The Near-Infrared Volatile Spectrometer System (NIRVSS) for Exploration of Volatile Deposits at the Lunar Poles

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An Engineering Design Unit (EDU) is undergoing performance and environmental testing at NASA Ames in FY2013.

**Scientific Rationale for the RESOLVE (Regolith and Environment Science and Oxygen & Lunar Volatile Extraction) Payload**

*Given*:
- There are potentially substantial hydrogen rich resources on the Moon.
- We must gain the necessary knowledge to guide future mission architectures to allow effective utilization of in-situ resources to their fullest extent and optimum benefit.

- **Understand the resources**
  - What are the resources (minerals, volatiles, water/ice)?
  - How abundant are the resources?
  - How much energy is required to locate, acquire and separate the resources?

- **Understand environmental impact on extraction and processing hardware**
  - What is the local temperature and illumination environment?
  - What are the local physical properties of the resources?
  - Are there volatiles that are detrimental to processing hardware or humans?

- **Design and utilize hardware to the maximum extent practical that has applicability to follow-on SRU missions**
  - Can we effectively capture and separate volatiles of interest?
  - Can we execute repeated processing cycles (reusable chamber seals, tolerance to thermal cycles)?

- **OVERView**

  - **Purpose**: Acquire subsurface samples for volatile analysis.
  - **Objectives**:
    - Conducting a full characterization of regolith components as it pertains to the surface temperature and volatiles.
    - Evaluate the NIRVSS EDU under realistic rover mission environments.

  - **Instrumentation**
    - Spectrometer
    - Drill Operations Camera (DOC)
    - Multi-Channel Spectrometer
    - Drill Operations System (SDS)
    - Gas Supply System (GSS)
    - Power Conditioning and Interface Board
    - Electronics Interface Board

- **Procedure**

  - **Test Objectives**:
    - Measure and report the thermal emission.
    - Measure the optical properties of the scientific and engineering performance requirements.

  - **Technical Challenges**
    - Testing must reflect a realistic operative environment.

- **Results**

  - **Thermal Background Correction**
    - The ratio of thermal emission to the total flux (thermal plus reflected sunlight) for a range of temperatures and two ranges of reflectance.
    - The spectral irradiance of terrestrial material was used. For the range of temperatures expected, 300-350 K, thermal emission from the surface contributes to the measured spectral signal and interferes with the 10.5 µm depth calculation.
    - In addition to the NIR spectrometer’s 3.0 µm measurement, the NIRVSS LCS provides an independent measurement for correcting lunar thermal emission.

  - **Grain Size Determination**
    - Measurement of the size of the materials being emitted.

**NIRVSS Spectrometer Module**

Two separate spectrometer modules with their control electronics are contained within a single enclosure. The instruments are powered by a 28 V external supply. Optical input is through a single fiber per each channel. The spectrometers were built by Thermofisher Scientific and draw flight heritage from the LORRISS Near-Infrar卧室 Spectrometers.

**NIRVSS Bracket Assembly**

The bracket assembly contains a dual-bulb lamp (designed to provide uniform illumination over 24° diameter), two spectrometer fiber inputs, the Drill Operations Camera (DOC) with lens, three Dexter pyrometers (the Longwave Calibration Sensor (LCS) suite), a power conditioning and interface board, operational/survival heaters and temperature sensors. The lamp, fiber, DOC, and LCS fields-of-view are co-boreighted.

**NIRVSS Science Requirements Trace to RESOLVE Level 2 (L2) Requirements**

- **NIRVSS-SRD-Spec-1** NIRVSS shall identify the presence of water when the total concentration of water is greater than 0.5% by weight. (Trace: L2-SRD-1)
- **NIRVSS-SRD-Spec-2** NIRVSS shall distinguish between water ice and bound or adsorbed water in the lunar regolith when the total concentration of water is greater than 0.5% by weight. (Trace: L2-SRD-117)
- **NIRVSS-SRD-Spec-3** NIRVSS shall resolve spectral features to identify mineral features (e.g., silicates, hydroxy-bearing minerals) and identify and quantify volatiles (e.g., CO2, H2O, H2, H2S, NH3, SO2, CH-bearing compounds). (Trace: L2-SRD-84, L2-SRD-85)
- **NIRVSS-SRD-DOC-1** NIRVSS DOC shall be capable of spatially resolving regolith grains of 0.5 mm. (Trace: L2-SRD-85)
- **NIRVSS-SRD-DOC-2** NIRVSS DOC shall be capable of imaging the lunar surface during traverse and auger/core activities. (Trace: L2-SRD-26)
- **NIRVSS-SRD-LCS-1** The NIRVSS Longwave Calibration Sensor shall distinguish the surface temperature between 200-350 K while roving and drilling activities. (Trace: L2-SRD-75)
- **NIRVSS-SRD-LCS-2** Test Goal: The NIRVSS Longwave Calibration Sensor shall identify when surface temperatures or auger tailings are less than 140 K. (Trace: L2-SRD-75)

**NIRVSS EDU Testing at NASA Ames 2013**

The NIRVSS EDU has undergone thermal vacuum (top left) and vibration testing (middle left). Results from early illumination tests (bottom left), at ambient pressure/temperature, are shown below. Blue regions highlight where water bands occur in this spectral range. The NIRVSS spectra (Blue and red solid lines) show water-detection in the test’s 30 cm distance path-length. Our SNR=100 at 2.0 µm and 3.0 µm. A performance requirement is shown by the horizontal black line. The NIRVSS SW module SNR (blue dashed line) exceeds this. Optimization of the LW module (red dashed line) is underway. Future performance tests will constrain the percentage of water in a test-lunar simulant when illuminated and viewed by NIRVSS.

**The Resource Prospector Mission** packages the RESOLVE payload on a rover-based platform. See Anthony Colaprete’s Talk Thu Jul 18, 2013 Session 6B 1:30-1:45pm PDT