LEOS: Lunar Environmental Observation Station
A TRL 6 Payload for the Lunar South Pole

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Abstract: The primary objective of the Lunar Environmental Observation Station (LEOS) is to measure surface parameters on the Lunar Surface, much like a weather station on Earth. The data LEOS will provide is temperature, light (UV and PAR), ionizing radiation (neutral and charged), and images from cameras. The LEOS station is at TRL6. All of the LEOS sensors are COTS that have passed Thermal Vacuum (-55°C to + 80°C at 10^{-6} torr) and GEVS vibration of 14.1G or have flown in Low Earth Orbit. Models predict the values for temperature, light, and radiation on the lunar surface but there are no sensors or instruments that have measured these parameters on the Moon. Data from the LEOS provides information of potential risks to a crewed mission prior to their arrival. The following sensors are included in the LEOS station: 1) PAR Photosynthetically Active Radiation light sensor. 2) Black Body Globe (Radiative flux, temperature. 3. Ultraviolet light sensor 4. CNP-TEPC- Ionizing Radiation. 5. Camera- visual images. LEOS mass is ~ 5kg.

The sensors were mounted on a ½-inch aluminum plate for Thermal Vacuum (Tvac) testing and a ½-inch aluminum plate for GEVS flight qualification vibration tests at 14.1G. Because these are Commercial-Off-The-Shelf (COTS) sensors, they were not designed for use in the space environment. Our first step was a 72-hour bake-out at70°C to ensure the commercial wiring would not harm the vacuum chamber. The sensors survived the bake-out and were placed in the thermal vacuum chamber for 10 days and a vacuum of 10^{-6} torr oscillating from -50°C up to + 80°C each 24-hour cycle. All of the sensors survived and operated at the extreme temperatures exposed in Tvac. After successful completion of Tvac testing, the sensors were mounted onto a circular aluminum plate mounted onto the Vibration table. The instruments were turned on before and after each axis rotation (Z, X, and Y) table shook in each axis for approximately 1 min at 14.1G. All of the sensors nominally operated after each axis resulting in a successful vibe test and the flight qualification of COTS environmental sensors. The poster describes each of the sensors and the respective measurements.

Li Cor LI- 193SA Spherical Quantum Sensor PAR (400 nm to 700 nm) TRL-6

The LiCor Biosciences spherical Photosynthetically Active Radiation (PAR) sensor is designed to measure the light spectrum in the range of 400nm to 700nm, the portion of light employed by biology for photosynthesis. The spherical shape provides the advantage to measure PAR from both the Sun above and reflected off the lunar surface. Measuring the PAR light that reaches the lunar surface is important to determine the feasibility of supporting plants and other photosynthetic organism growth on the Lunar surface. The operation of the sensors is to collect data every 5 seconds, averaging the data per minute, with the average, max, and min values relayed to the C&DH. The power needs for this sensor is zero watts, since it is a quantum sensor. The size of the sensor is 6.1 cm X 3.18 cm X 10.7cm (2.4 in x 1.25in, x 4.2in). Mass of the sensor is 0.23 kg.

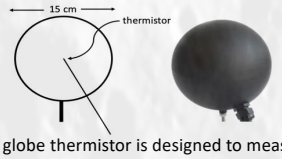
https://www.licor.com/env/products/light/quantum-underwater-sphere

Apogee Su-200-SS UV, 300 to 400 nm, TRL 6

Two Apogee Sensors are designed to measure the ultraviolet light from the Sun as well any light reflected from the lunar surface. Measuring the ultraviolet light that reaches the lunar surface is important due to damaging effects on biological systems. The operation of the sensors is to collect data every 5 seconds, averaging the data per minute, with the average, max, and min values relayed to the C&DH. The power needs for each sensor is zero watts, since it is a quantum sensor. The size of each sensor is 3.5cm in diameter, 3.7cm in height (1.38in, 1.46 in). Mass of each sensor is 0.16 kg.

https://www.apogeeinstruments.com/su-200-ss-uv-a-sensor

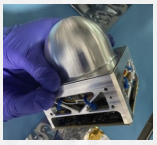
Campbell Scientific Black-body globe (radiative flux) TRL 6



The Black globe thermistor is designed to measure the radiative flux (thermal energy) from both the exosphere and reflected from the lunar surface rocks and ice. The temperature of the lunar surface is important in planning biological experiments and crewed exploration. The precision of the Black Globe is 0.5°C. The Black Globe operational regime is taking a measurement every 5 minutes converting voltage to a temperature. The average, min, and max temperature for an hour is relayed to the C & DH board. The power needs for the sensor is less than a watt, since it is a passive resister. The size of the sensor is a 15cm (6in) black coated copper sphere, with a mass of 0.46kg.

www.campbellsci.com/blackglobe

CNP-TEPC -ionizing radiation – TRL 7



Hanu, A.R., Barberiz, J., Bonneville, D., Byun, S.H., Chen, L., Ciambella, C., Dao, E., Deshpande, V., Garnett, R., Hunter, S.D. and Jhirad, A., 2017. NEUDOSE: A CubeSat Mission for Dosimetry of Charged Particles and Neutrons in Low-Earth Orbit. *Radiation research*, *187*(1), 42-49.

Mass is 0.33kg
https://mcmaster
neudose.ca

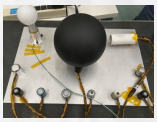
The **C**harged and **N**eutral **P**article- **T**issue **E**quivalent **P**roportional **C**ounter (CNP-TEPC) is designed to measure charged and neutral particles on the lunar surface. Measuring the ionizing and neutron radiation on the Lunar surface is essential for determining the radiation environment biological systems will be exposed to on the lunar surface in the south pole region. The core of CNP-TEPC is the Tissue Equivalent Proportional Counter (TECP). The spherical TEPC simulates 2 µm of adipose tissue and enables measurement of the lineal energy distribution of incident radiation in the range of ~0.1–1,000 keV/µm. The TEPC is sensitive to both charged and neutral particles. Although included as part of the LEOS payload; the CNP-TEPC was not included in the LEOS Tvac and Vibe testing since it successfully operated in Low Earth Orbit reaching TRL 7 in 2023. The CNP-TEPC was developed by McMaster University with support from the Canadian Space Agency. The CNP-TEPC is described in detail in Hanu et al. (2017). Power requirements are 3watts peak, 1.5 watts operational. The size is 9.65cm x 9.65cm x 11.6cm.

Camera: MCAM: MicroCameras, TRL 7

This camera aims to be used, amongst others, for monitoring and health check of satellites, as imaging payload for observation satellites or for small and micro-satellites, as rover visual systems, but also for science instruments or any applications in harsh environmental conditions with limited resources. Its lightness and compactness is a valuable asset for tight payload mass & volume requirements. Mass is ~ 0.7 kg per camera. This camera was not included in the LEOS of Tvac and Vibe testing since it achieved TRL 6, on the Lunar South Pole through Viper testing and TRL 7 for the space environment through a successful LEO mission. https://microcameras.space/cameras/

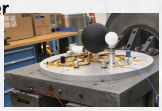
Additional COTS environmental sensors that are TRL 6 for the Lunar South Pole area through this project .

Apogee SI-111-IR – Infrared Radiometer,
Apogee SL-510- Pyrgeometer Upward-looking
Apogee SL-610- Pyrgeometer Downward-looking
Apogee SP-110- Silicon-Cell Pyranometer
Apogee SP-510 -Pyranometer Upward looking
Apogee SQ-500-Full Spectrum(389nm to 692nm) Quantum Sensor
Apogee SQ-610- ePAR (400nm to 750nm)
Apogee SQ-100X- Quantum Sensor (370nm to 650nm)
https://www.apogeeinstruments.com



Sensor set-up for the bake-out & Tvac

The sensors operated simultaneously in Thermal (-55°C to +80°C), Vacuum (10^{-6} torr) in the NASA ARC EEL Thermal Vacuum chamber for ten-days prior to passing GEVS flight-qualification Vibration tests at 14.1G. The temperature range these sensors operated at is beyond the -40°C to +60°C anticipated temperature range at the Lunar South Pole Region. At the conclusion of this project 12 environmental sensors achieved TRL 6 for the Lunar South Pole. We thank the NASA ARC Innovation Fair for selecting this project and the NASA ARC EEL staff for providing guidance through-out the project. P.I. E.A. Quigley, NASA ARC STA, Co-I, H.D. Smith and A.G. Duncan – KIPR, NASA ARC STT.



Sensor set-up for vibration test