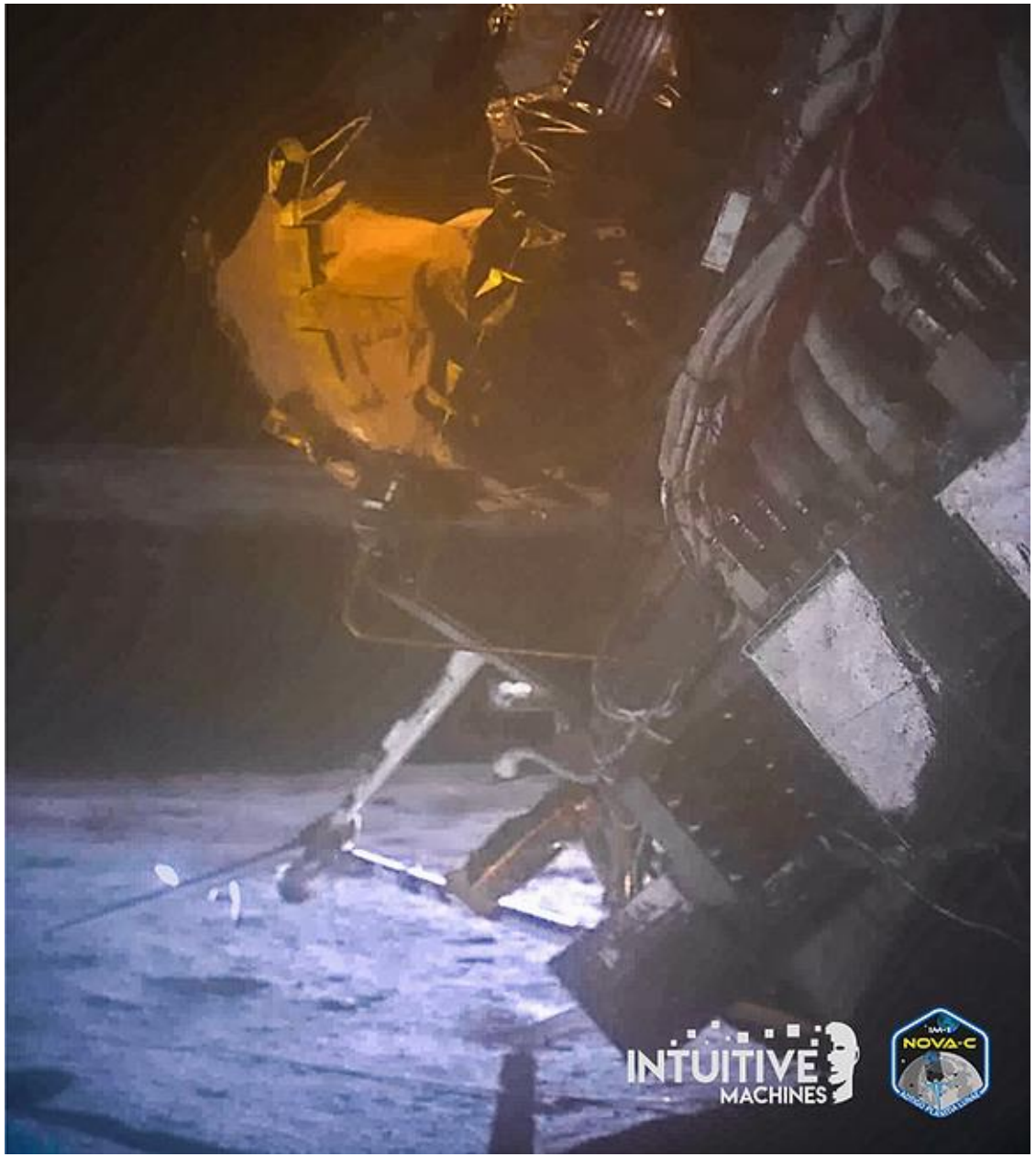

Intuitive Machines Odysseus Lander on the Moon

The Dawn of Radio Astronomy from the Moon: ROLSES on the Odysseus Lander

Professor Jack O. Burns
University of Colorado Boulder
on behalf of the ROLSES team
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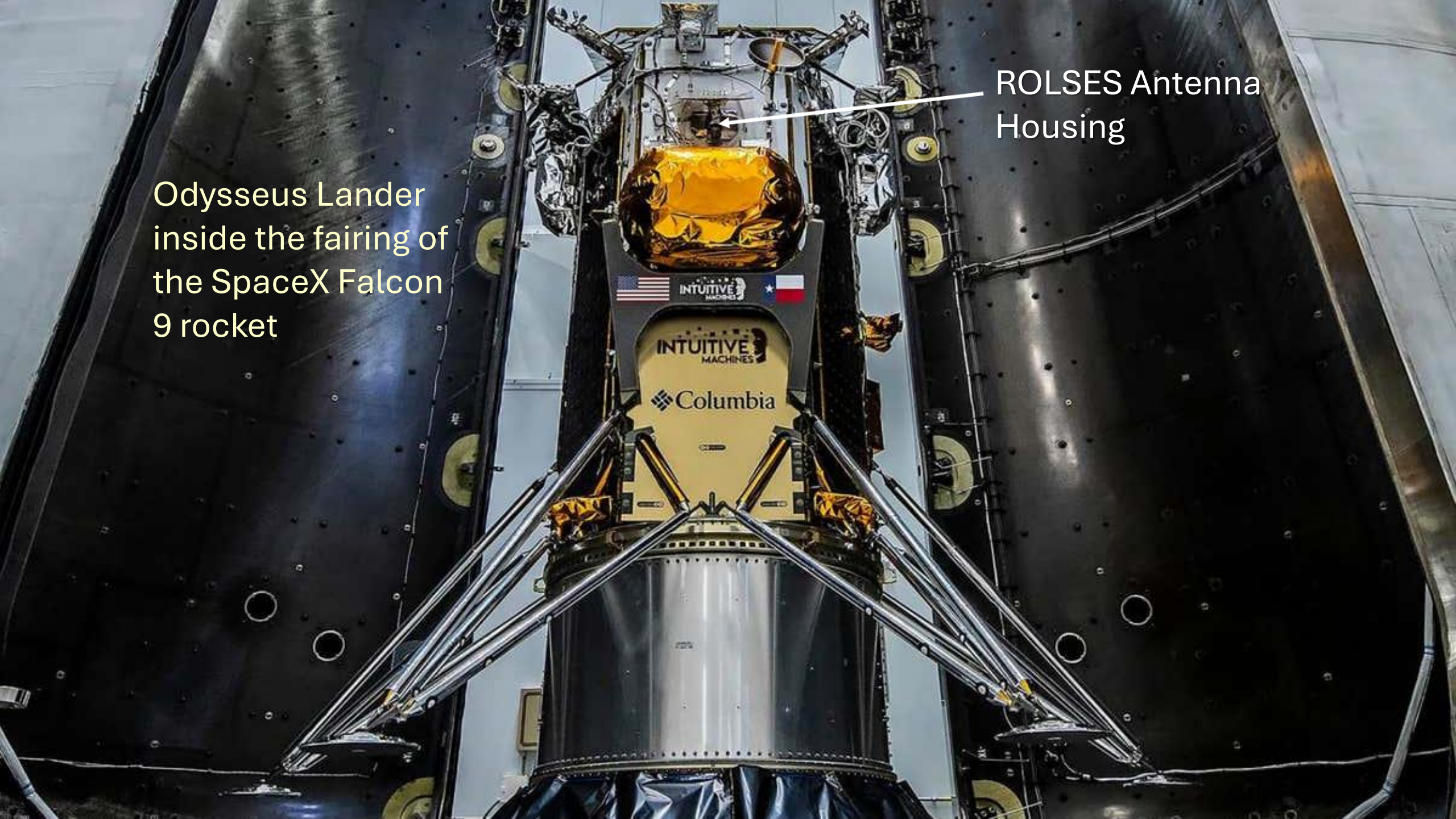
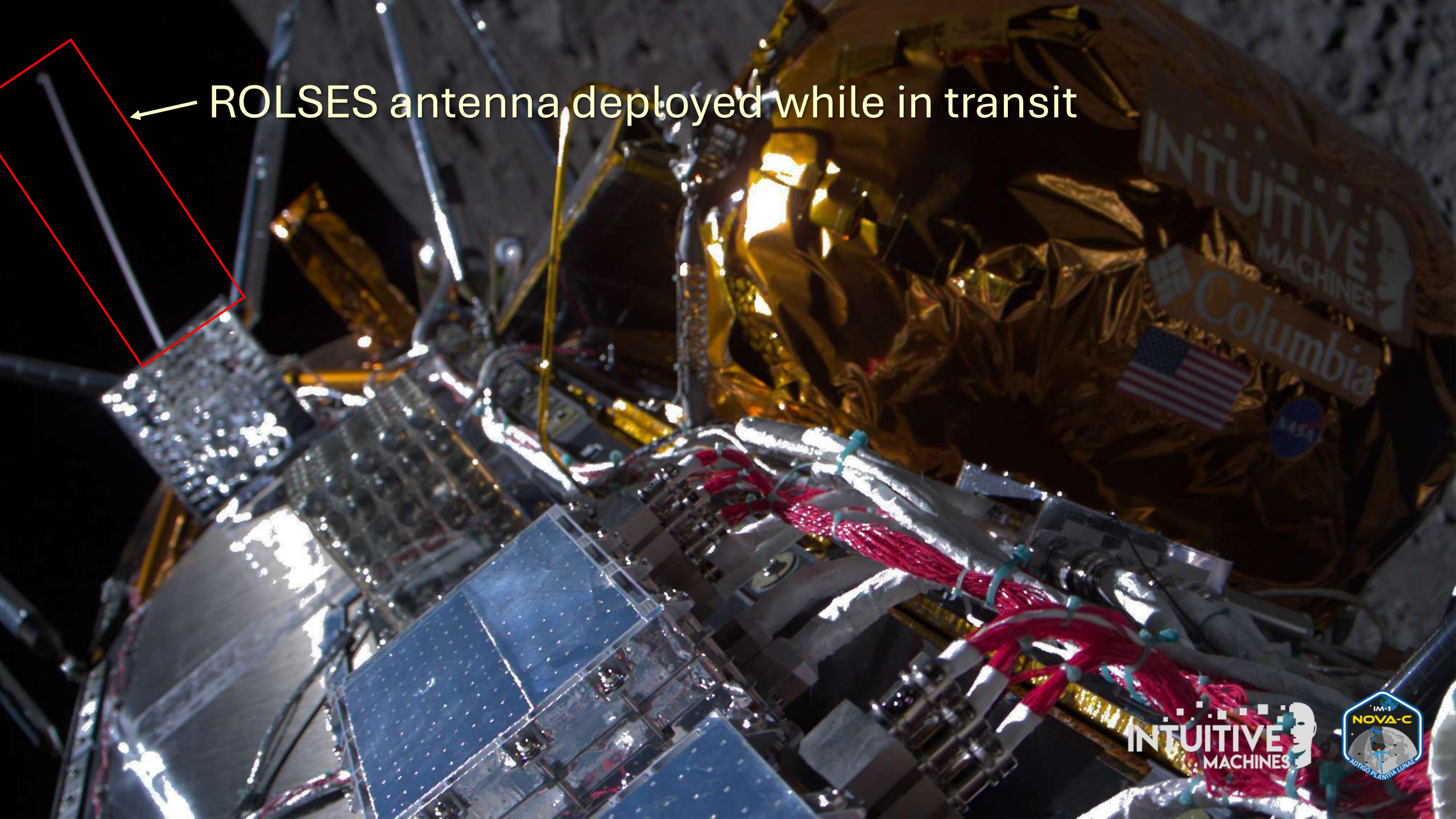
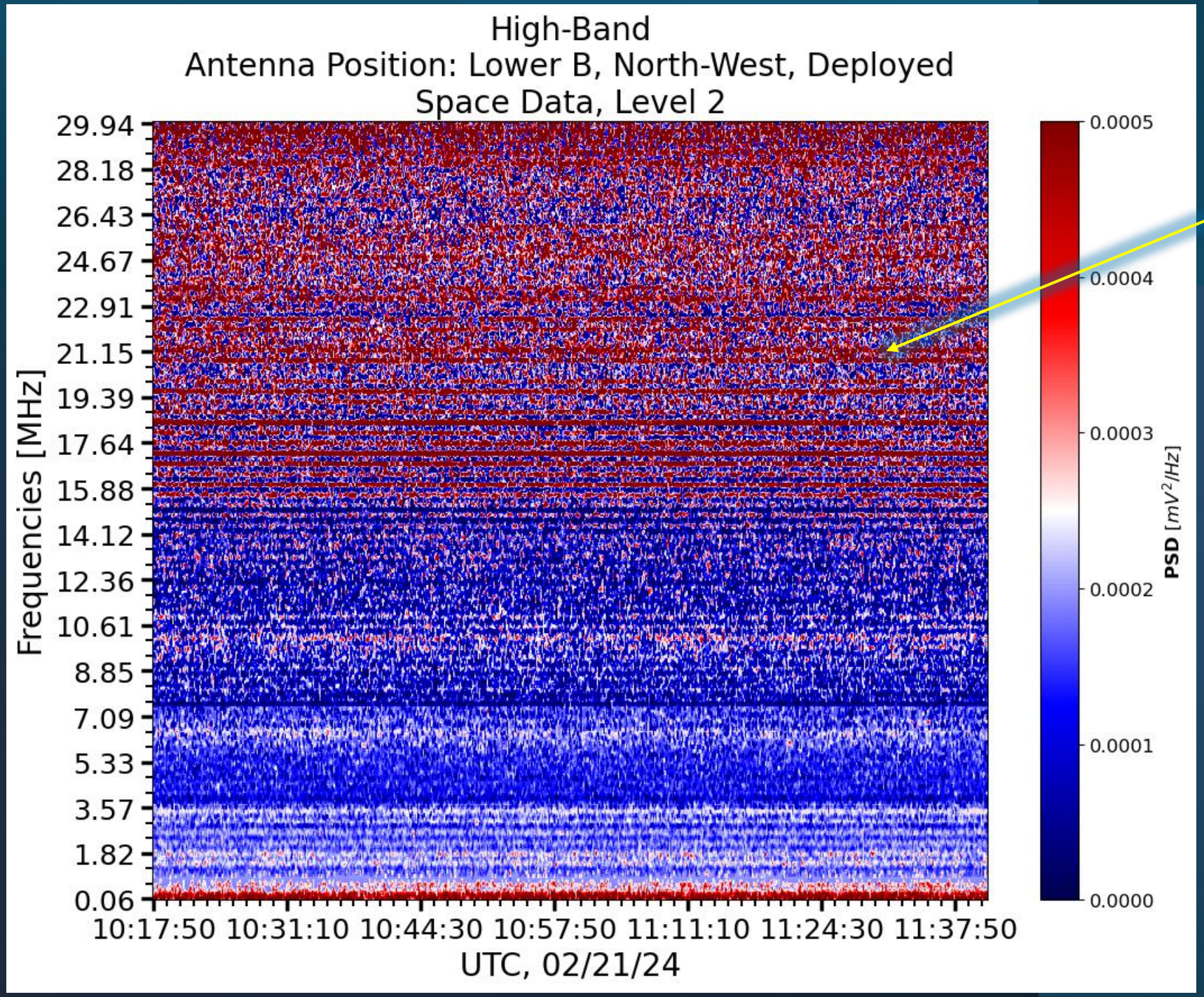

ROLSES Antenna Housing
Odysseus Lander inside the fairing of the SpaceX Falcon 9 rocket
INTUITIVE MACHINES
INTUITIVE MACHINES
Columbia


Launch 15 February 2024
Landing 22 February 2024
SPACEX

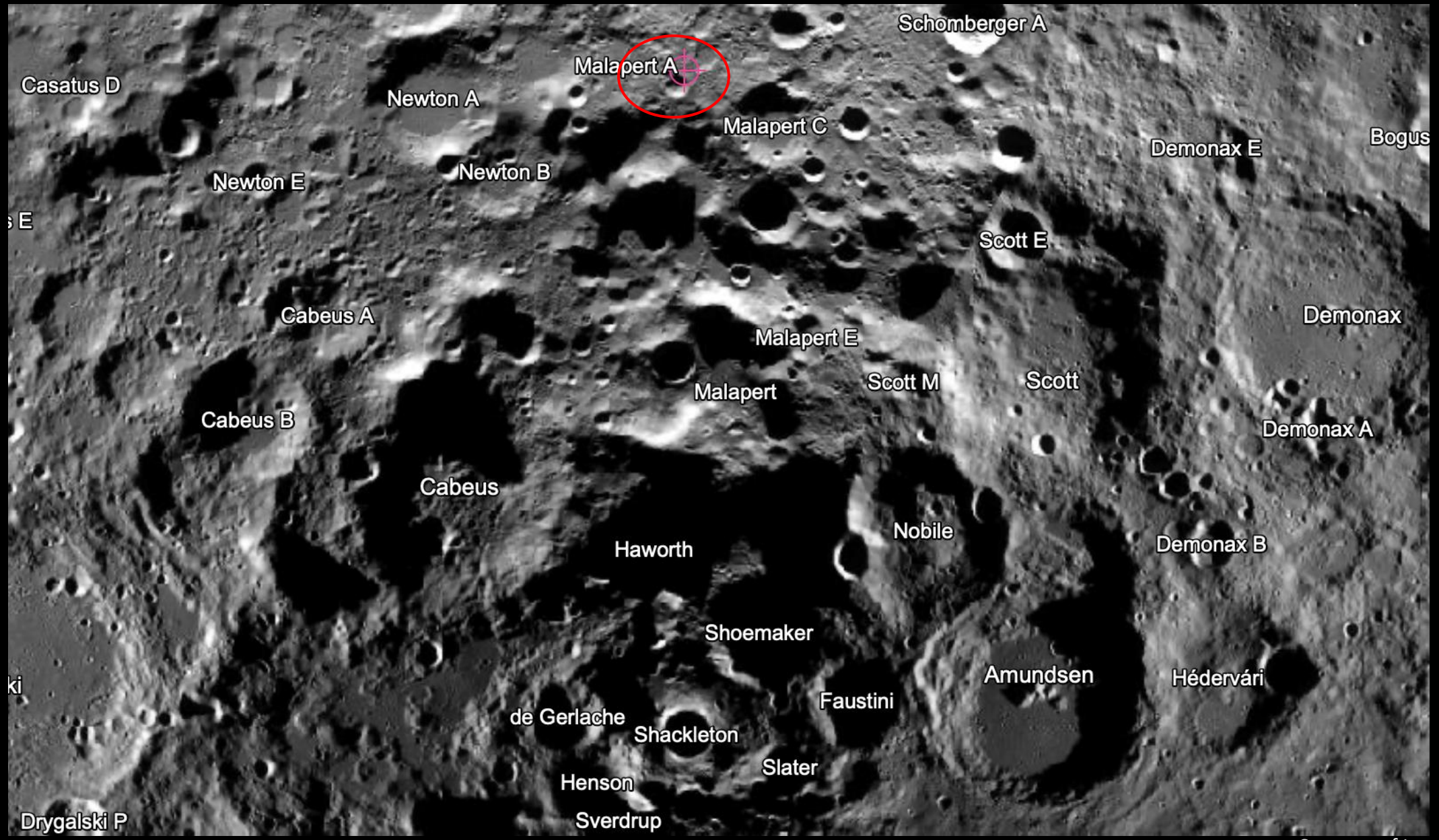
Deployment of Odysseus Lander from SpaceX second stage rocket


ROLSES antenna deployed while in transit
INTUITIVE MACHINES
Columbia
IM-1
NOVA-C
ADTIGO PLANITIA LUNAE



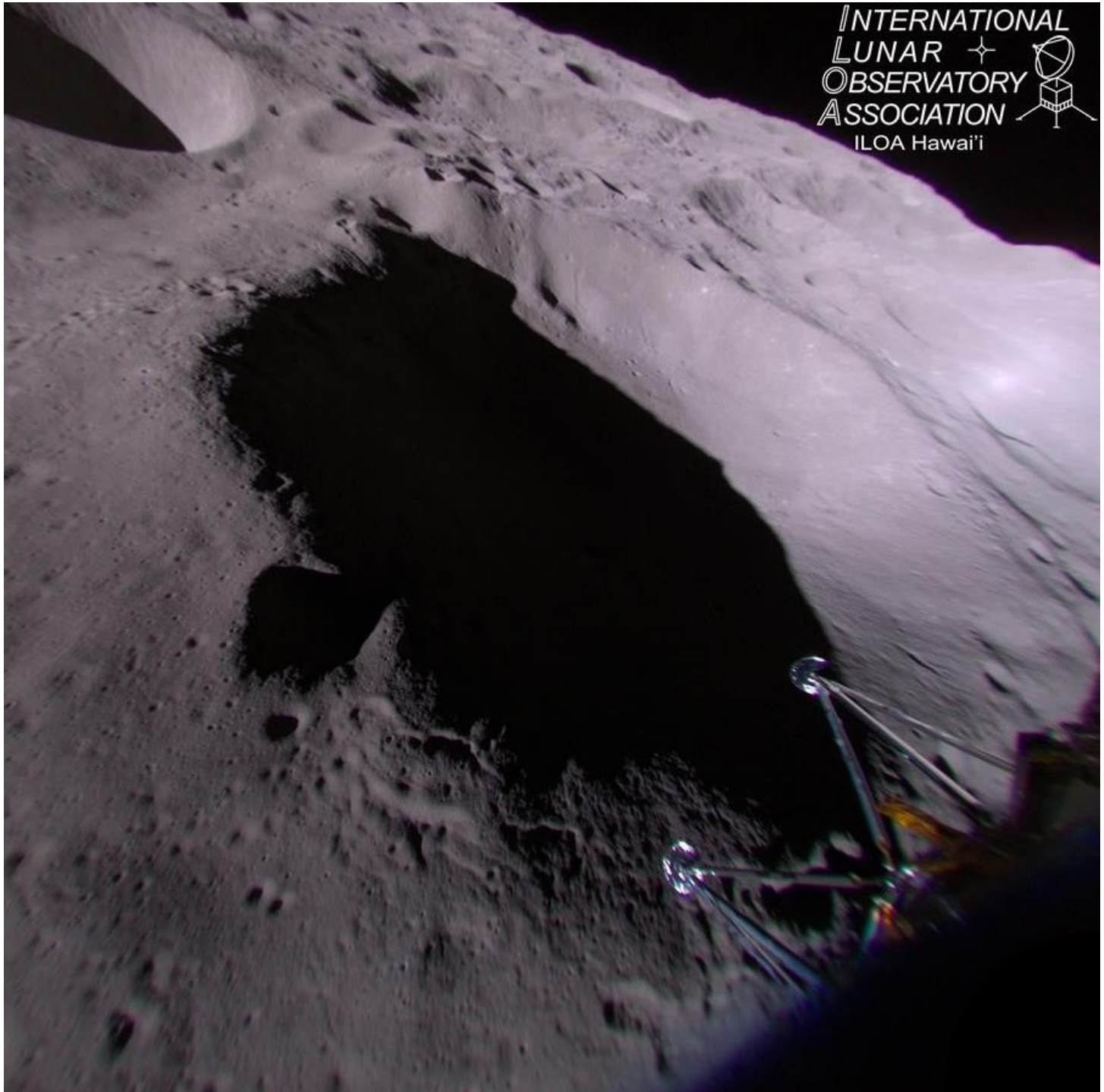
Terrestrial transmissions breaking through the ionospheric plasma

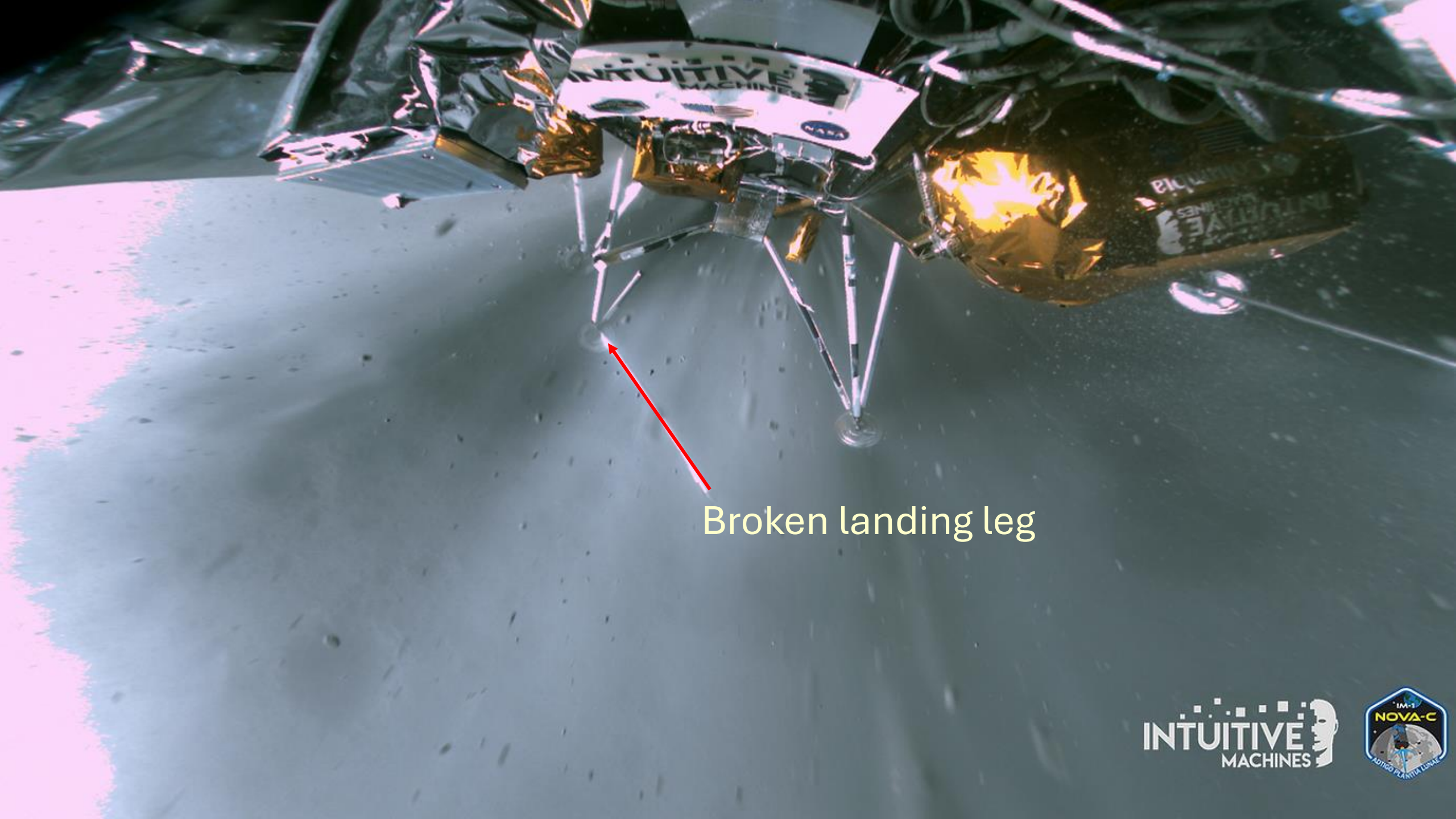
IM-1 LANDING SITE – THE MOON'S SOUTH POLE



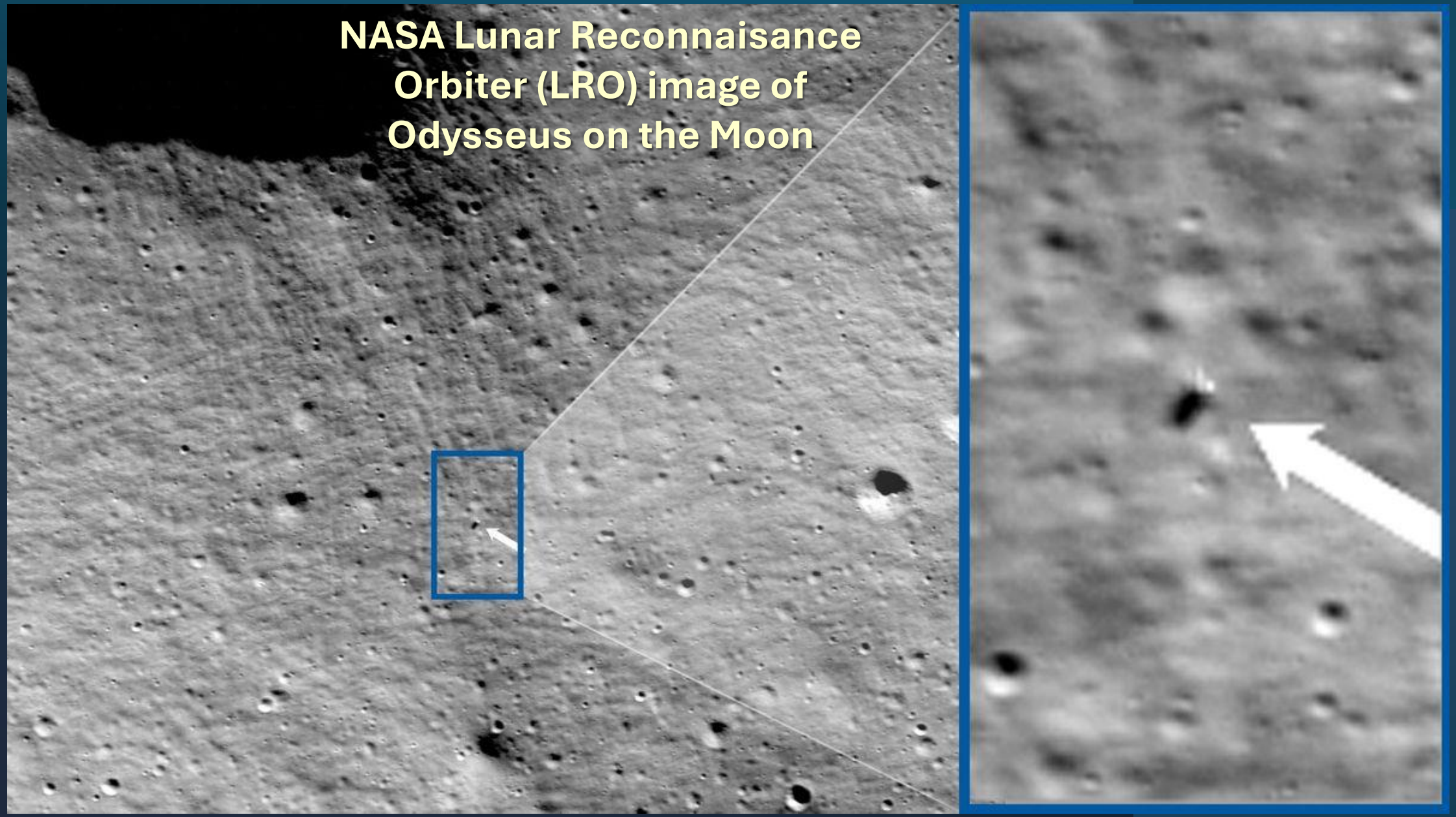
Courtesy of Intuitive Machines

Landing Approach

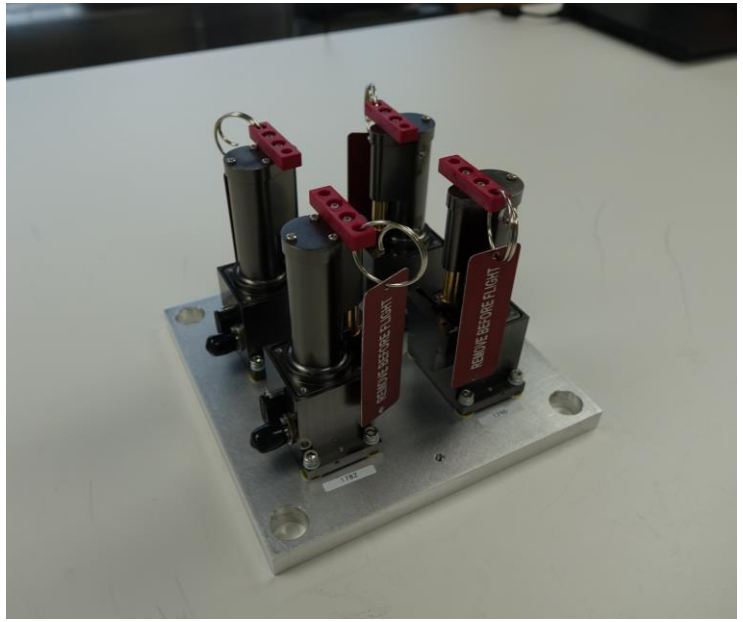



Broken landing leg

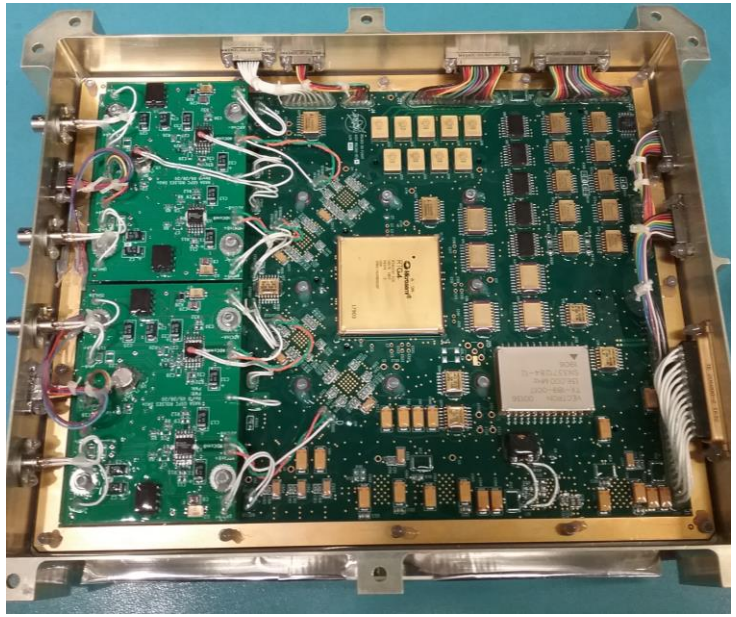
On the surface - Tilted


NASA Lunar Reconnaisance Orbiter (LRO) image of Odysseus on the Moon

IM-1 with ROLSES antennas deployed



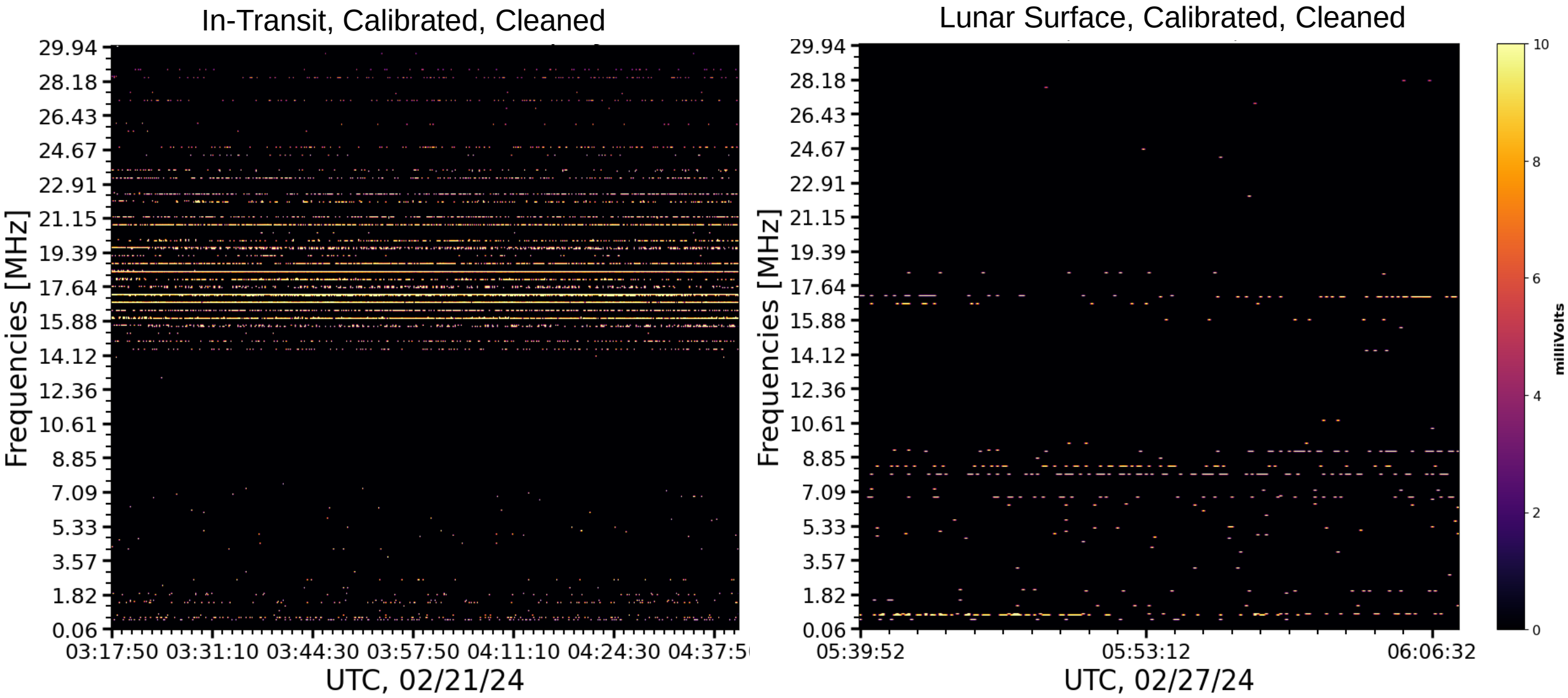
Stowed STACER antennas



ROLSES spectrometer board

Radio wave Observations at the Lunar Surface of the Electron Sheath (ROLSES)

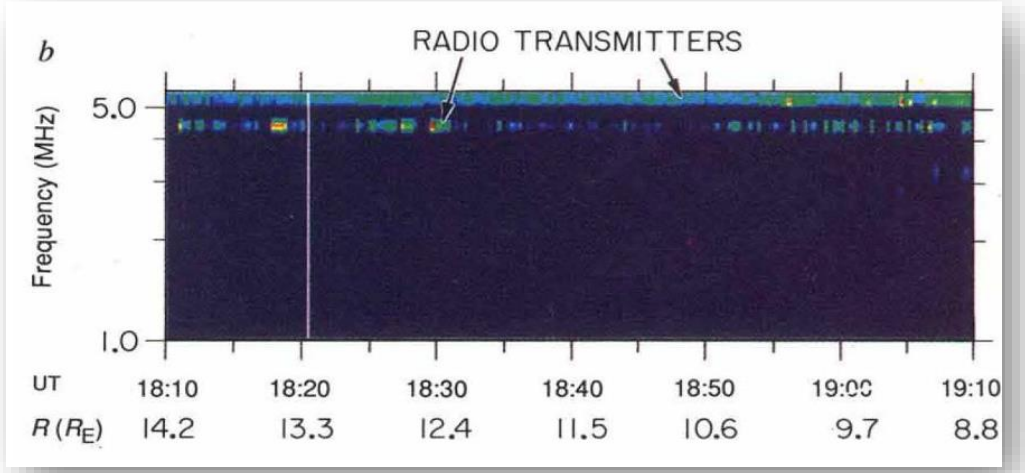
- ROLSES Team: N. Gopalswamy (PI), R. MacDowall, W. Farrell, J. Burns, D. Bradley, M. Reiner, E. Wollack, D. McGlone, M. Choi, S. Murphy, R. Katz, I. Kleyner, D. Rapetti, J. Hibbard, J. Dorigo Jones.
- ROLSES instrument is a new build with heritage from NASA SMAP Earth Remote Sensing satellite:
  - Four 2.5-m monopole antennas.
  - Radio spectrometer with 2 bands: 2 kHz – 1 MHz and 300 kHz – 30 MHz.



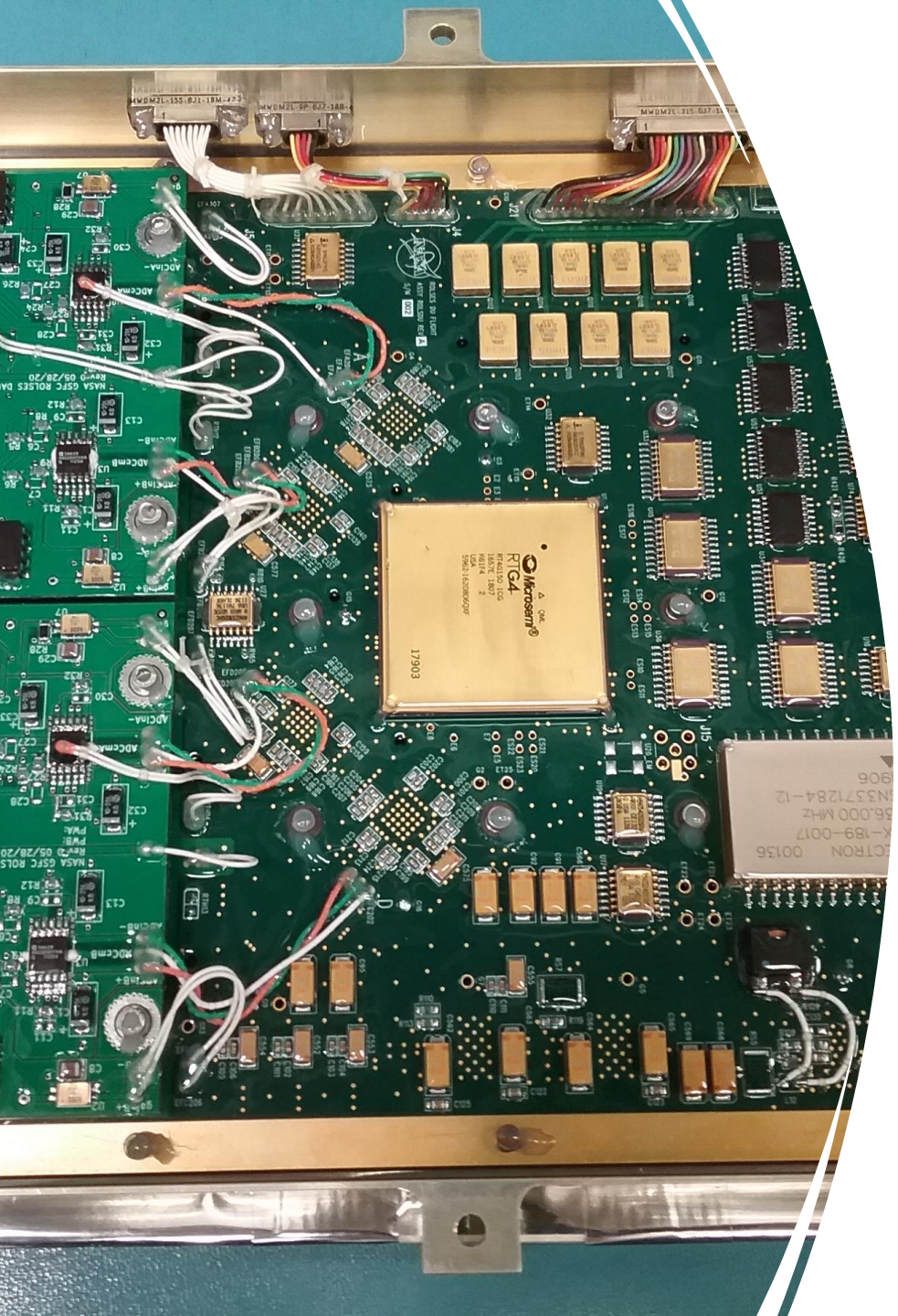
Clear, good Signal-to-Noise measurements of Human-made Earth Transmissions

ROLSES is Updated Sagan SETI Experiment on Galileo

- As part of a “control experiment”, Sagan *et al.* (1993, *Nature*, 365, 715) identified narrow-band 4-5 MHz transmissions from Earth during Galileo fly-by attributed to “intelligence”.



- With ROLSES, we can update & extend this SETI prototype experiment with multiple advantages:
  - ROLSES time-resolution is 8 seconds compared to 18.7 seconds for Galileo
  - Broader bandwidth with ROLSES that is well above Earth’s plasma frequency.
  - Perspective from the distance of the Moon gives us a full hemisphere view of Earth.
  - ROLSES provides a comparison spectrum of Earth ground-truth to use with observations of nearby exoplanets with the **FARSIDE** radio array.



Lessons Learned & Upgrades for ROLSES-2

ROLSES-2 assigned to the CP-21 CLPS manifest, Gruithuisen Domes on lunar near side, in 2026

- Upgrade antenna actuator for higher temperatures.
- Internal Cal source to monitor gain variations.
- Improved shielding from internal interference.
- 4 antennas operate as cross dipoles to measure polarization.
- Consider using LuSEE-Night radio beacon for beam calibration?

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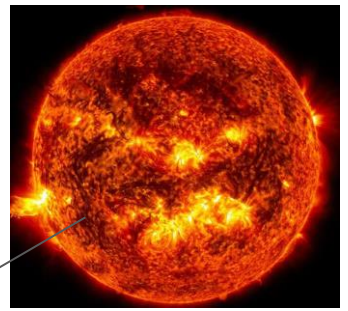
Center for Astrophysics & Space Astronomy
University of Colorado Boulder
Boulder, CO 80516
jack.burns@colorado.edu

Supplemental Slides

Earth-Moon-Sun orientation diagram during ROLSES in-transit observations:

2/21/2024, 03:17-04:37 UTC
=2/20/2024, 21:17-22:37 CST

First quarter, 2/17-2/18



Waxing gibbous, 2/21 (~90% illumination)

ROLSES

The Moon passed the meridian of Chicago, IL @21:39 CST on 2/20, and the meridian of Dallas, TX @22:17 CST on 2/20.
→ **ROLSES was directly above CST (~10PM local time) during the in-transit observations**

Full moon, 2/24-2/25

ROLSES Science Goals

- Determine the electron sheath density from ~1 to ~3 m above the lunar surface by measuring electron plasma frequency ($\upsilon_{pe} \propto n_e^{1/2}$).
- Demonstrate detection of solar, planetary, & other radio emission from lunar surface.
- Measure Galactic spectrum at <30 MHz.
- Aid development of lunar radio arrays.
- Measure the local EM environment, including that from the lander.
- Measure reflection of incoming radio emission from lunar surface and below.