AN ULTRA-COMPACT IMAGING SPECTROMETER FOR THE LUNAR SURFACE: UCIS-MOON.
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Introduction: We are developing an ultra-compact imaging spectrometer (UCIS) [1, 2] for use in future landed missions to the Moon under the Development and Advancement of Lunar Instrumentation (DALI) program. Our instrument, named UCIS-Moon, is a short wavelength infrared (SWIR) imaging spectrometer that will achieve spatial resolutions of centimeters to meters when mounted on the mast of a lunar lander or rover. It will collect reflectance spectra from 600 – 3600 nm at 10 nm spectral sampling. Spectra from this wavelength range can be used to detect common lunar minerals, OH species, molecular H_2O, water ice, and organics (Fig. 1). Data from UCIS-Moon will therefore provide information about lunar volatiles and minerals within their geologic context.

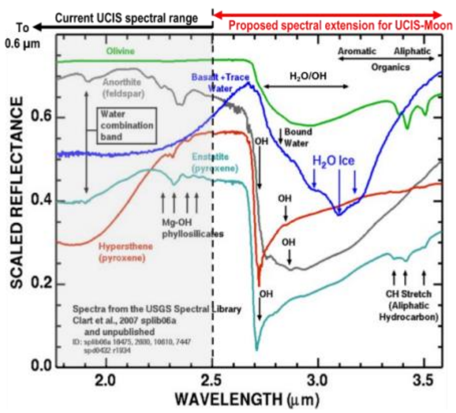

Fig. 1: Laboratory measurements showing the character and diversity of volatiles distinguishable with spectral range of UCIS-Moon

Science goals: Despite recent advances in the field of remotely studying lunar volatiles, there are many unknowns related to the origin, form, abundance, composition, mobility, and accessibility of surface OH/H_2O lunar volatiles. UCIS-Moon will use high spatial and spectral resolution imaging spectroscopy to map lunar volatiles at a single landing site. Data from UCIS-Moon will also be used to simultaneously identify lunar minerals and their associated geologic context. This will provide insight into lunar igneous processes and evolution, resolve questions related to lunar stratigraphy, and demonstrate the optical effects of space weathering. The specific measurements needed to achieve the goals and objectives for UCIS-Moon are summarized in Table 1.

Table 1: Lunar science enabled by UCIS-Moon and associated measurement requirements

Goal	Objective	Measurement
Volatile Goals: Understand sources, distribution, temporal variability, and ISRU potential of lunar volatiles	Resolve OH and H_2O absorption bands at the scale of rocks and outcrops	1.85 – 3.6 µm spectral range with ≤20 nm spectral sampling and SNR ≥50
	Spatially resolve mineral absorptions, OH, and H_2O absorptions at the scale of rocks and outcrops.	IFOV ≤ 1.7 mrad (5 mm at 3 m, 5 cm at 30 m)
	Resolve OH and H_2O concentration in rocks and regolith and map spatial variation; monitor temporal variability of solar wind generated OH	Measurements at multiple times of the lunar day, including very early to mid-morning and afternoon to late evening to capture periods of possible volatile content change
Geology Goals: Understand Igneous Processes; Lunar Stratigraphy; and Space Weathering on the Moon	Identify key minerals and lithologies; map spectral properties of rocks & soils of multiple exposure ages	0.6 – 2.5 µm spectral range with ≤20 nm spectral sampling and SNR ≥100
	Map the spatial relationships between materials	IFOV ≤ 1.7 mrad (5 mm at 3 m, 5 cm at 30 m)

Design: UCIS-Moon is a compact Offner imaging spectrometer that accommodates a 600-pixel-cross track field CHROMA focal plane array provided by Teledyne Imaging Sensors Inc (Fig. 2, top) [3]. The spectrometer is identical in design to the High-resolution Volatiles and Minerals Moon Mapper (HVM3) that will be flown on the upcoming Lunar Trailblazer mission [4]. The expected optical performance characteristics are summarized in Table 2.

To achieve the instrument's science goals at the lunar surface, we have developed a specialized thermal design that will permit UCIS-Moon to operate in the challenging surface lunar thermal environment at all times of day and within permanently shadowed regions. Depending on location and time of day, lunar surface temperatures range from ~100 – 400 K, and are even lower in permanently shadowed regions [5]. UCIS-Moon's performance is tied directly to its operating temperature, and we completed thermal subsystem design trade studies that accommodate these challenging thermal environments (Fig. 2, bottom).

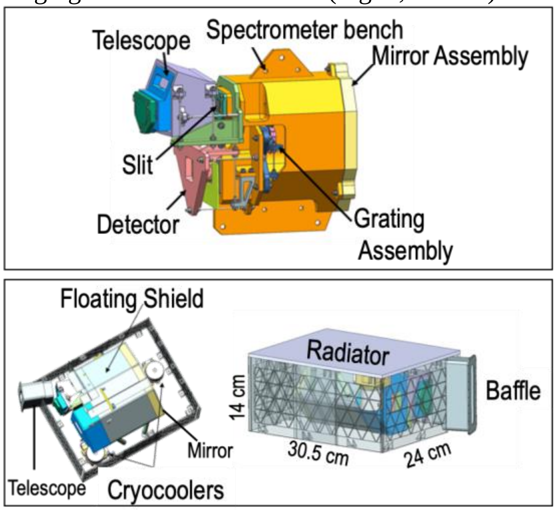

Fig. 2: UCIS-Moon optical design and thermal housing

Table 1: UCIS-Moon instrument characteristics

Platform	Lunar lander/rover
Wavelength range	600-3600 nm
Sampling	10 nm
Spectrometer architecture	Offner
FOV	≥ 30 degrees
IFOV	1.15 mrad
SNR	>100 @ <2500 nm >50 @ >2500 nm
Spectral uniformity	<10%
Spatial uniformity	<10%

Project status: Warm assembly was completed in late summer 2022 (Fig. 3). We are currently completing cold-alignment and calibration of UCIS-Moon in lunar relevant conditions. UCIS-Moon will be calibrated using best practice characterization of uniformity, spectral and spatial response used for previous instruments such as High-resolution Volatiles and Minerals Moon Mapper (HVM3) and Mapping Imaging Spectrometer for Europa (MISE). Radiometric response will be characterized using a National Institute of Standards and Technology-traceable lamp from 600-2500 nm, and in longer wavelengths, a custom thermally controlled black body installed into the vacuum chamber to eliminate interference from atmospheric water vapor (same as HVM3).

Future work: UCIS-Moon will be demonstrated to TRL-6 by April 2023 and is expected to be proposed to future landed lunar missions.

Acknowledgments: This work was funded by a NASA Development and Advance of Lunar Instrumentation (DALI) program solicitation NNH18ZDA001N-DALI. This research was carried out the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.

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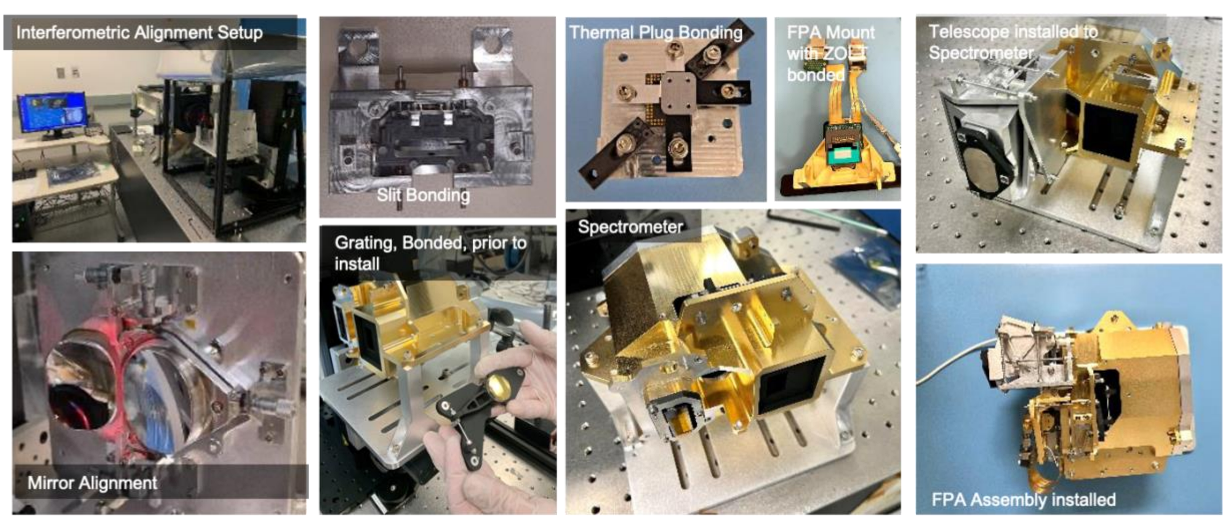

Fig. 3: UCIS-Moon warm assembly photos