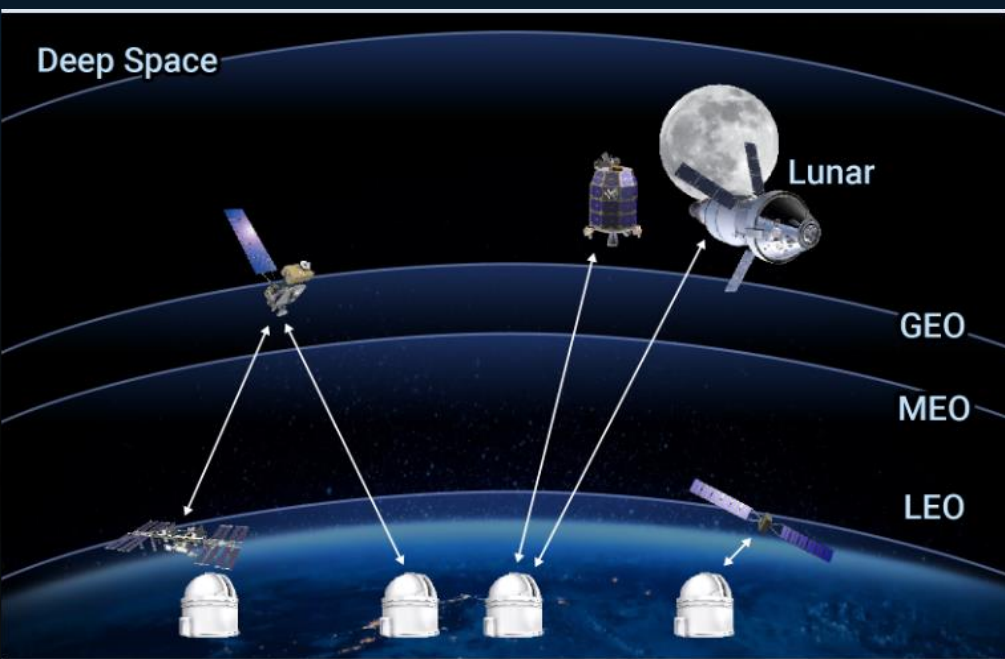


10+ Years of Successful NASA Lasercom Demonstrations

D. O. Caplan, C. Timmerman – MIT Lincoln Laboratory



SUMMARY

- Lasercom is a mature technology ready for wider adoption for space-based missions
- Various architectures demonstrated:
 - Ground-to-LEO; LEO-to-GEO
 - Ground-to-GEO relay
 - Lunar orbit and deep space
- Demonstrated practical solutions to lasercom implementation challenges, such as pointing, acquisition, and tracking

PROBLEM STATEMENT

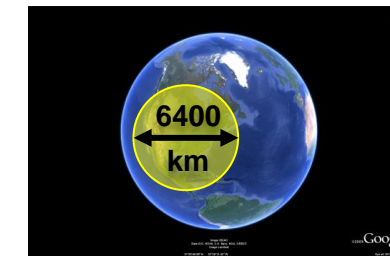
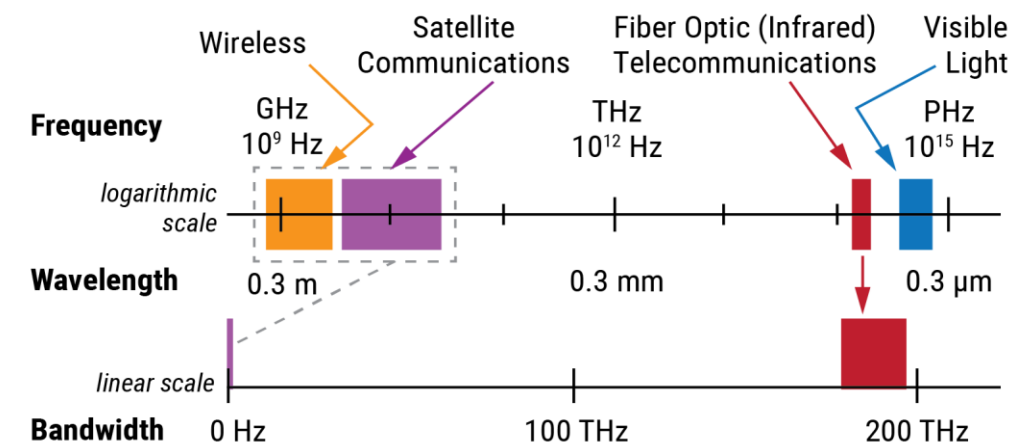
- Many recent NASA missions have produced large amounts of science data
- RF DSN and near-Earth networks are oversubscribed; this creates persistent communications bottlenecks for missions
- There is a need for high data rate uplinks for firmware or software updates and teleconferencing



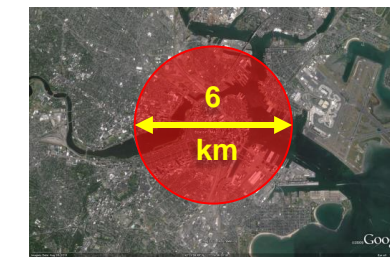
APPROACH

Lasercom provides:

- High data rate communications over long distances
- A large, unregulated spectrum
- Significantly reduced SWaP (size, weight, and power)
- Security (no interference, low probability to interception)



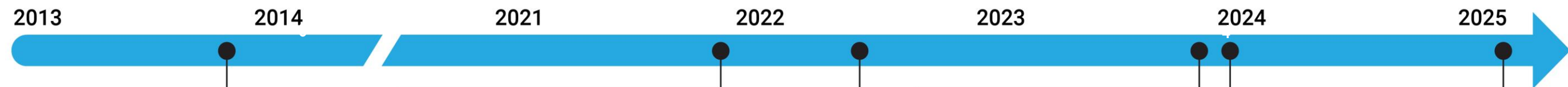
RF Ka Band (26 GHz)
75 cm Antenna



Optical C-Band (1550 nm)
10 cm Antenna

FUTURE WORK

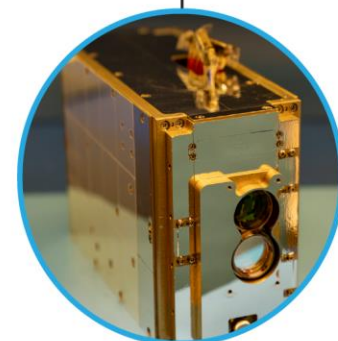
- Develop ground infrastructure to support high-rate lasercom links from LEO to deep space
- Proliferate lasercom technology to support space exploration missions—to the Moon, Mars, and beyond
- Make lasercom an integral part of near-Earth communications infrastructure



LLCD
Lunar Laser Communications Demonstration
622 Mbps downlink
20 Mbps uplink
Lunar-to-Earth



LCRD
Laser Communications Relay Demonstration
1.2 Gbps downlink
1.2 Gbps uplink
GEO-to-Earth and GEO-to-LEO

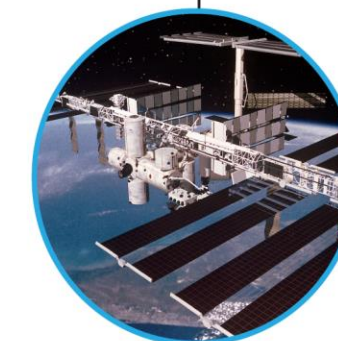


TBIRD
Terabyte Infrared Delivery
200 Gbps downlink
LEO-to-Earth

1



DSOC
Deep Space Optical Communications
Up to 267 Mbps downlink
Deep space



ILLUMA-T
Integrated LCRD LEO User Modem and Amplifier Terminal
155 Mbps downlink
1.2 Gbps uplink
LEO-to-GEO

2



O2O
Orion Artemis II Optical Communications System
260 Mbps downlink
20 Mbps uplink
Lunar-to-Earth

3

LEO: Low Earth Orbit GEO: Geostationary Orbit
RF: Radio Frequency DSN: Deep Space Network

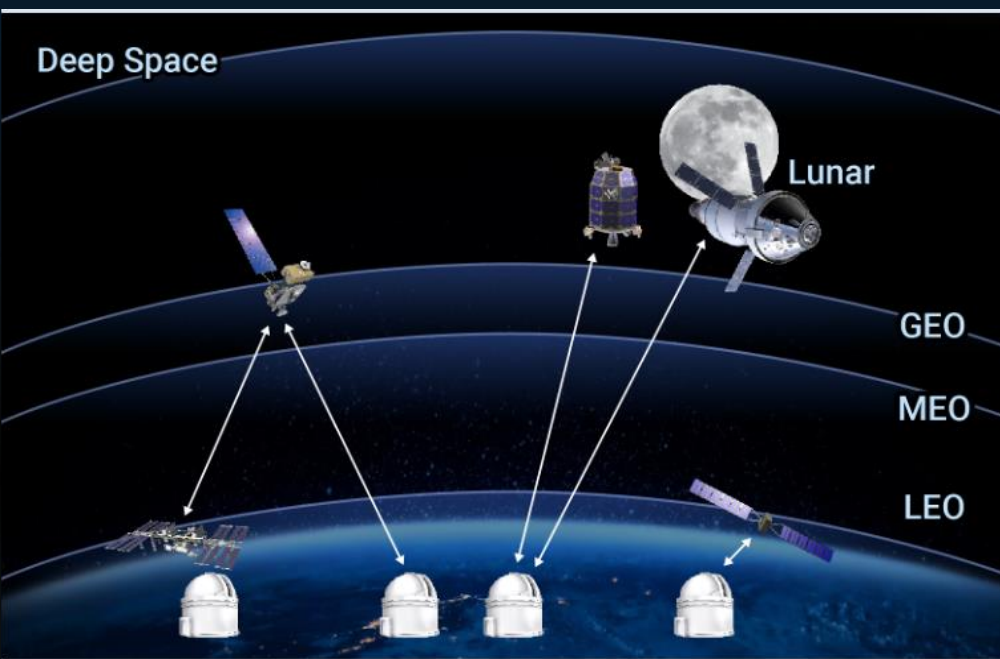
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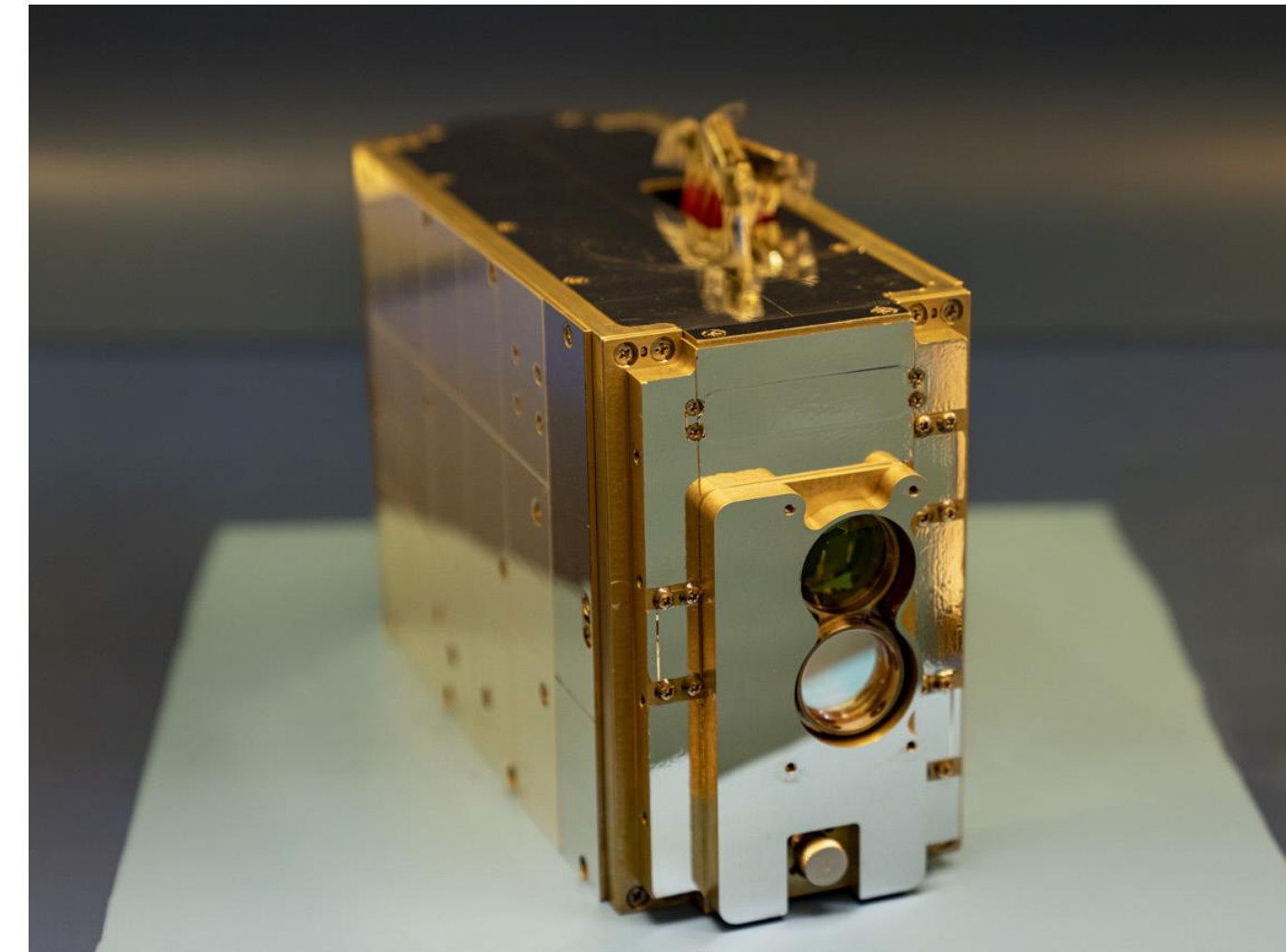
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TBIRD: TeraByte InfraRed Delivery

TBIRD is a lasercom payload on a 6U CubeSat currently operating in LEO.

- Launched in May 2022
- LEO-to-ground 200 Gbps downlink (more than 1000 times faster rate than RF links)
- Leverages COTS fiber telecom equipment
- Achieves robust data transfer through fading atmospheric channel
- Transfers large data volumes in a single few-minute pass (>4 TB)
- Demonstrates body pointing architecture with payload pointing feedback



COTS: Commercial off the Shelf

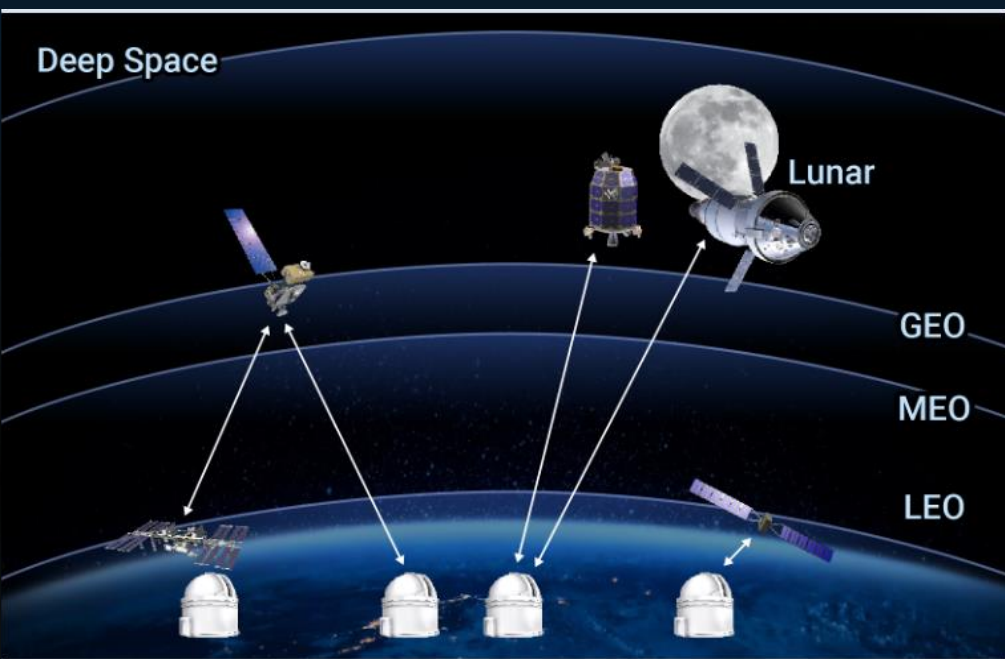
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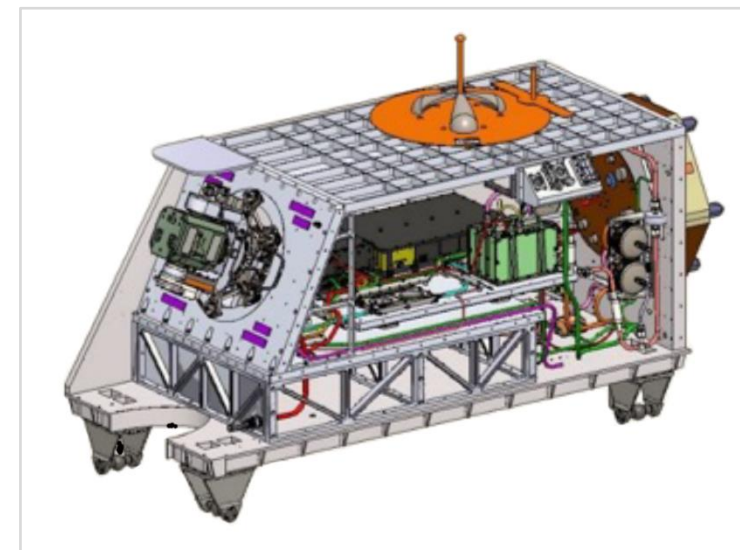
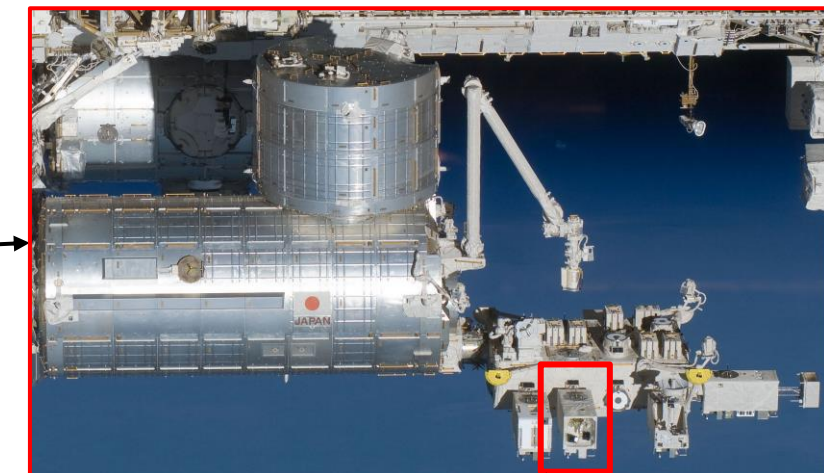
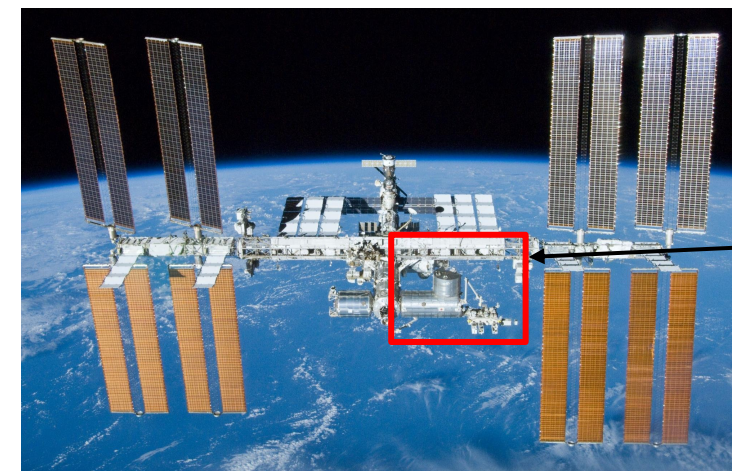
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ILLUMA-T: Integrated LCRD LEO User Modem and Amplifier Terminal

ILLUMA-T is a lasercom terminal currently installed on the International Space Station (ISS).

- Enables optical communications from the ISS to Earth via LCRD optical relay satellite in geostationary orbit
- Launched, installed, and successfully activated in November 2023
- Operated daily supporting multiple data transfers
- Multi-rate modem design provides 1.2 Gbps downlink and 155 Mbps uplink
- Developed in collaboration with NASA, MIT LL, and industry partners



4

ISS: International Space Center
LCRD: Laser Communication Relay Demonstration

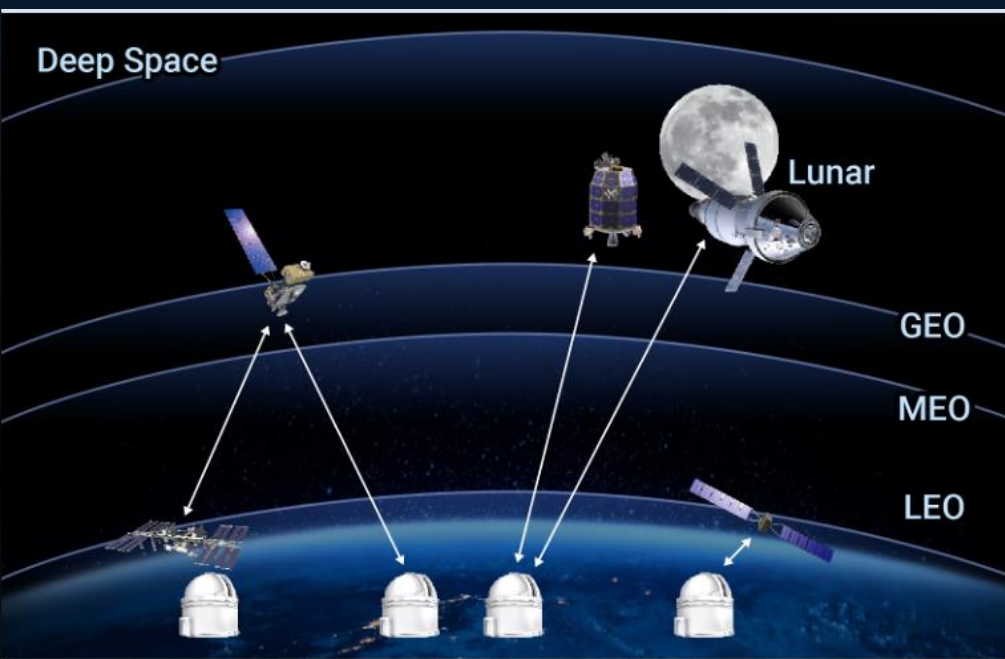
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O2O: Orion Artemis II Optical Communications System

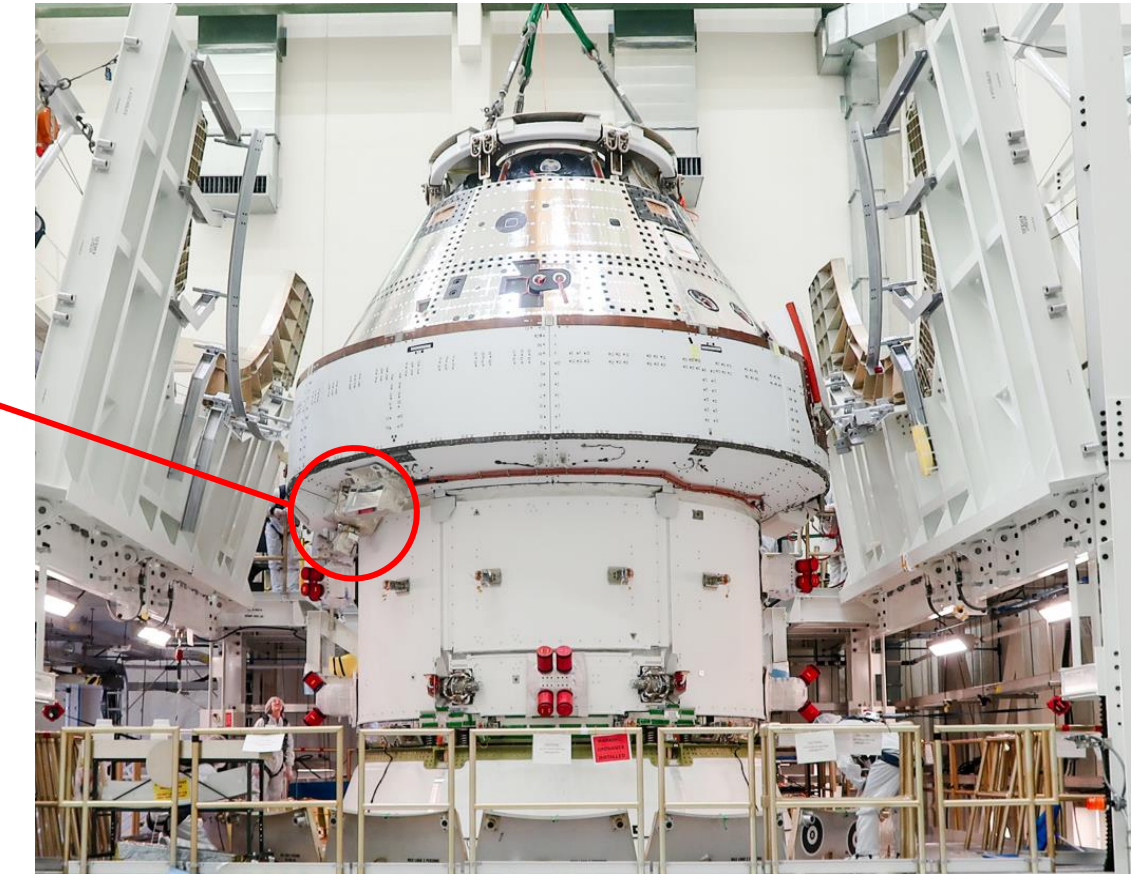
Artemis Mission is NASA's platform for human exploration of the Moon and Mars.

O2O is a laser communications system on the Orion vehicle supporting links between Earth and Lunar orbit.

- Provides teleconferencing, high-resolution image and video transfers, and other high-volume science data
- Up to 260 Mbps downlink and 20 Mbps uplink
- Supported by two ground terminals
- Mission scheduled to launch in 2025



4



O2O terminal delivered to KSC and installed on Orion vehicle



NASA JPL Ground Terminal
Table Mountain, Wrightwood, CA



MIT LL Ground Terminal
White Sands, NM

KSC: Kennedy Space Center
JPL: Jet Propulsion Laboratory

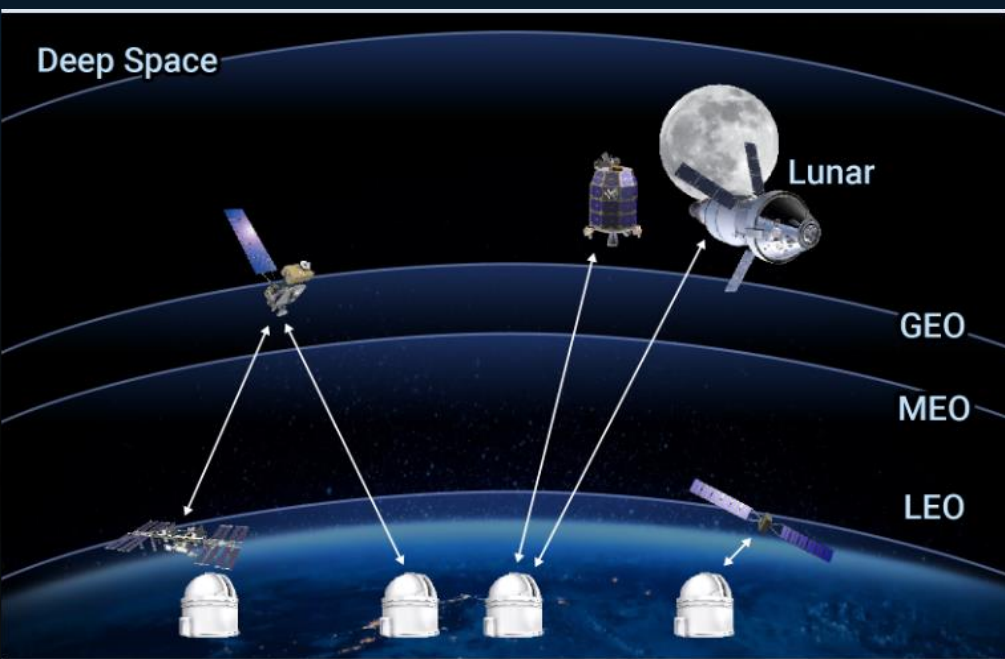
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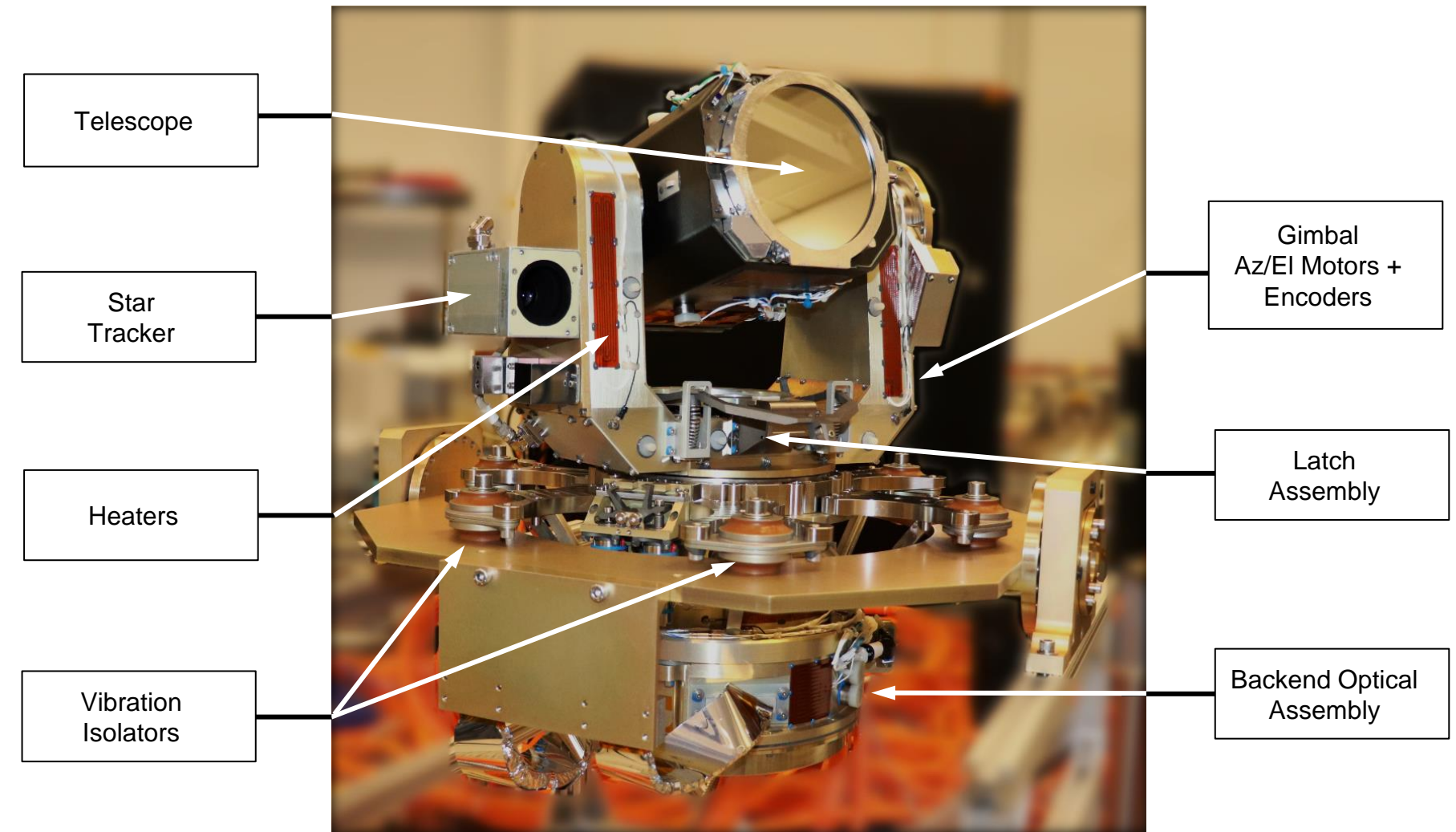
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MAScOT: Modular, Agile, Scalable Optical Terminal

MAScOT is an MIT LL–developed optical module that points laser beams and launches optical signals for free space propagation.

- Two-axis gimbal for a wider field of regard
- 10 cm aperture telescope used for both uplink and downlinks
- Modular design that is easily adapted to different lasercom missions



GENERAL INSTRUCTIONS

SLIDES

Use slide 2 as the foundation for your poster, and then duplicate slide 3 for expanded content. Slides 2 and 3 are instructional and are meant to be replaced by the author's content using the styles shown. Blank versions of slides 2 and 3 are included at the end of this file.

GENERAL LAYOUT

This poster has two main sections:

- The panel to the left that holds a persistent overview comprises the poster branding, a title, a list of authors, an overview graphic, and a summary
- The majority space on the right is where the research content is displayed and your story is told

TYPOGRAPHY

Please keep to the styles used—specific styles were created for the title, authors, headings, subheadings, general text, bullets etc.

Please do not change the font sizes—these are intentional. If you do not have enough space for your text or graphics, consider using an expanded content page.

EXPANDED CONTENT



If you need more space beyond the home screen to further elaborate on a point, present a video, or zoom in on a diagram or chart, you can create a separate page for that content and link to it via an expanded content button (indicated by a numbered circle).

Expanded content buttons are repeated for accessibility in the lower left corner of the poster. You may not need any of these buttons, but if you do, try to limit them to no more than four.

GRAPHICS

This poster will be able to display many types of graphics, including:

- Images (photos)
- Videos (try to keep these under 30 seconds for time/size)
- Diagrams (illustrations)
- Data plots (outputs from Matlab or simple charts)
- Tables (tabulated data)

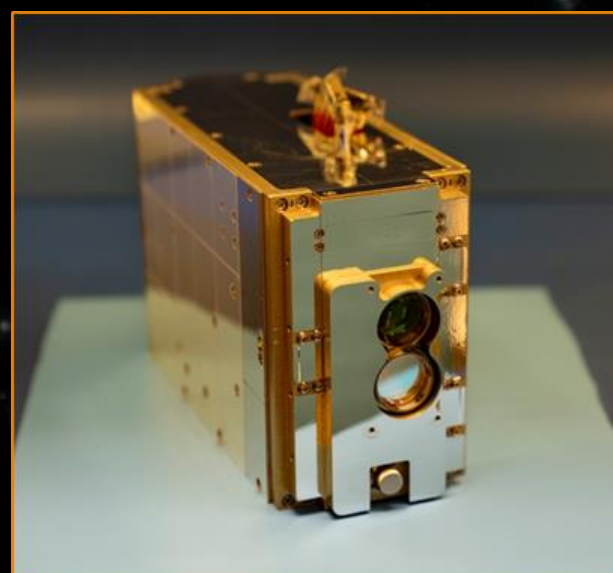
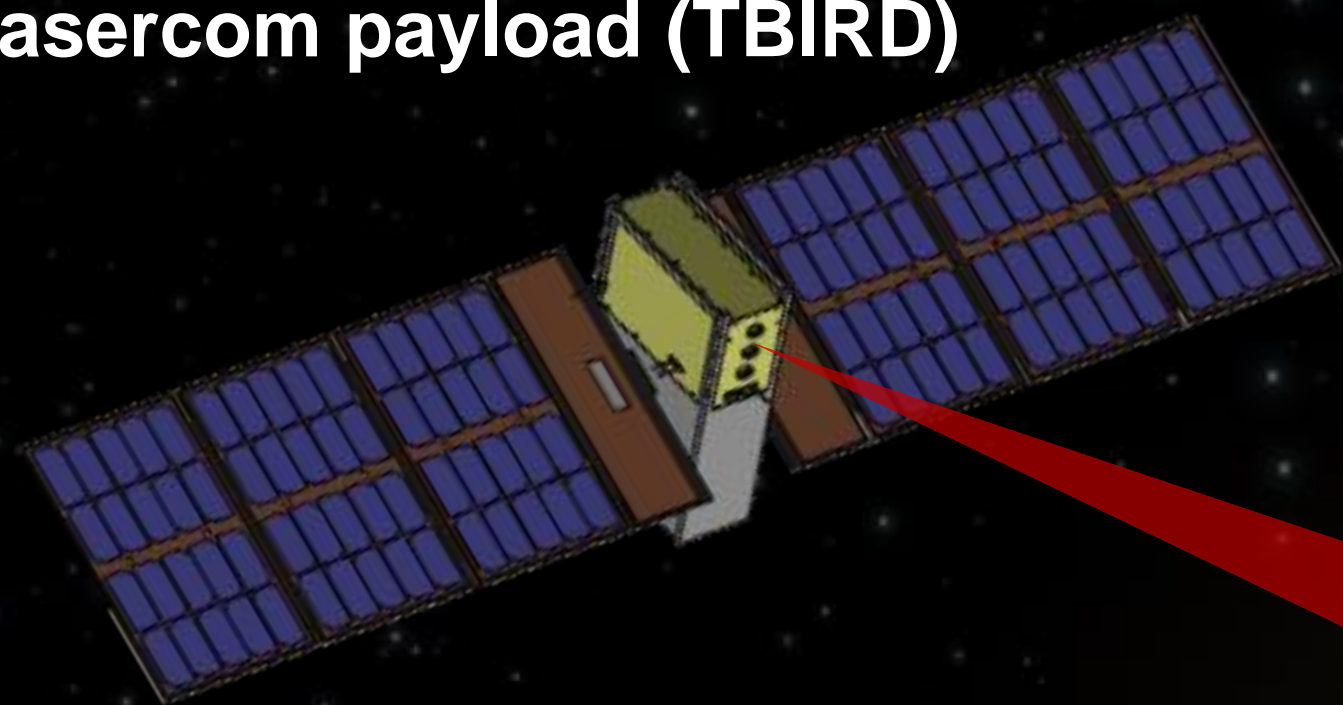


Terabyte Infrared Delivery (TBIRD) Mission



6U CubeSat in LEO (PTD-3)
3U Lasercom payload (TBIRD)

- TBIRD is payload of NASA Pathfinder Technology Demonstrator 3 (PTD-3) mission
- Leveraged fiber telecom equipment for 200 Gbps burst delivery (TBs per pass)
- Achieved robust data transfer through atmospheric channel
- Demonstrated body pointing architecture with payload pointing feedback



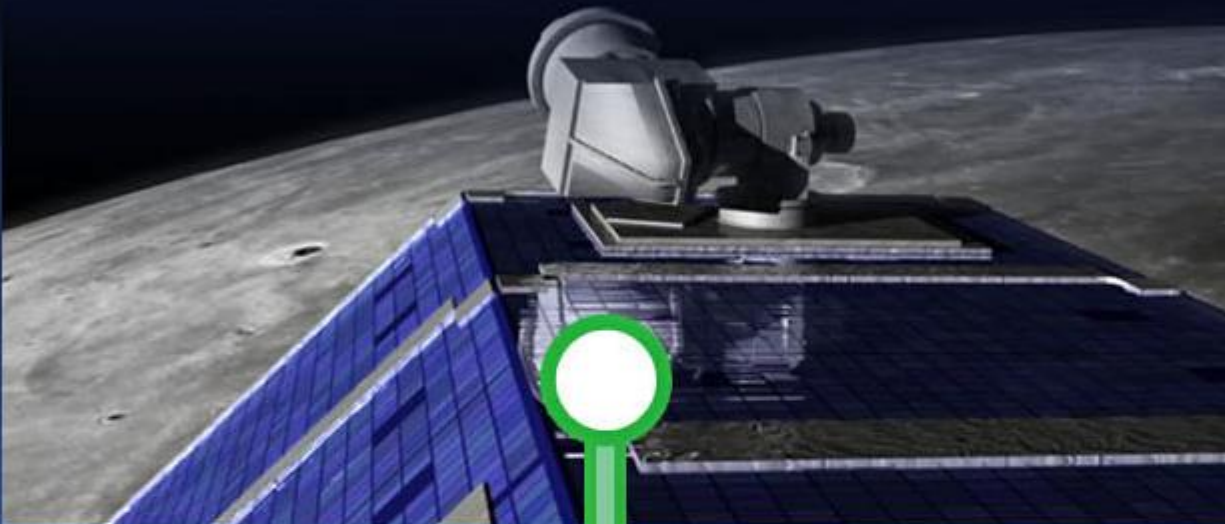
200 Gbps downlink



Ground terminal at JPL's
Optical Communication
Telescope Laboratory (OCTL)
in Southern California

LLCD

Lunar Laser Communications Demonstration



DSOC

Deep Space Optical Communications



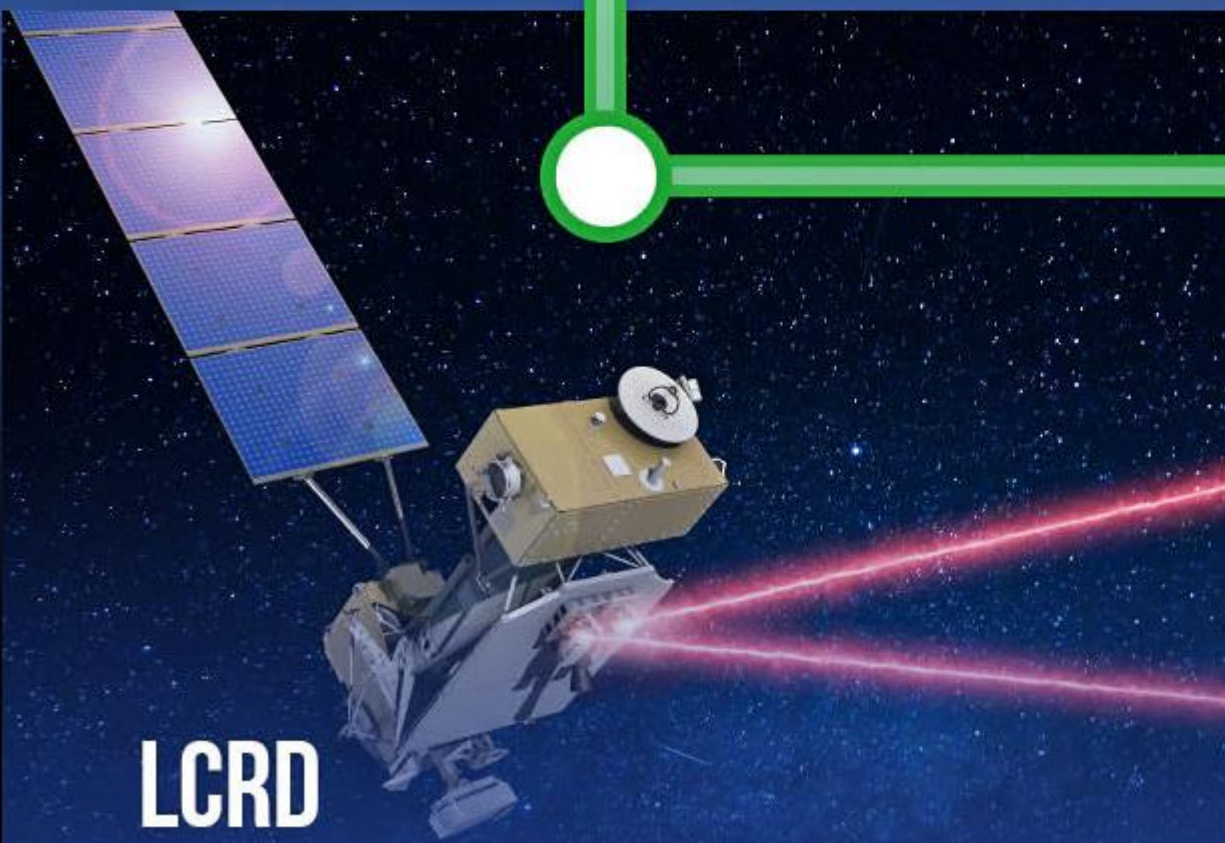
ILLUMA-T

Integrated LCRD LEO User Modem and Amplifier Terminal



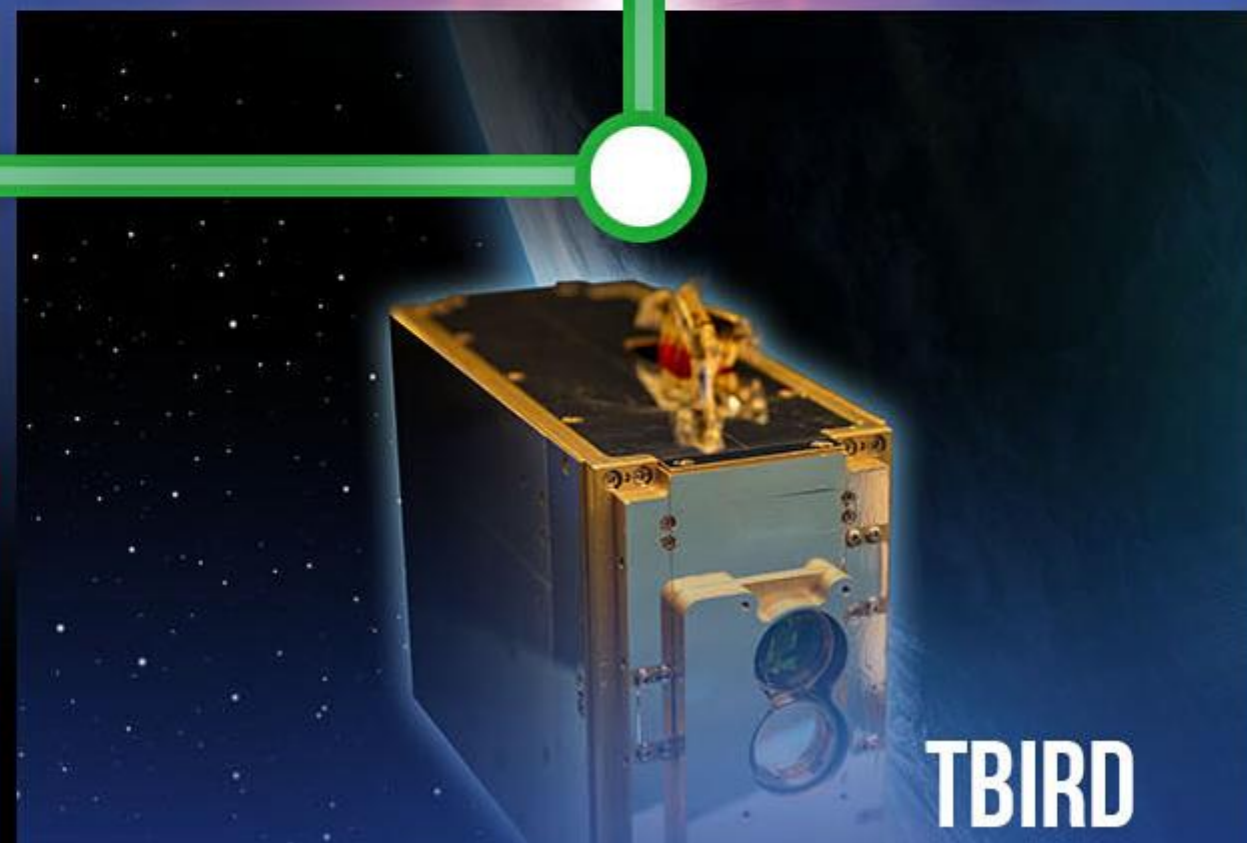
LCRD

Laser Communications Relay Demonstration



TBIRD

TeraByte InfraRed Delivery

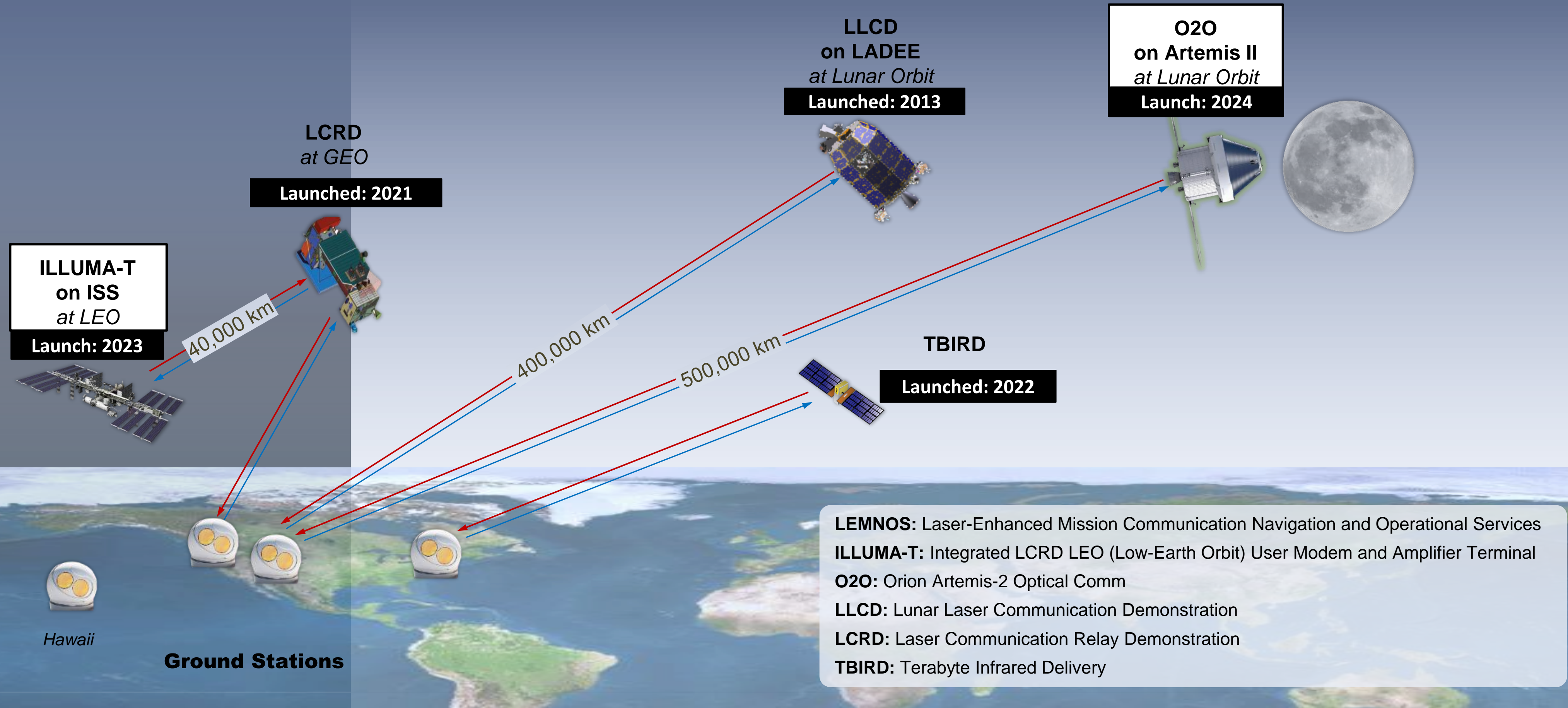


020

Orion Artemis II Optical Communications System

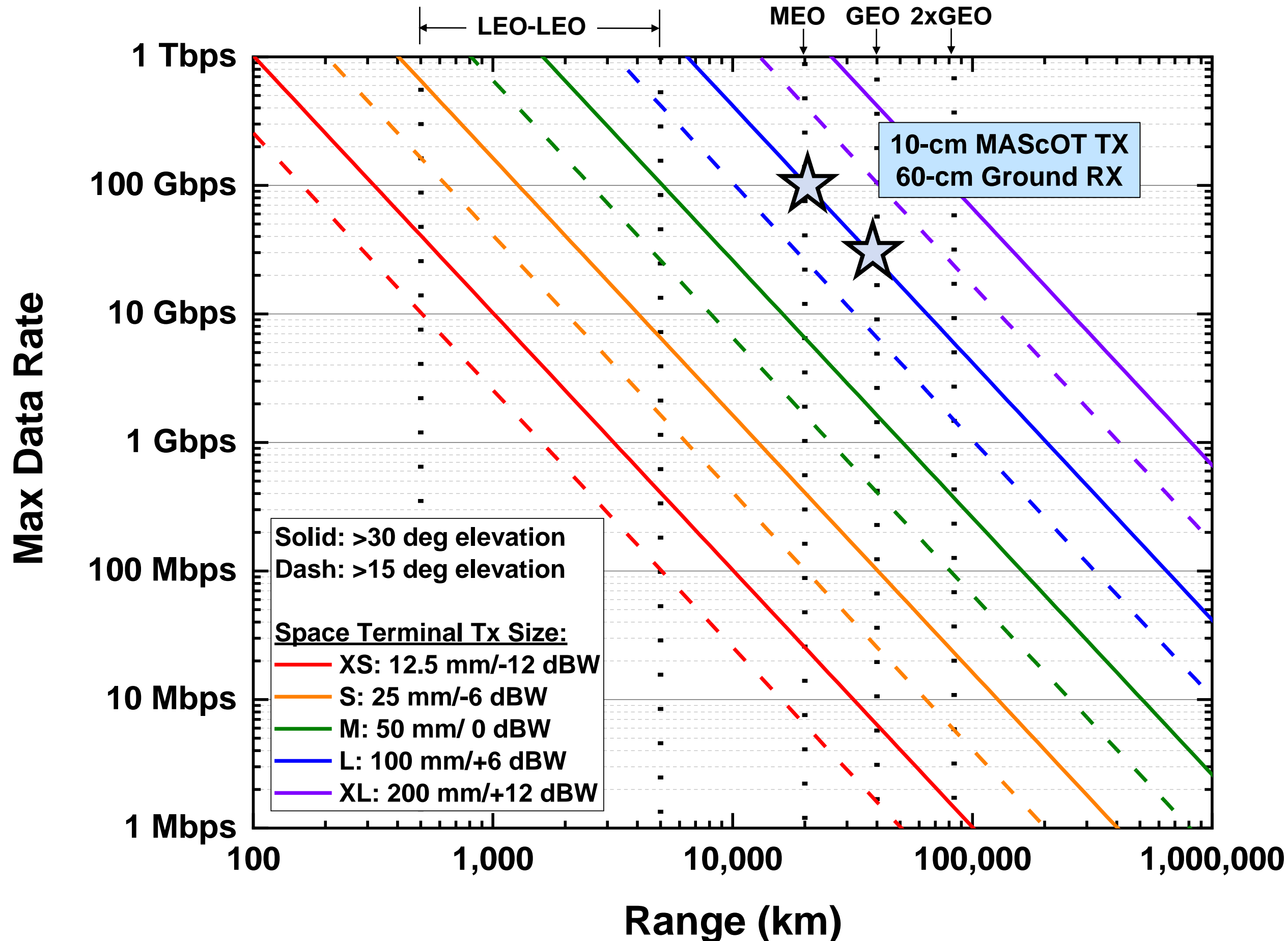


NASA / MIT LL Lasercom Demonstrations



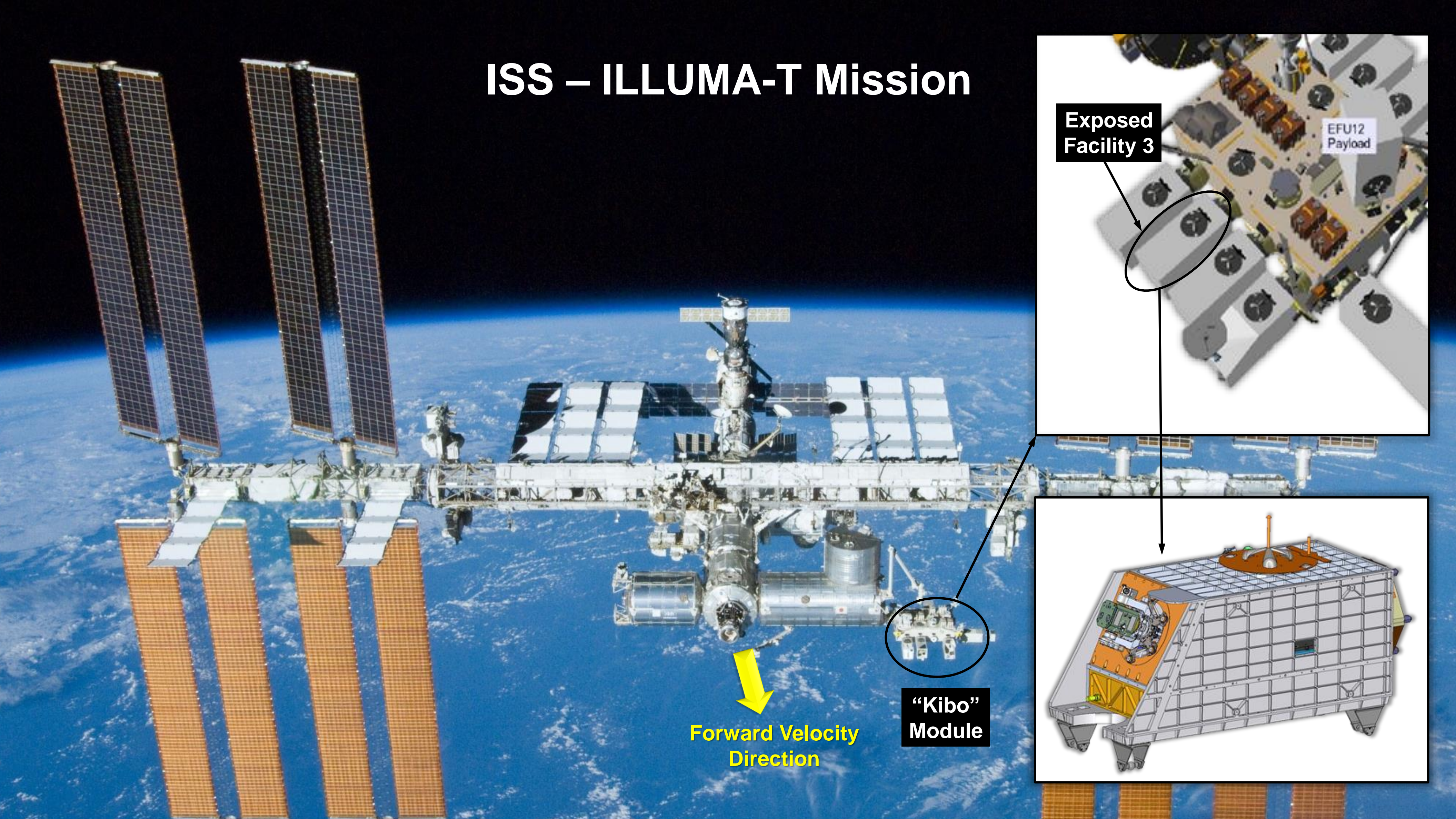


Downlink: Curves of Constant Link Efficiency



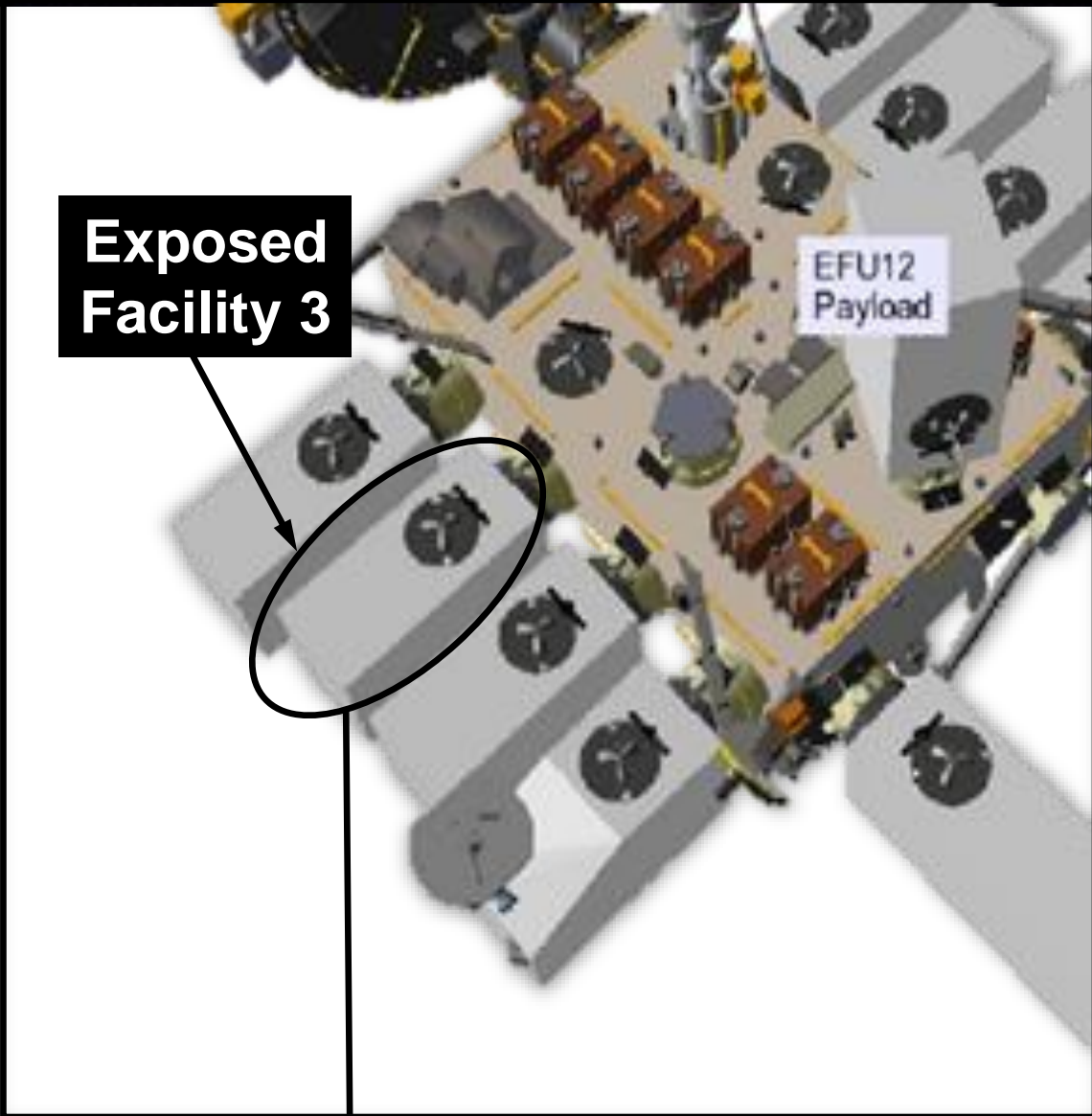
- **Ground Rx**
 - 600 mm Rx aperture
 - Adaptive Optics
- **BPSK/QPSK with coherent Rx**
 - Rate 0.87, 7.5 dB ppb
- **Link parameters**
 - Loss and margin allocations: 16 dB
 - Channel/turbulence losses:
 - 5 dB at 30 deg elevation
 - 11 dB at 15 dB elevation

ISS – ILLUMA-T Mission

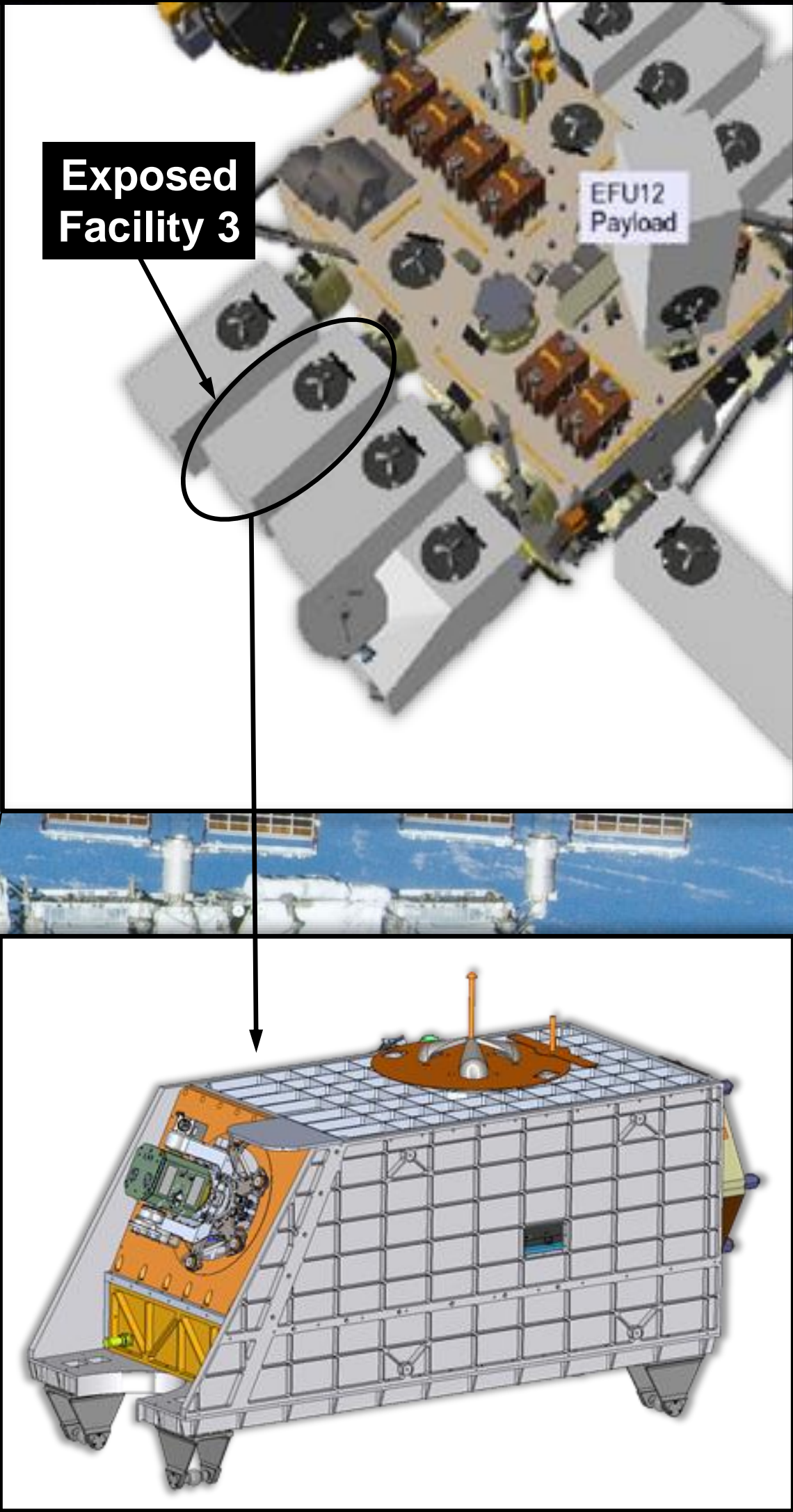
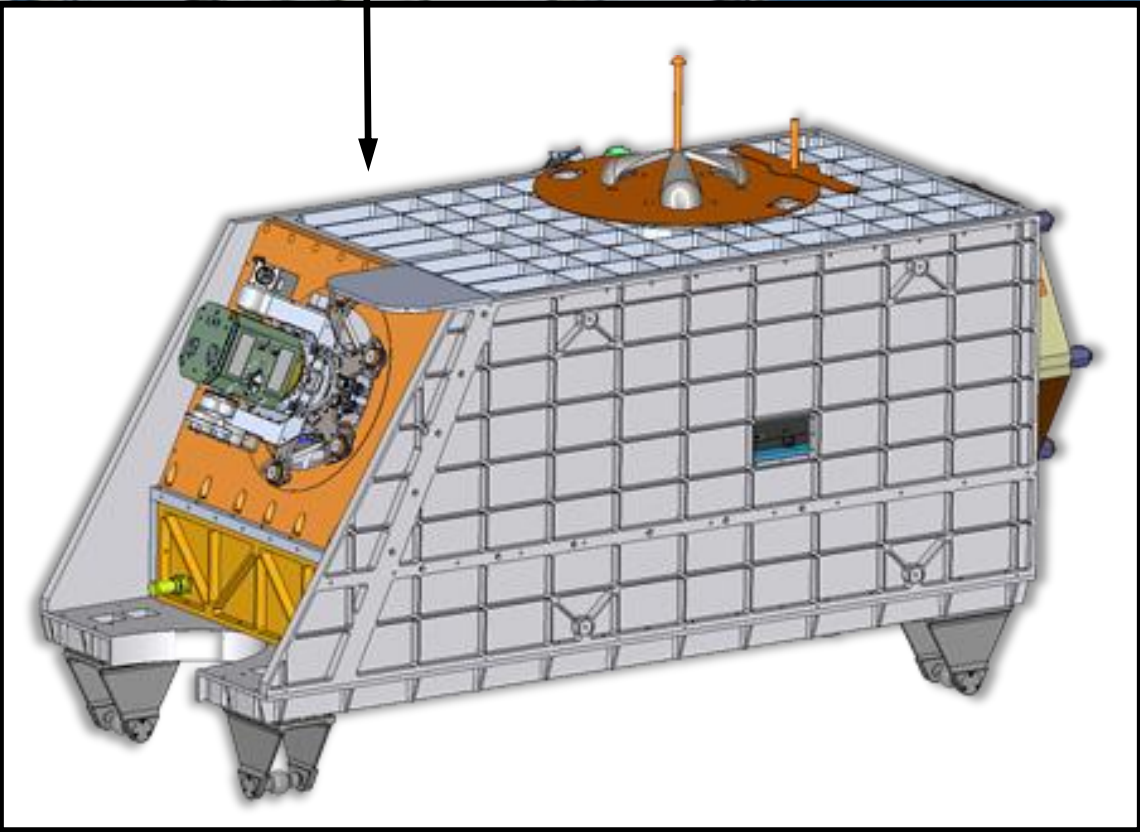


Forward Velocity
Direction

“Kibo”
Module



Exposed
Facility 3





Artemis II Mission – O2O

O2O **(Orion EM2 Optical Com)**

- Provides 80 Mbps downlink for Orion
- Provides 20 Mbps uplink

