The Volatiles Investigating Polar Exploration Rover Payload

National Aeronautics and Space Administration

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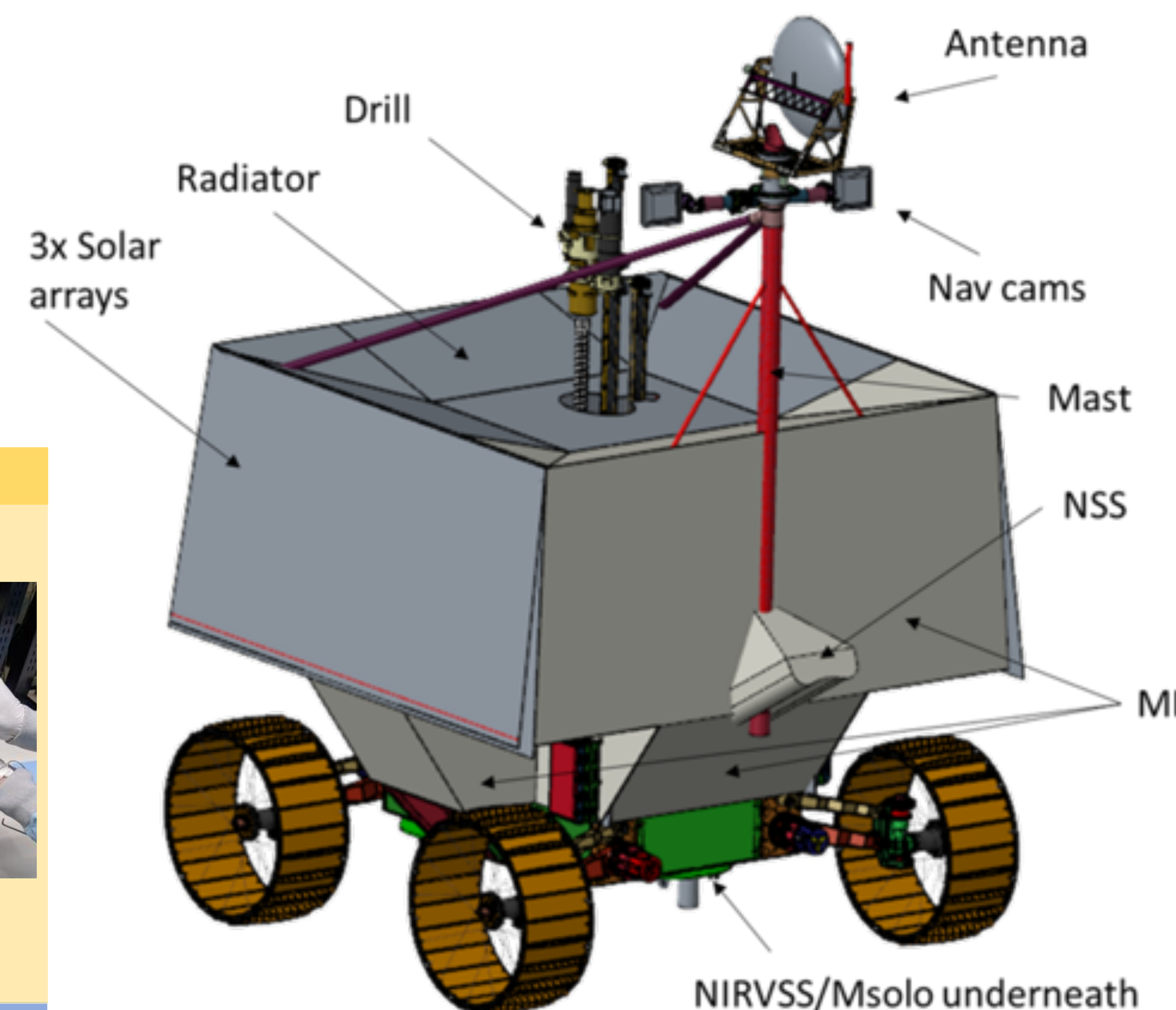
Overview

The Volatiles Investigating Polar Exploration Rover (VIPER) is a mission being developed through NASA's Lunar Discovery and Exploration Program (LDEP) with launch in 2023 [1]. A critical goal to both science and exploration is to understand the form and location of lunar polar volatiles, including water. The lateral and vertical distributions of these volatiles inform us of the processes that control their emplacement and retention, and help formulate in-situ resource utilization (ISRU) architectures. While significant progress has been made from orbital observations [2-6], measurements at a range of scales from centimeters to kilometers across the lunar surface are needed to generate adequate "volatile mineral models" for use in evaluating the resource potential of volatiles at the Moon.

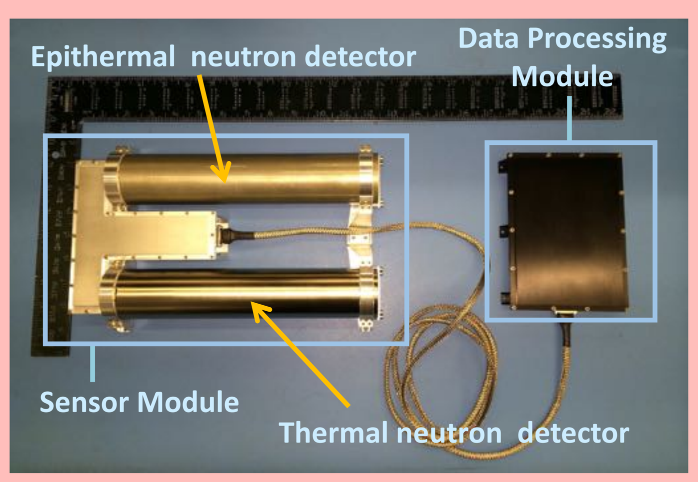
The VIPER mission includes a rover-borne payload that (1) can locate surface and near-subsurface volatiles, (2) excavate and analyze samples of the volatile-bearing regolith, and (3) demonstrate the form, extractability and usefulness of the materials. With a nominal 90 day mission at the lunar surface, VIPER will explore a range of regions where ice is not expected, where it is expected at shallow (<1 m) to deep (~1m) depths or at the surface in permanently shadowed regions. Observations by VIPER will ground-truth our understanding of the distribution and retention of lunar volatiles.



VIPER is a ~430 kg, 1.5m x 1.5m x 2.5m solar-powered mobile platform equipped with prospecting instruments for lunar volatiles and a 1-m drill. VIPER is planned to rove several kilometers, collecting data on different kinds of lunar environments affected by light and temperature — those in complete darkness, occasional light and in constant sunlight. Once it enters a permanently shadowed location, it will operate on battery power alone and will not be able to recharge until it drives to a sunlit area. VIPER has a top speed 20 cm/s and prospecting speed 10 cm/s.

Neutron Spectrometer System (NSS)

NSS will provide estimated hydrogen abundance via epithermal neutron flux and bulk regolith chemical information by way of the thermal-to-epithermal neutron flux.



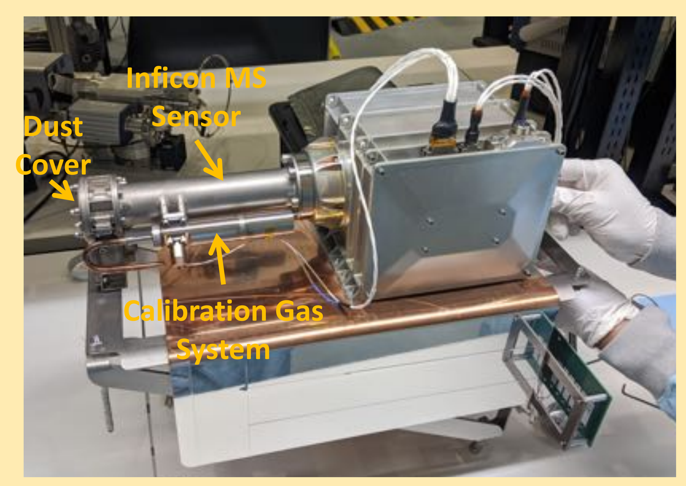
NSS is at TRL 6 and has been utilized in prior field studies [7-8].

- Measures cosmic-ray generated neutrons in lunar surface materials.
- Detects low energy neutrons with two helium-3 gas proportional counters.
- Cadmium covered counter detects only epithermal neutrons with energies >0.5 eV.
- Uncovered counter detects both thermal (<0.5 eV) and epithermal energies (>0.5 eV).
- Difference between two counters can provide an estimate of burial depth of hydrogen-rich material as deep as 1 meter.
- Continuously on while roving.

Mass Spectrometer Observing Lunar Operations

MSolo will provide measurements of molecular volatile species (including water), their relative intensities, and isotopic ratios.

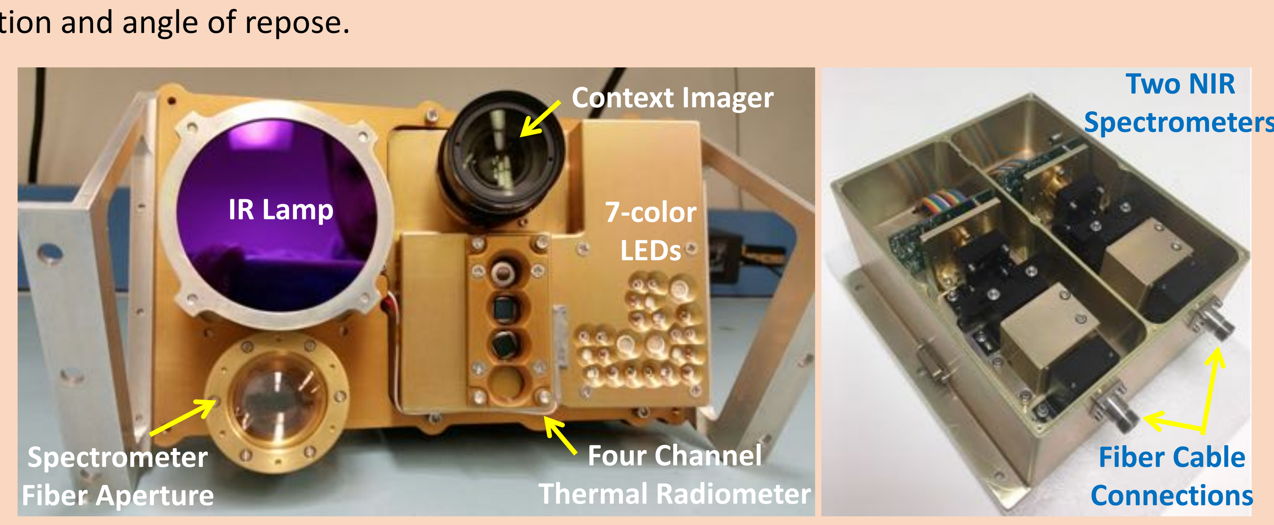
- Quadrupole mass spectrometer can detect and differentiate low molecular-weight volatiles between atomic mass units (amu) 1 – 100 amu.
- Provides unit mass resolution to measure isotopes including D/H and O^{18}/O^{16}.
- Includes faraday cup and electron multiplier detectors for high and low pressure analysis, respectively.
- Quickly switches between detectors, allowing gases with high and low partial pressures to be detected at the same time.
- Operates continuously while roving. During a drilling activity, detects volatiles sublimating from the drill cuttings when delivered to the soil surface.



Near InfraRed Volatiles Spectrometer System (NIRVSS)

NIRVSS will provide measurements of solid volatile (ices) composition, minerology, surface temperatures and fine scale geomorphology.

- Enables detection of water and other volatiles species (CO_2, CO, H_2, H_2S, NH_3, SO_2, CH_4 and C_2H_4).
- Can determine the forms of water and distinguish between absorbed/bound/in the form of ice (crystalline or amorphous) or absorbed/bound hydroxyl.
- Panchromatic 4-megapixel camera with seven colored LEDs over 340 to 940 nm provides context imaging.
- Spectrometers measure reflectance between 1300-2400 and 2200-4000 nm with spectral resolutions of <20 and <50 nm, respectively.
- Carries an infrared lamp to illuminating shadowed scenes.
- Four-channel thermal radiometer measures surface temperatures and provides for thermal emission correction of spectra.
- Views the surface under the rover and operates continuously while roving. During a drilling activity, directly views the drill cuttings as they deposited on the surface to capture bulk geotechnical characteristics such as compaction and angle of repose.



NIRVSS is at TRL 6 and has been utilized in prior field studies [9-11]. The bracket assembly (left) is attached to the spectrometer box (right) via electronic, data communication and fiber-optic cables.

The Regolith and Ice Drill for Exploring New Terrain (TRIDENT)

TRIDENT will provide measurements of subsurface temperature and strength of regolith vs. depth to distinguish between ice-cemented ground or a mixture of regolith and ice particles.

- Delivers 10 cm sample segments down to 1 meter depth to the surface for inspection by NIRVSS and MSolo.
- Drill head designed with rotation and percussion decoupled to enable use of more energy intensive percussive system only when required (e.g., to penetrate harder formations).
- Drill auger designed to capture cuttings and soils and efficiently move cuttings out of the hole.
- Drill bit has an integrated temperature sensor to monitor bit temperature during drilling.

TRIDENT drill undergoing testing in lunar chamber at NASA Glenn.[12]

VIPER Payload at a Glance

	Mass, CBE (kg)	Volume (cm x cm x cm)	Power, Average (W)	Data Rate (prospecting) kbps	Data Rate (drilling) kbps
MSolo	6	15.5 x 20 x 46	35	15	15
NIRVSS	3.6	Spectrometer: 18 x 18 x 8.5 Bracket: 20.4 x 13 x 15.1	Spectrometer: 12 Bracket Assembly: 5.3 Lamp: 12.3	47.15	59.1
NSS	1.9	Sensor Module: 21.3 x 32.1 x 6.8 Data Module: 13.9 x 18.0 x 3.0	1.5	0.712	0.712
TRIDENT	21.3	Stowed Drill: 33.3 x 20.6 x 168 Avionics: 28.2 x 23 x 12.7	Idle: 30 Augering: 100 Percussion: 195	N/A	15

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