THE ULTRA COMPACT IMAGING SPECTROMETER (UCIS): IN SITU IMAGING SPECTROSCOPY FOR MARS, THE MOON, and ASTEROIDS.

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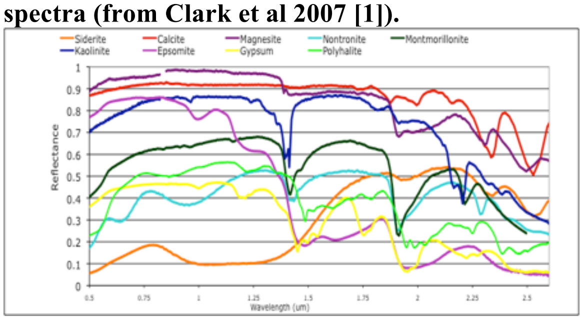
Introduction: In Situ imaging spectroscopy provides a way to address complex questions of geological evolution for aqueous, volcanic, and impact processes by mapping mineral composition at the spatial scale of rocks and outcrops. A compact instrument is needed to be able to adequately address these science questions from a landed platform. The Ultra Compact Imaging Spectrometer (UCIS) is designed to address the science needs and implementation constraints for in situ spectroscopy.

Figure 1. Diagnostic clay, sulfate, and carbonate spectra (from Clark et al 2007 [1]).



Why Visible to Short Wavelength Infrared Imaging Spectroscopy: Spectroscopy from 500-2600 nm is an established technique for measuring the mineralogy of sedimentary (e.g. figure 1) and igneous (e.g. figure 2) rocks, outcrops, and regoliths. Minerals exhibit absorption features that are highly diagnostic of their structure and composition. Imaging spectroscopy allows for mineralogy to be mapped at geological important special scales thus allowing for the investigation of the spatial relationship between minerals and compositions. The next step after "What is it made of?" is "How is it put together?" The combination of mineralogy and geologic context allows for detailed investigation of geologic and geochemical processes of planets, asteroids, comets, and moons.

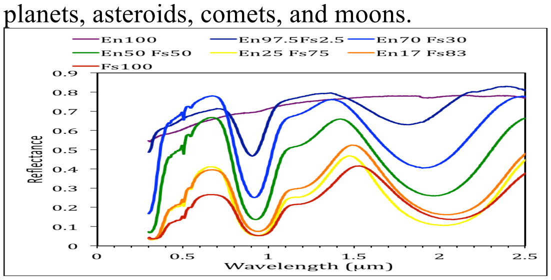


Figure 2. Pyroxene spectra ranging from 100% Mg rich (En100) to 100% Fe rich (Fs100). (Spectra from Klima et al., 2007 [2]).

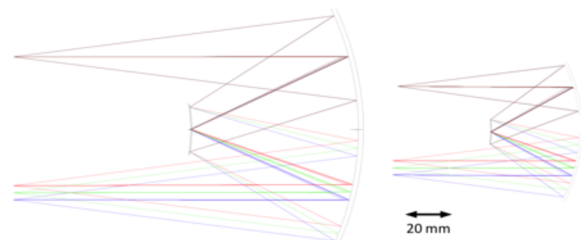


Figure 3. Optical ray traces for the M3 (left) and UCIS (right) imaging Spectrometers.

In Situ Imaging Spectroscopy: In Situ instrumentation is highly mass and power constrained. Traditional imaging spectrometers such as Cassini VIMS, MRO CRIMS, and Chandryaan-I M3 are too massive and power intensive to put on a rover or lander (see table 1). UCIS is an Offner spectrometer with Moon Mineralogy Mapper (M3) heritage. However, the optics of UCIS are much more compact than M3 (figure 3). This allows for significantly lower instrument mass and volume.

Table 1. Evolution in Imaging Spectrometers

Inst.	Mass	Power	Type	Built
Cassini VIMS (JPL)	37 kg	~22 W	Orbital (Saturn)	1997
MRO CRISM (APL)	33 kg	~45 W	Orbital (Mars)	2005
Ch-I M3 (JPL)	8 kg	~13 W	Orbital (Moon)	2008
UCIS (JPL)	< 2 kg on mast, 1.4 kg electronics	~5.2 W	In Situ	2012

The Ultra Compact Imaging Spectrometer (UCIS): UCIS is a JPL developed imaging spectrometer (figure 4) suitable for inclusion on a Mars or lunar rover or asteroid lander but packaged for operation at terrestrial ambient conditions. UCIS is an Offner spectrometer using JPL e-beam gratings, HgCdTe detectors with many components having direct heritage from M^3. Spectrometer specifications are given in Table 2.

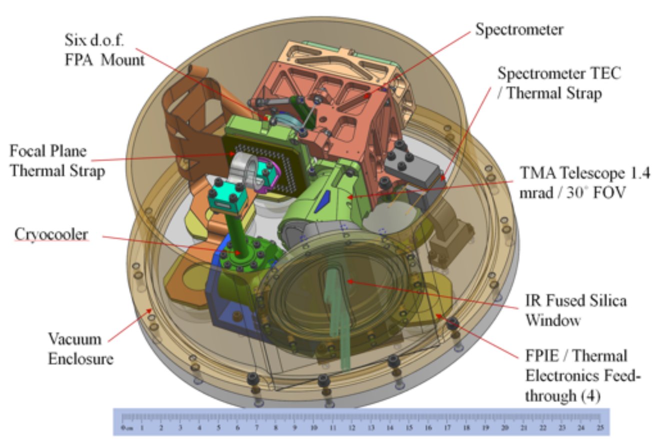
Table 2. UCIS Spectrometer Specifications.

Spectral	Range	500-2600 nm
	Sampling	10 nm
Spatial	Field of view	30 deg
	Instantaneous FOV	1.4 mrad
	Spatial swath	380 pixels
Radiometric	Range	0 – 97% R
	SNR	>300 *
Uniformity	Spectral cross-track	>97% **
	Spectral IFOV mixing	< 3% ***

*: specified through entire spectral range, for typical hematite reflectance. **: straightness of monochromatic slit image (smile <3% of pixel width). ***: misregistration of spectrum to array row (keystone).

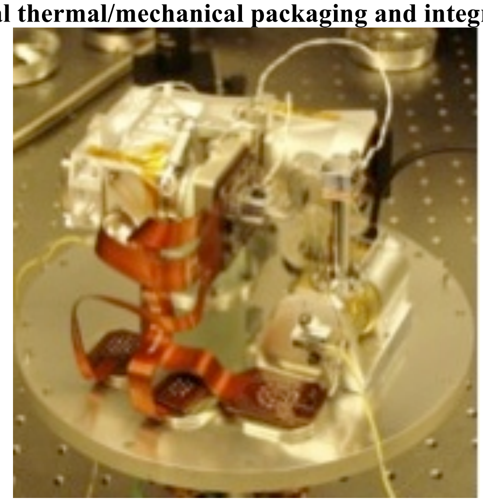
Thermal Designs: Imaging spectrometers require cryogenic temperatures. Under terrestrial ambient conditions, water ice condenses on the cold portions of the instrument. Water ice in thin layers can attenuate light and reduce/eliminate the signal and with extended exposure (especially after the spectrometer warms up and the ice melts) may cause damage to the instrument. The UCIS instrument is intended for use in actual field operations on Earth. Thus the system design was completed with a vacuum enclosure and thermal control system suitable for a terrestrial desert environment. However other UCIS thermal designs exist for Martian, lunar, comet, and asteroid versions of the instrument.

Figure 4. UCIS (Terrestrial Field Version).



Current UCIS Status: UCIS in its terrestrial field configuration is in the final stages of integration (figure 5). Initial optical measurements [3] and subsequent testing indicate that UCIS is expected to meet the optical performance requirements given in Table 2. The focal plane array has also been successfully integrated. Final integration of the thermal control system is now underway. First light on the integrated instrument expected the end of January 2012. Future work includes requirement verification, instrument calibration and field demonstration. Full imaging spectrometer data is expected to be available at the March LPSC meeting.

Figure 5. UCIS as of Jan 4, 2011 undergoing final thermal/mechanical packaging and integration.



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References:

[1] Clark, R. N et al.: USGS digital spectral library splib06a: U.S. Geological Survey, Digital Data Series 231. http://speclab.cr.usgs.gov/spectral-lib.html, 2008.
[2] Klima RL, CM Pieters, MD Dyar (2007) Spectroscopy of synthetic Mg-Fe pyroxenes I: Spin-allowed and spin-forbidden crystal field bands in the visible and near-infrared. *Meteoritics and Planetary Science* 42: 235-253.
[3] Van Gorp et al., Optical design and performance of the Ultra-Compact Imaging Spectrometer, SPIE Optics and Photonics, San Diego, Aug 21-25, 2011.