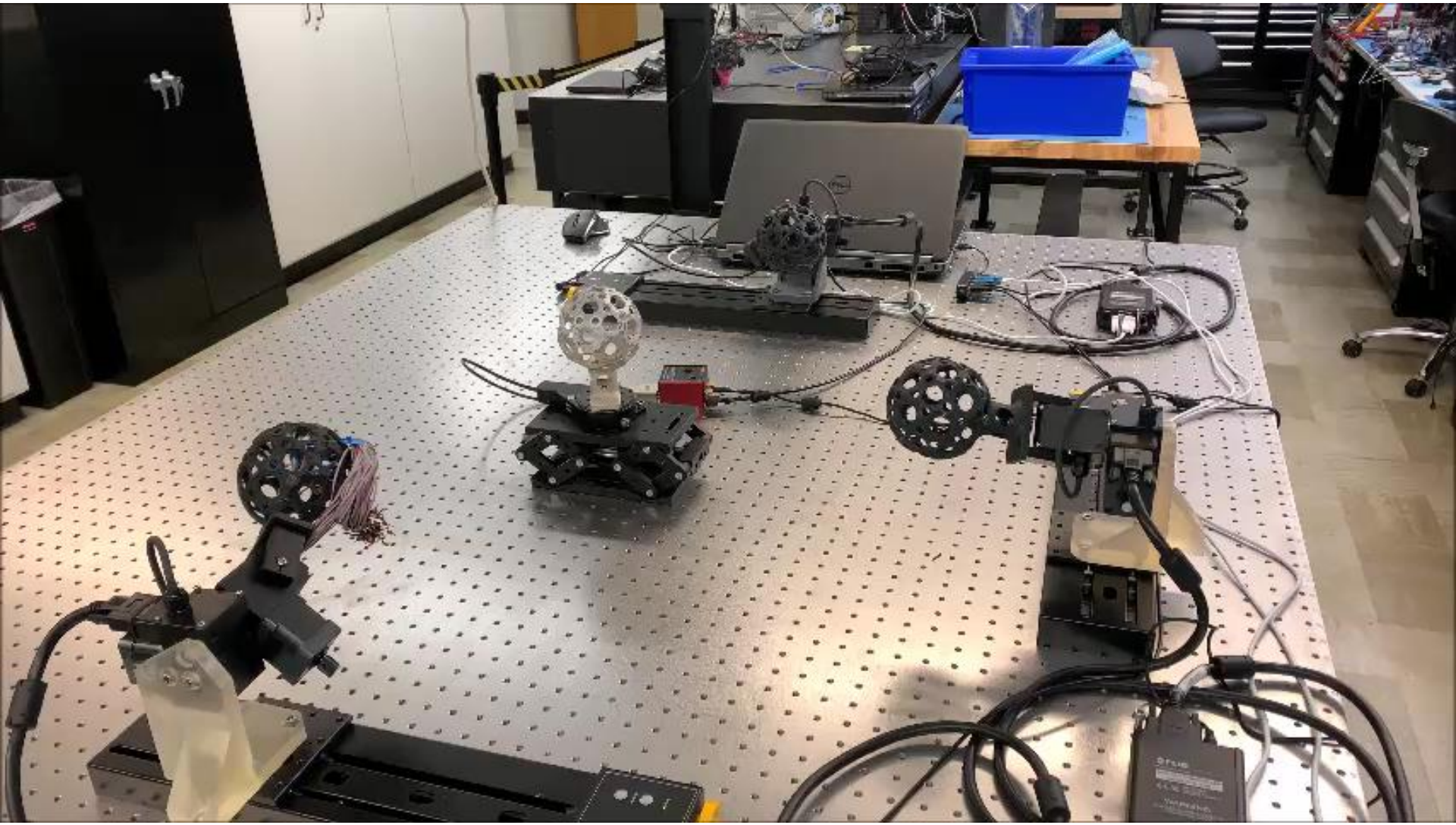
Chosen Configuration

4. Swarm Testbed



Swarm emulator using automated platforms

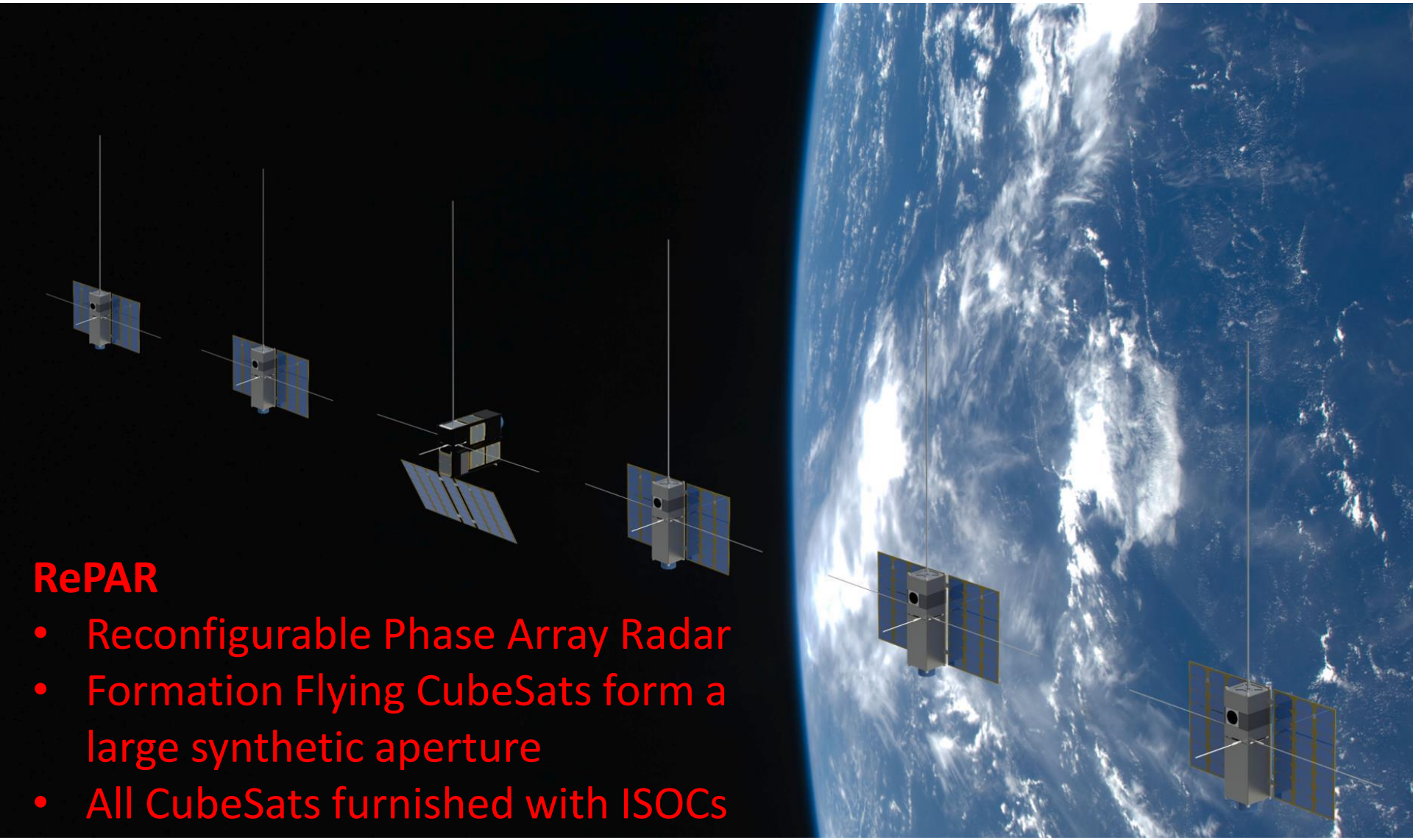
4. Swarm Testbed



Swarm emulator using automated platforms

Omnidirectional Optical Communicator

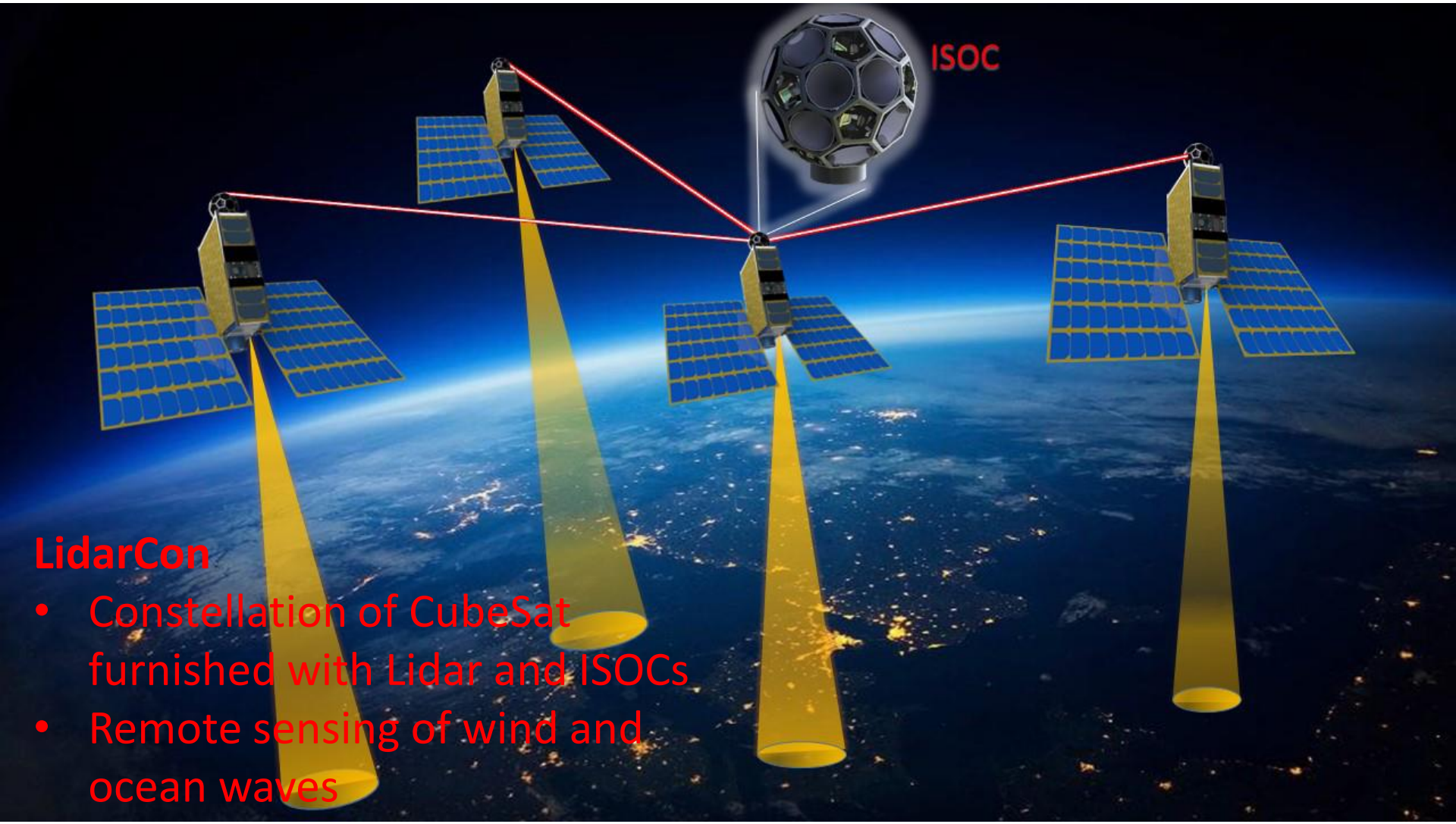
5. Mission Examples



RePAR

- Reconfigurable Phase Array Radar
- Formation Flying CubeSats form a large synthetic aperture
- All CubeSats furnished with ISOCs

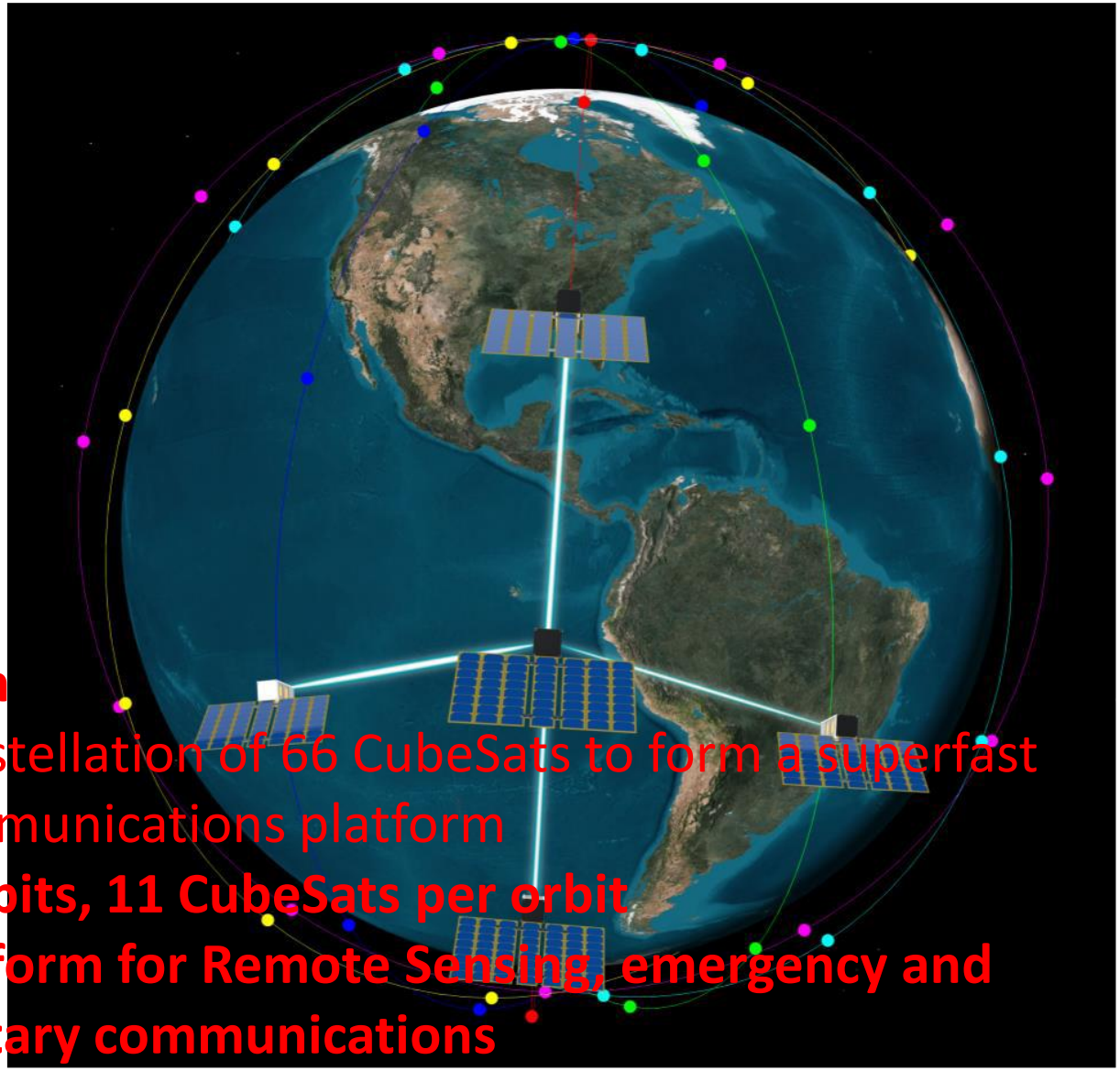
5. Mission Examples



LidarCon

- Constellation of CubeSat furnished with Lidar and ISOCs
- Remote sensing of wind and ocean waves

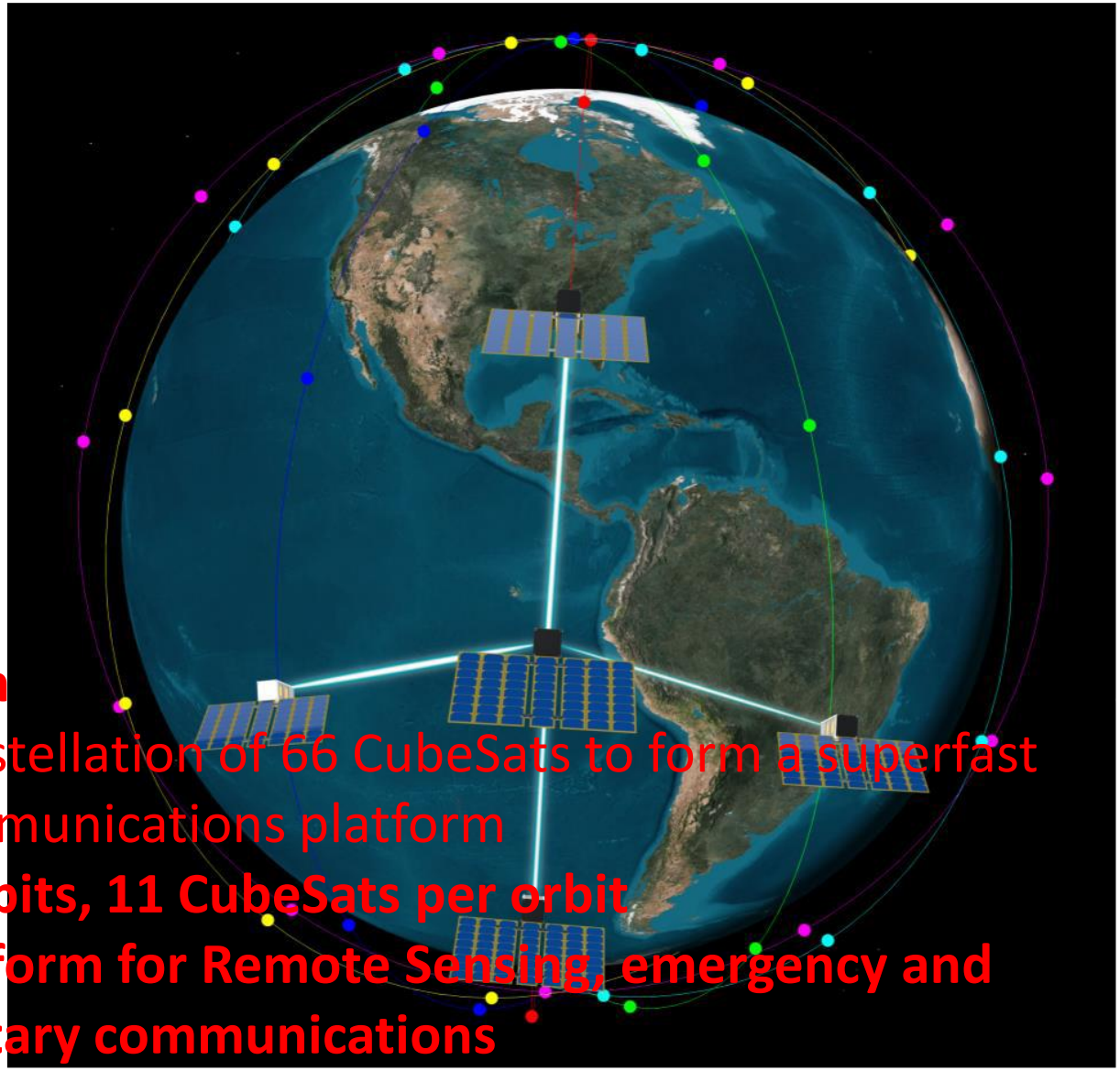
5. Mission Examples



iSATcon

- Constellation of 66 CubeSats to form a superfast communications platform
- **6 orbits, 11 CubeSats per orbit**
- **Platform for Remote Sensing, emergency and military communications**

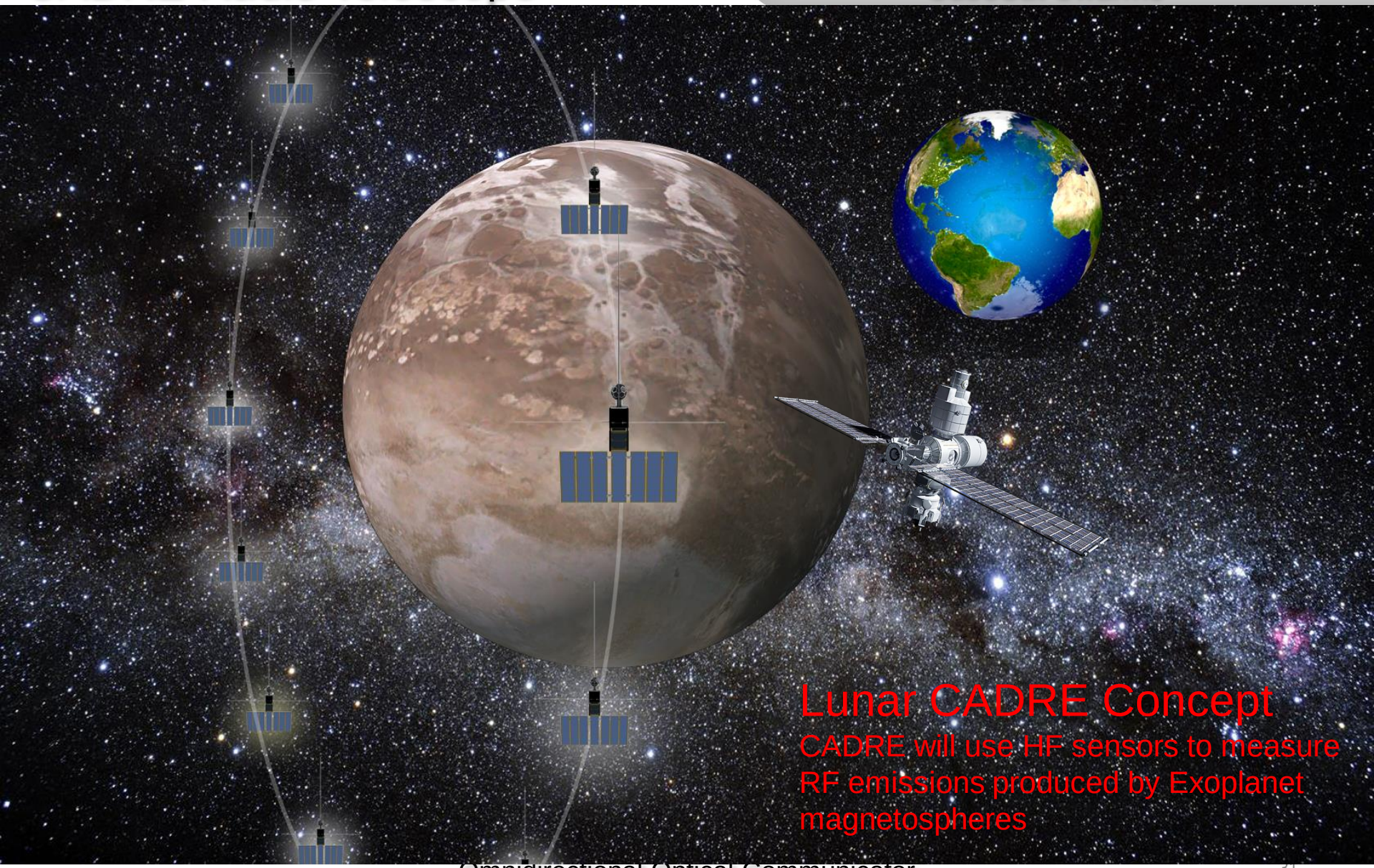
5. Mission Examples



iSATcon

- Constellation of 66 CubeSats to form a superfast communications platform
- **6 orbits, 11 CubeSats per orbit**
- **Platform for Remote Sensing, emergency and military communications**

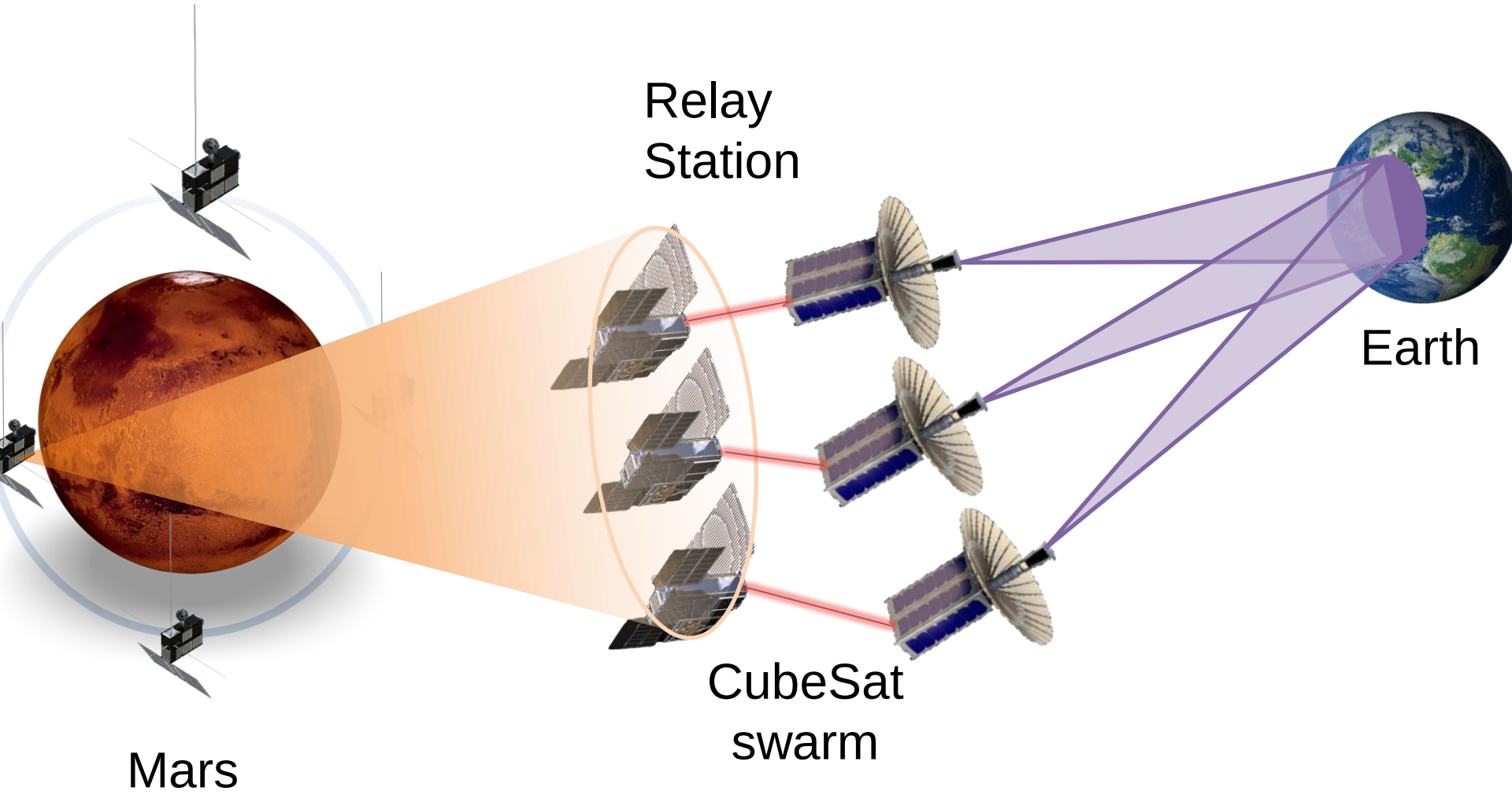
CADRE Radio Telescope



Lunar CADRE Concept

CADRE will use HF sensors to measure RF emissions produced by Exoplanet magnetospheres

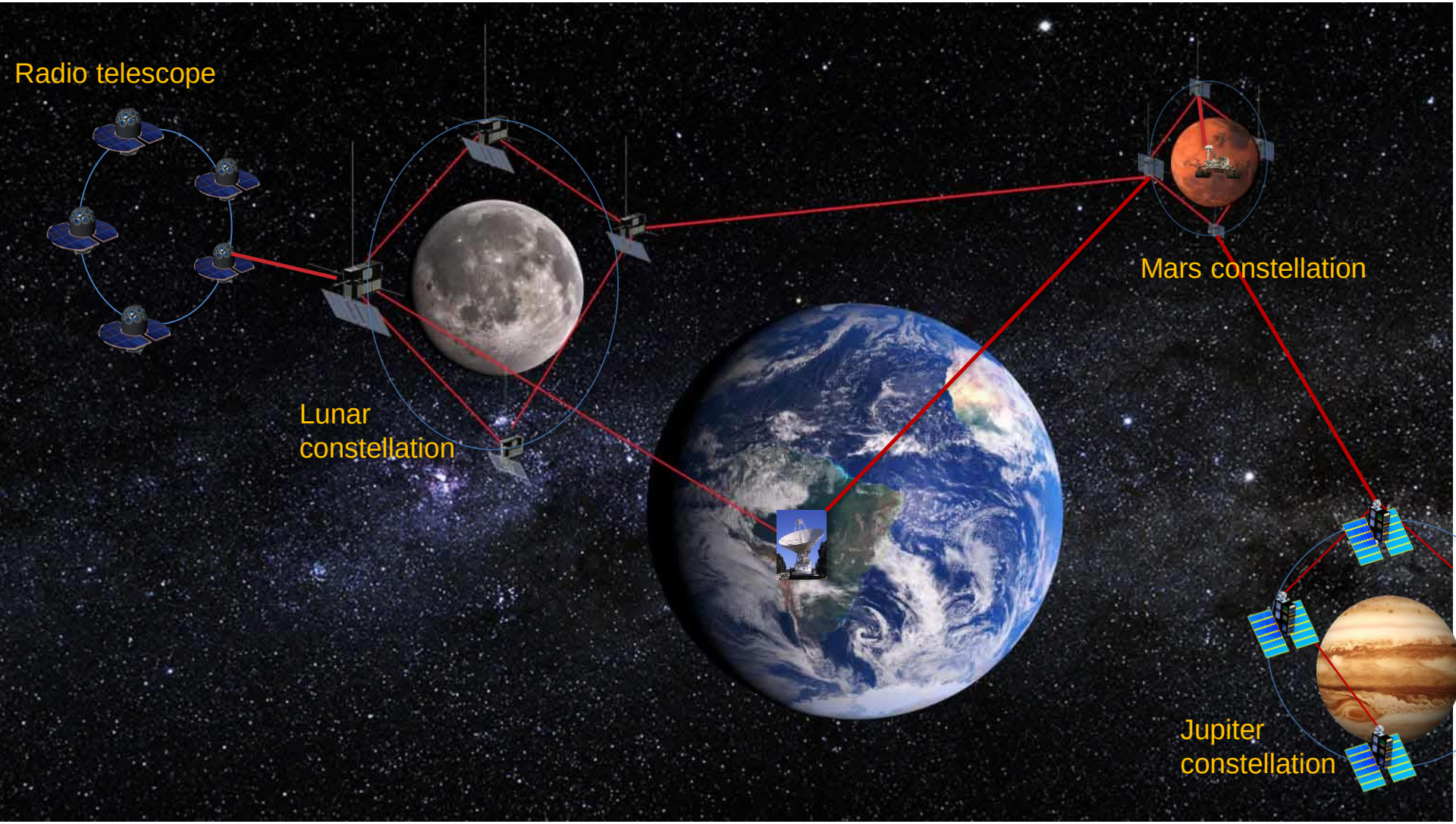
5. Mission Examples

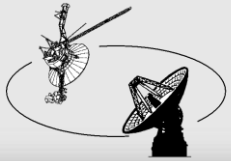


Swarms for Communications

Omnidirectional Optical Communicator

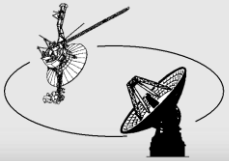
5. Mission Examples





6. Conclusions

- A novel Omnidirectional Optical Communicator has been presented
- We presented design considerations and preliminary results of the ISOC testing
- We also discussed Q4 - a technology demonstration mission for the ISOC and mission examples enabled by the ISOC
- The ISOC is a potential enabler for future swarm and constellation missions



Thank You

Questions?