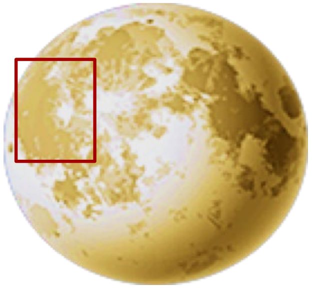
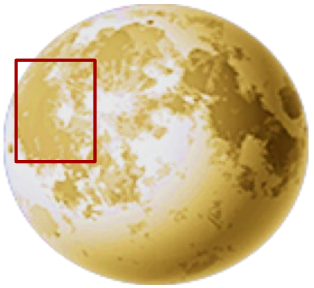


# Radio Observations of the Lunar Surface photoElectron Sheath (ROLSES) - a NASA Provided Lunar Payload (NPLP)

Bob MacDowall, Damon Bradley, William Farrell, Michael Reiner, Nat Gopalswamy, Ed Wollack, David McGlone/NASA/GSFC;

Jack Burns/U. Colorado/Boulder

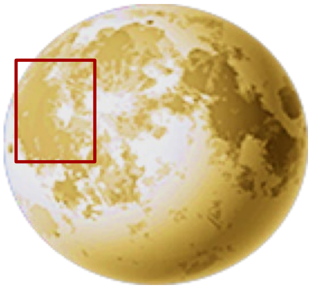
July 24, 2018



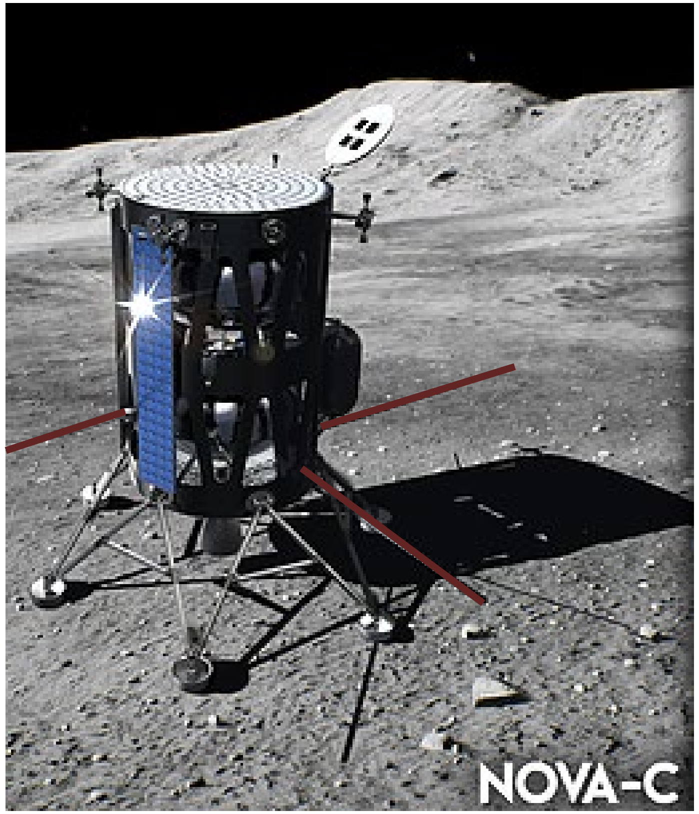
# Outline

- Background
- ROLSES Introduction/status
- Commercial lander status
- Science objectives
- Technical objectives
- Hardware review and details

# ROLSES Status

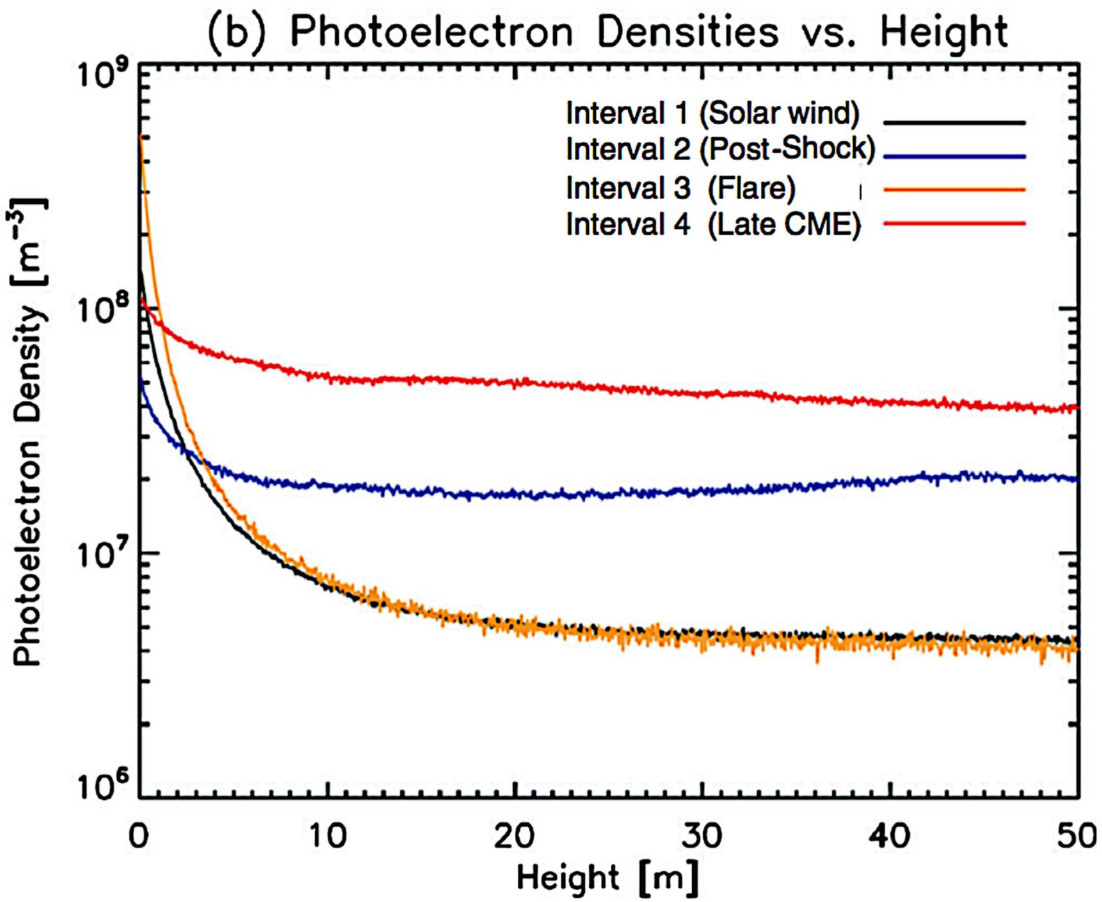


- Proposal referred to STEREO spacecraft WAVES instrument, but we are building a new digital electronics board, using the design of the GEDI (Global Ecosystem Dynamics Investigation) electronics board.
- Frequency range: 10 kHz to 30 MHz (high frequency in support of other lunar radio mission proposals)
- Four monopole Stacer antennas, used as dipoles at 1 m and 2-3 m above the lunar surface.  Two dipoles are orthogonal, to support some directional measurements.
- The commercial lander that is supposed to transfer ROLSES to the lunar surface is the NOVA-C provided by Intuitive Machines, LLC, Houston Texas.
- The landing site is Oceanus Procellarum, the largest of the lunar mare.



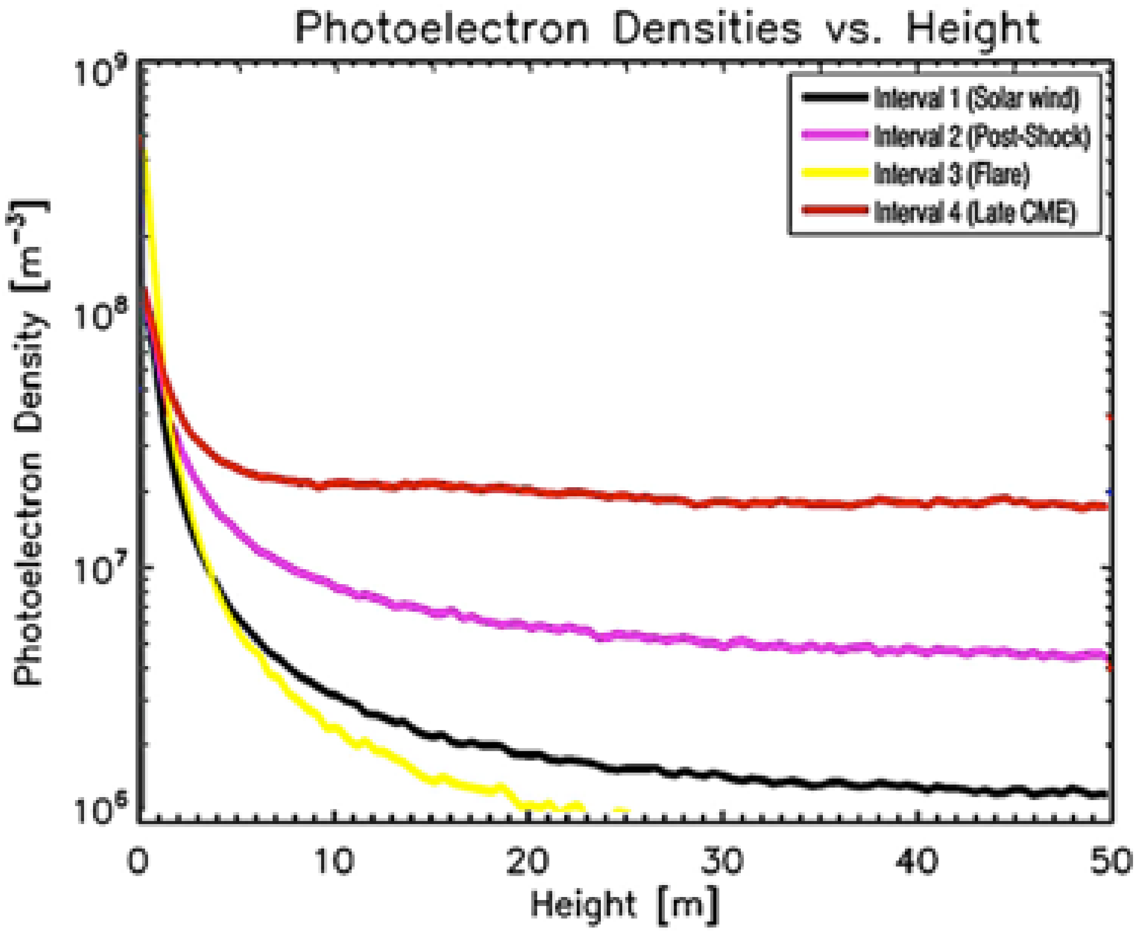
# Lunar surface photoelectron sheath

- ROLSES will determine the photoelectron sheath density from 0 to ~3 m above the lunar surface.
- This is of scientific value and is also important to determine the effect on the antenna response of larger lunar radio observatories with antennas on the lunar surface.
- The photoelectron density as a function of height above the lunar surface is indicated in the plot at right from the simulation code by Poppe and Horanyi [2010] for various solar wind environments. At 1 m height which corresponds to a plasma typical solar wind, density shown as 5 x $10^7$ $m^{-3}$ , electron frequency ($f_{pe}$) ~ 64 kHz.

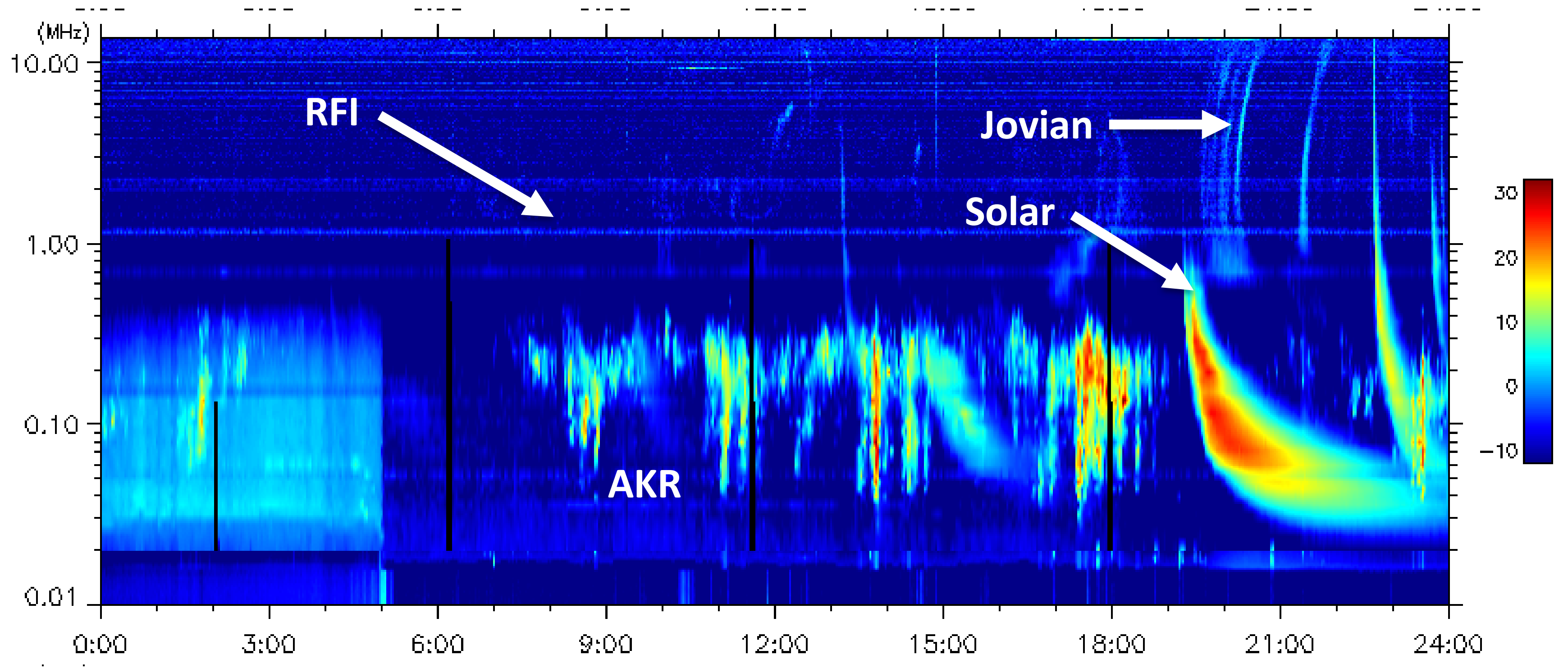


# Lunar surface photoelectron sheath 2

- Another model of the photo-electron sheath gives somewhat different results. We want ROLSES to provide the correct density and scale height.
- Note that in the plot at right using the Zimmerman et al. (2011) modeling code density values at ~1 and ~3 m for a typical solar wind environment would be 3 x $10^7$/ $m^3$ and $10^7$/ $m^3$.
- ROLSES measures these values based on the thermal noise spectrum, possible wave activity at the electron plasma frequency ($f_{pe}$), and absorption of the radio spectra of remote radio sources at frequencies at and below $f_{pe}$.



# Demonstrate detection of solar, planetary, and other radio emission from lunar surface

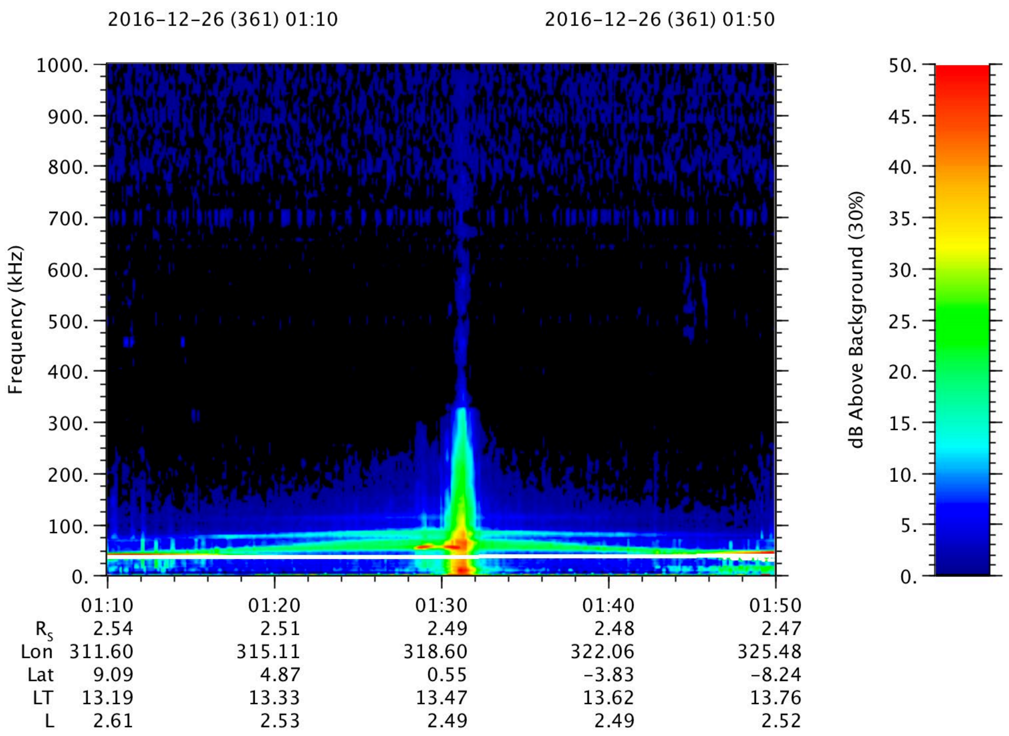



The WAVES instrument on the Wind spacecraft at Solar-Earth L1 shows solar radio bursts, Earth's auroral radio bursts (AKR), terrestrial ground-based transmitters (RFI), and Jovian radio emissions, during the 24 hr interval of 2/20/2012. ROLSES could do the same.

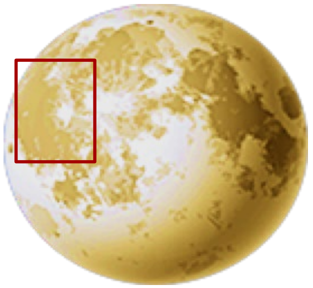
# Interplanetary/Interstellar Dust Impacts

- Spacecraft in the interplanetary environment or orbiting planets may be struck by dust particles, which releases electrons and ions from the surface, affects the surface photoelectron environment, and creates signals that are detectable.

- The plot at right shows the dust signal detected by the Cassini spacecraft when crossing the Saturn F-ring.
- ROLSES might detect dust impacting NOVA-C lander in a similar way. The time resolution of 5 sec does not permit detecting individual dust particles, but could detect dust "clouds".



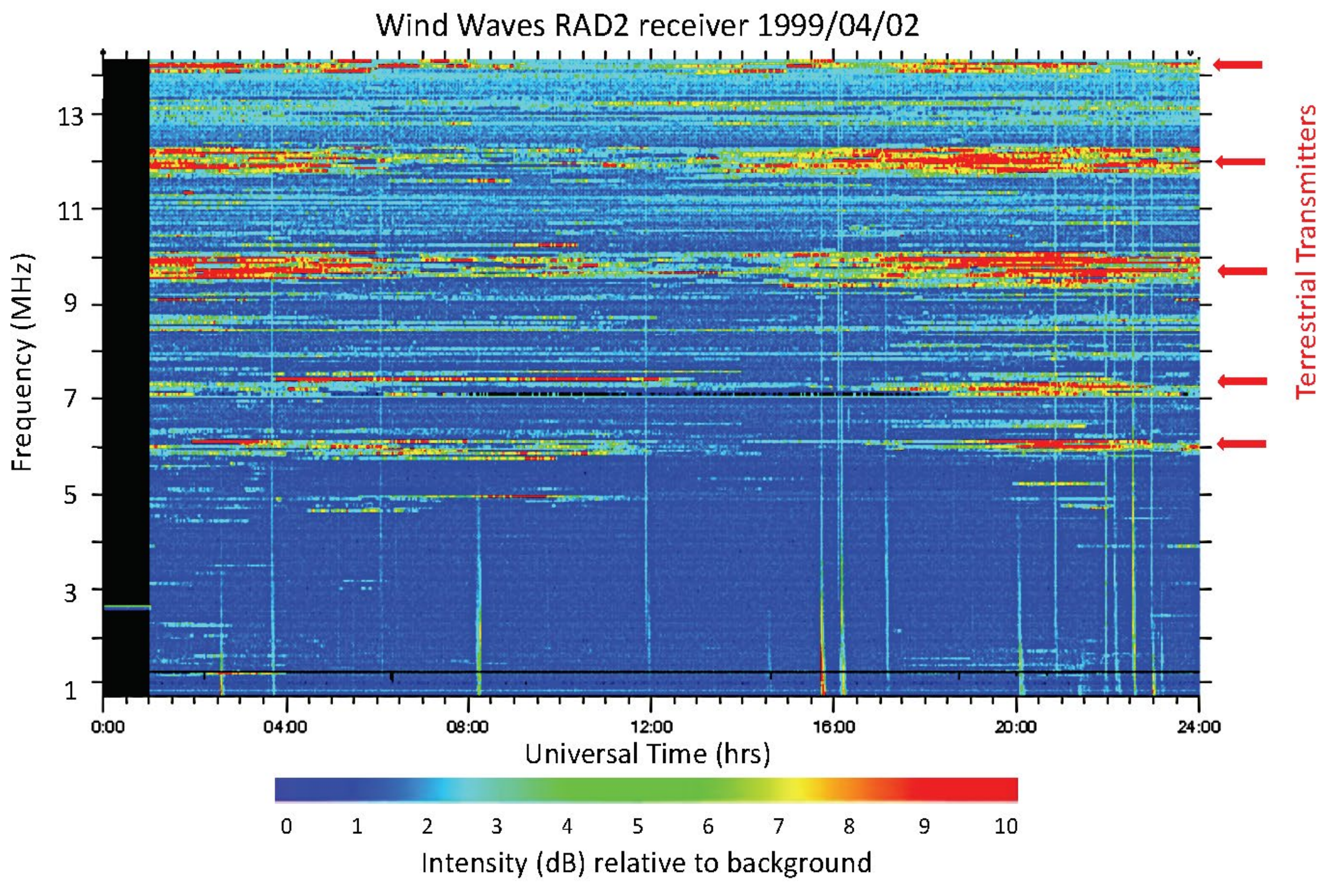
# Measure reflection of incoming radio emission from lunar surface and below



- There is no ground plane below the ROLSES antennas, so some detected radio waves will likely penetrate the lunar surface.
- They may be reflected at some depth, and ROLSES may be able to detect such reflection.
- Previously, the Apollo 17 lunar Surface Electrical Properties (SEP) instrument made such measurements at 6 frequencies, with a signal generator that sent radio waves down to a few km into the Moon.
- R. Grimm (Icarus, 2018) describes recent analysis of the SEP results in detail, e.g., “Because no deep interfaces were detected, the thickness of the Taurus-Littrow volcanic fill must exceed 1.6 km and possibly 3 km.”

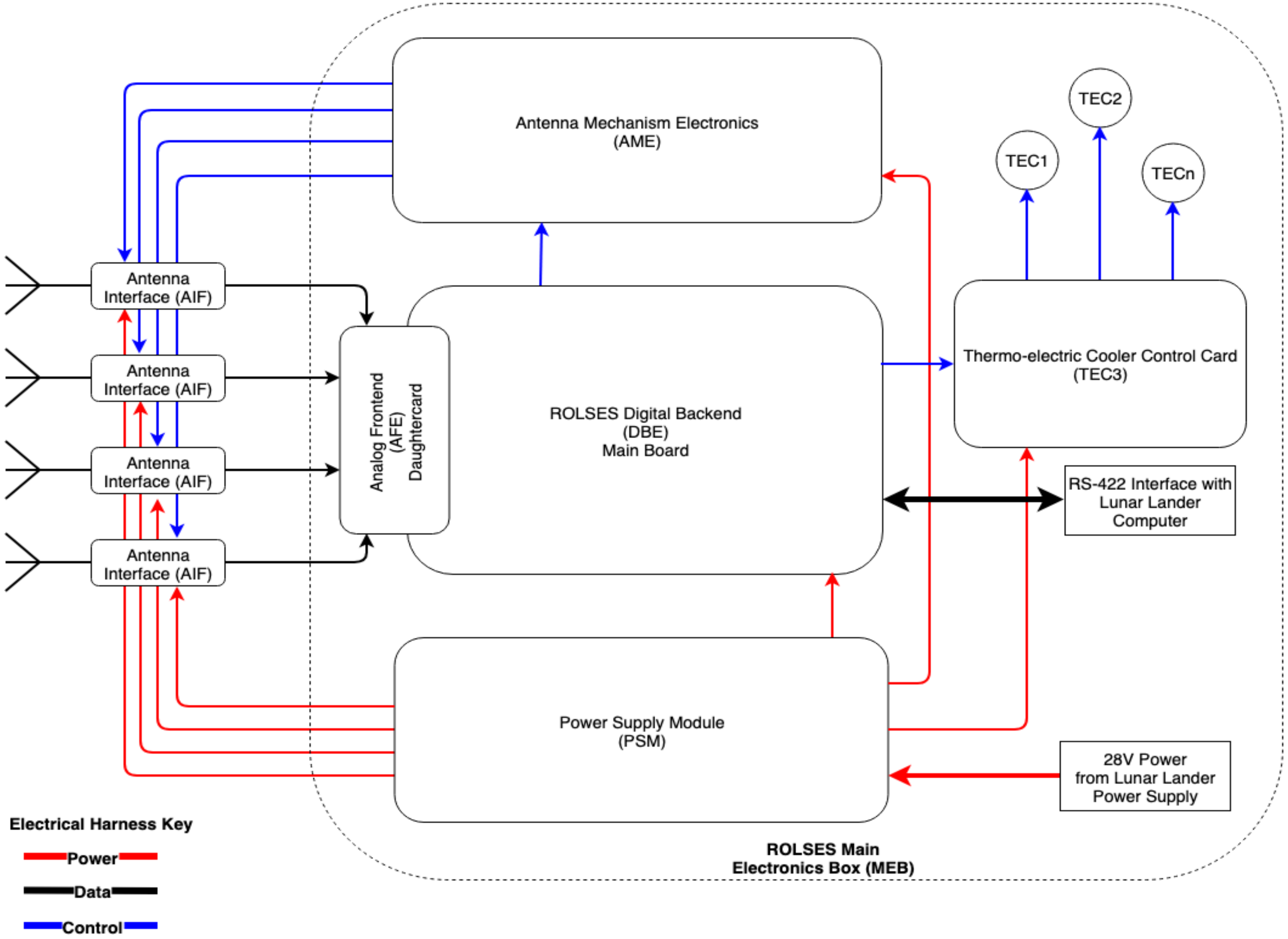
# Measure Present range/intensity of Terrestrial RFI

- ROLSES will provide continuous spectra of radio frequency interference (RFI) from terrestrial transmitters for the ~10-day mission; information to confirm how well a near-side lunar surface-based radio observatory could observe and image solar radio bursts in the frequency range of 0.01 to ~10 MHz for the first time.
- Plot at right shows terrestrial RFI observed by Wind WAVES in 1999 when it passed the Moon.



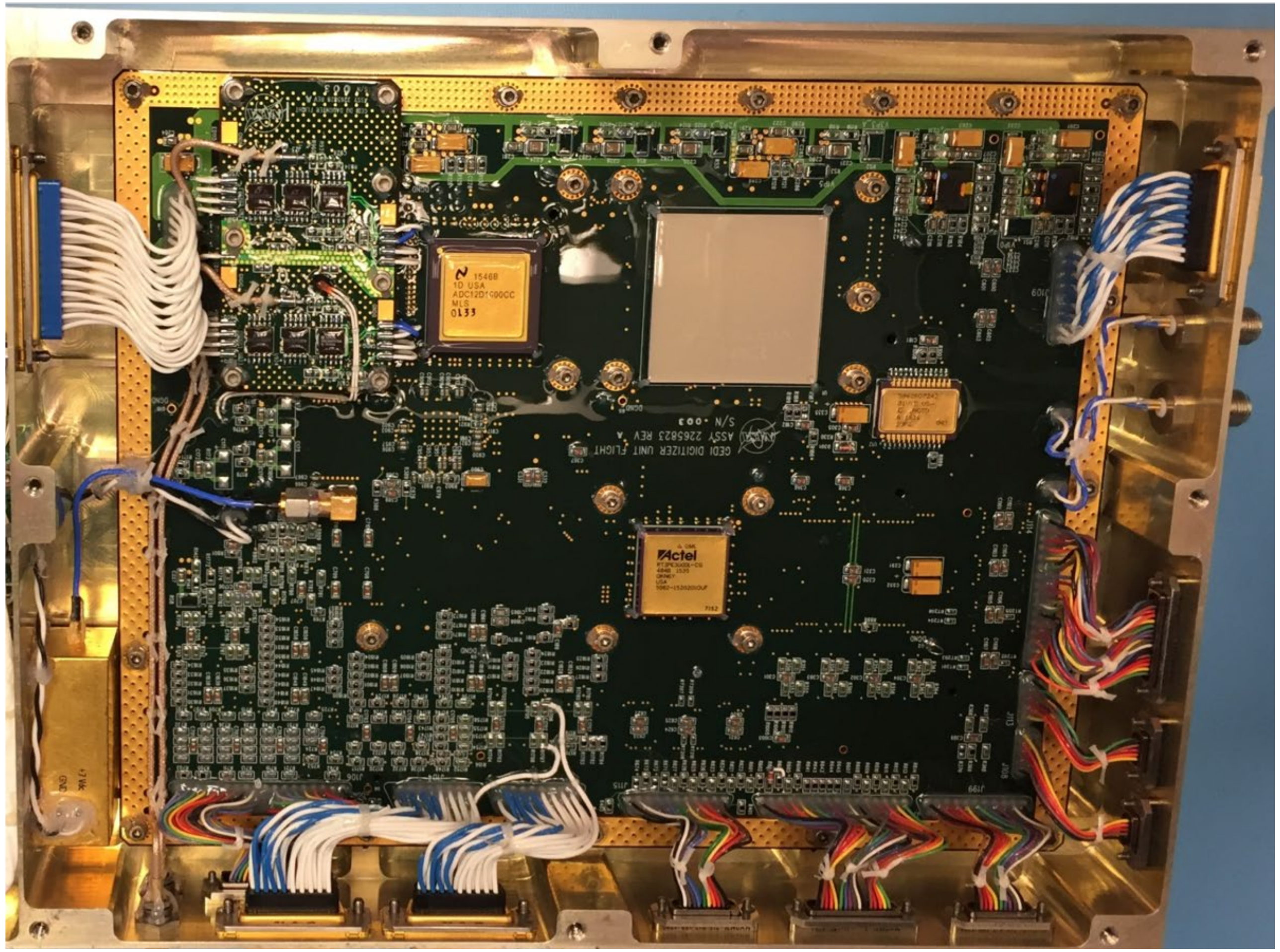
# ROLSES diagram

- Antennas
- Pre-amps
- Antenna deployment electronics
- Data-processing electronics
- Power regulation electronics
- Cooling system

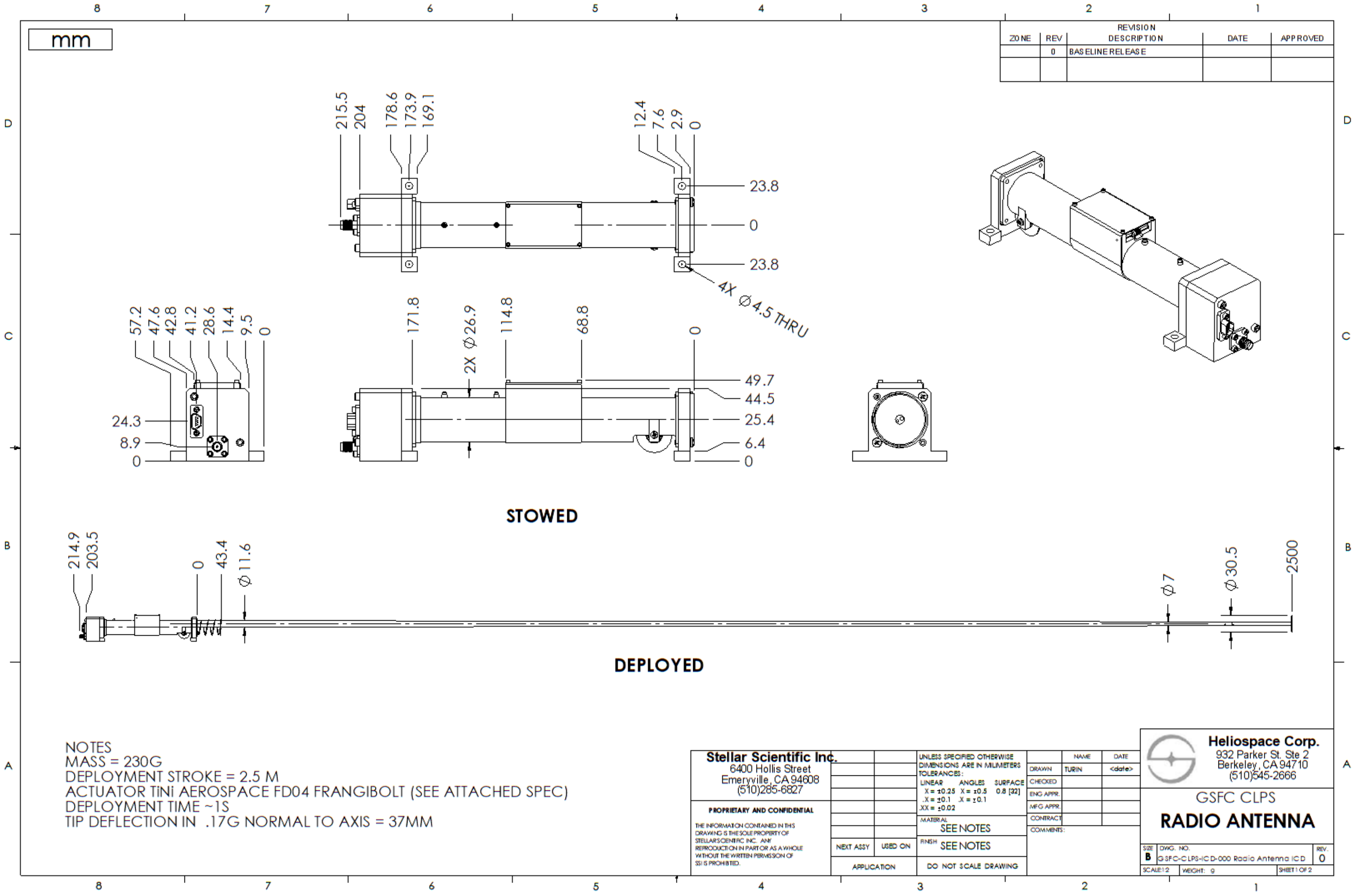


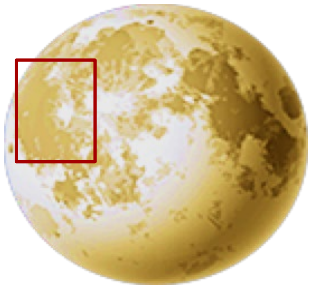
# Electronics Board

- ROLSES will use the electronics board from the Global Environment Dynamics Investigation (GEDI), currently on ISS.
- It includes a daughter board  at the front of the system, which we will modify.



# Stacer Antennas from Heliospace

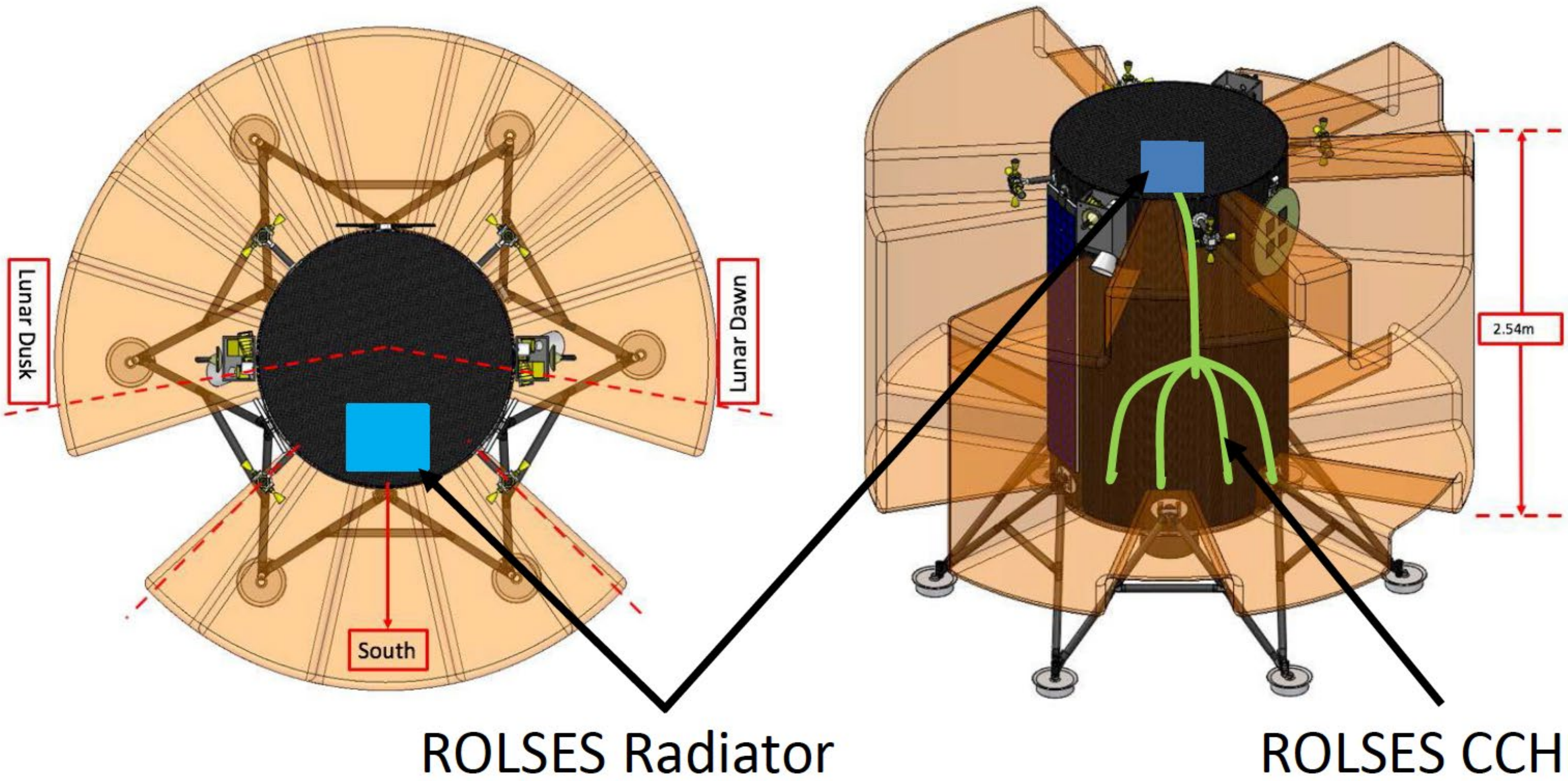




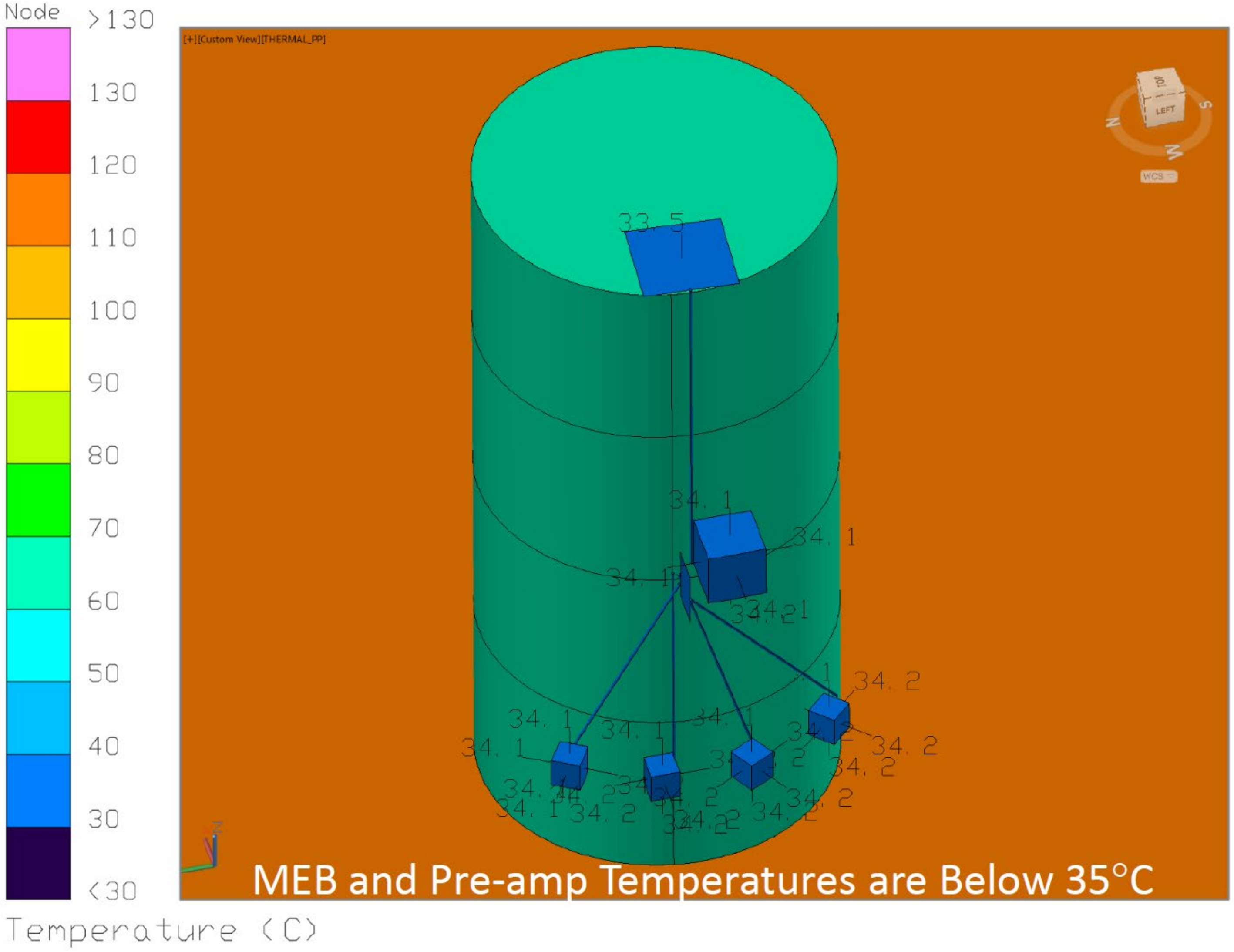
# ROLSES parameters

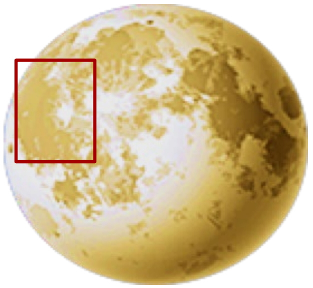
- Frequency coverage: 10 kHz - 30 MHz
- Mass: 4 kg (e-box) + 400 g (4 preamps) + 1 kg (4 antennas) ~ 5.4 kg
- Mechanical volumes:
  - Electronic & thermal control box: : 20cm x 25cm x 8cm
  - Preamps (4) each 5 cm x 5 cm x 2 cm
  - Stacer antenna deployer base units 21 cm x 5 cm x 5 cm
- Power: 8 W, 10.5 W peak
  - Requires 1.25 A @ 7 Vdc for 35 sec to deploy each Stacer antenna
- Data rate: ~ 17 kbps

# ROLSES Thermal Block Diagram



# Worst Hot Case Predictions

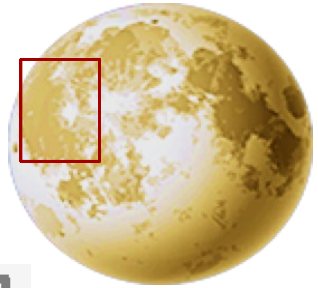


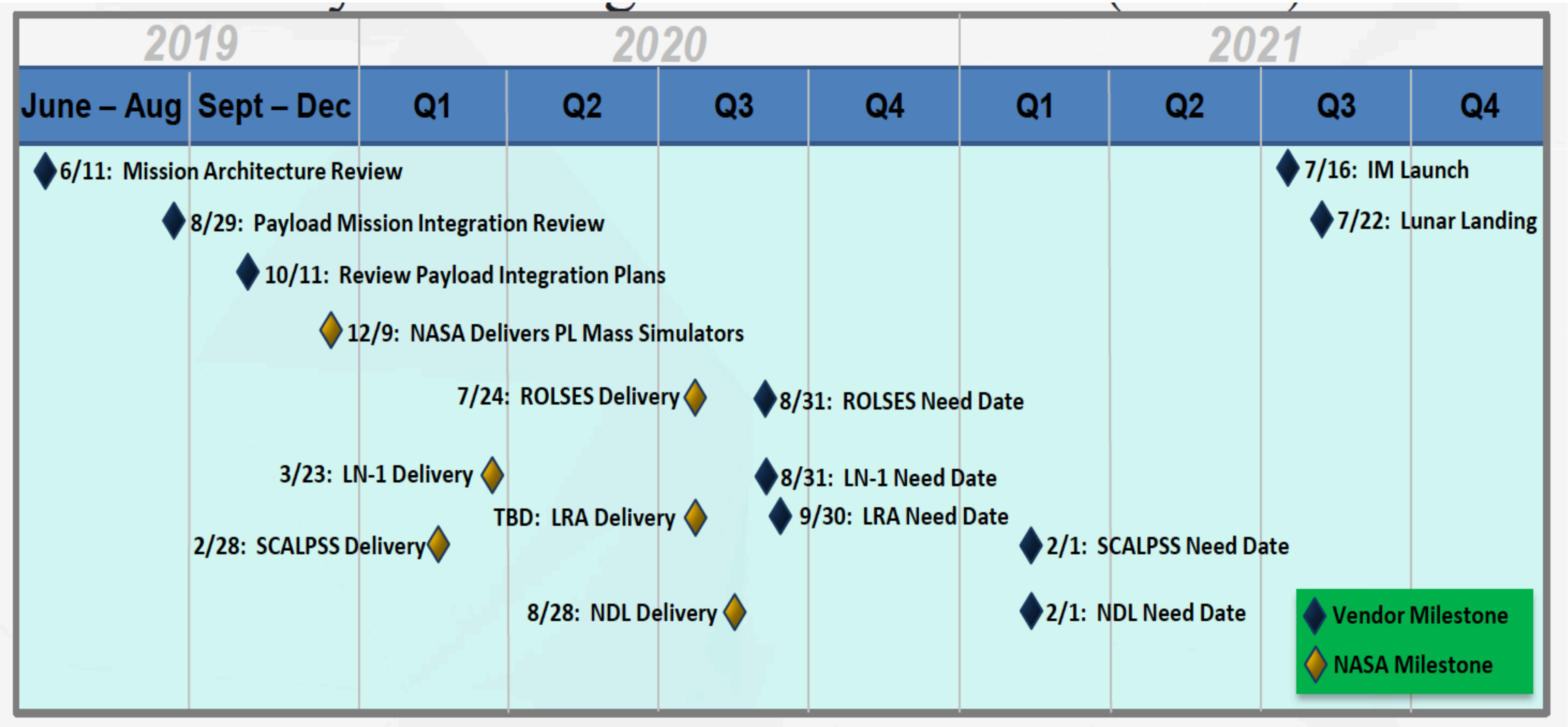


# Data acquisition

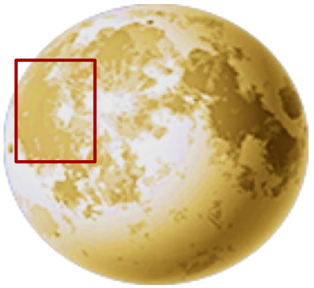
- ROLSES will have two frequency bands, 10 kHz – 1 MHz and 300 kHz – 30 MHz.
- The two frequency bands will each be analyzed using a 512-bin real-time digital Weighted-Overlap and Add (WOLA) spectrometer.
  - Low frequency band resolution: 1.76 kHz
  - High frequency band resolution: 58.01 kHz
  - Spectral time resolution will be approximately 5 seconds
- Payload data rate proposed not to exceed 17kbps to lunar lander, but we might get more.

# Schedule, etc.






- ROLSES can meet all of the schedule items indicated in the Mission Architecture Review.



# Summary

- The ROLSES NASA Provided Lunar Payload will focus on determining the photoelectron density and scale height near the lunar surface.
- Other scientific and technical observations include:
  - detection of solar and terrestrial radio bursts from the lunar surface
  - possible detection of clouds of dust impacting the system at high velocity
  - reflection of incoming radio waves from the lunar surface
  - current levels of terrestrial RFI from ground-based transmitters
  - We look forward to delivering ROLSES next year, and obtaining data from the lunar surface in 2021.