TEN METER-SCALE THERMAL INFRARED SPECTROSCOPY AND THERMOPHYSICAL PROPERTIES FROM MARS ORBIT P. G. Lucey[1], T. D. Glotch[2], A. D. Rogers[2] and Benjamin Greenhagen [3]. [1]University of Hawaii, 1680 East West Road, Honolulu HI, 96822, lucey@higp.hawaii.edu; [2]Department of Geosciences, Stony Brook University; [3]Jet Propulson Laboratory, Pasadena CA

Introduction: Recent data from the Mars Reconnaissance Orbiter (MRO) have clearly demonstrated the breakthrough value of combining high spatial resolution topography with unprecedented decameter-scale compositional imaging. While the discoveries to date have confirmed and extended the new paradigm for the evolution of the Mars chemical environment [1-3], near-infrared (NIR) imaging spectroscopy from the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) does not capture all the compositional and physical property information accessible to remote sensing that is critical to landing site identification and characterization, as well as rover trafficability.

A two year PIDDP program has demonstrated that hyperspectral imaging at thermal-infrared (TIR) wavelengths can be carried out at extremely high spatial resolution, using a low-resource spectrometer that uses minimal cooling, and hence power [4-6]. Equipped with a 50 cm telescope (similar to HiRISE), this instrument would return TIR hyperspectral images (tuned to the 3-12 µm region most important to detecting a variety of mineral phases on Mars), and temperature images used to retrieve surface physical properties, at approximately 10-meter resolution. This instrument (refered to herein as HiTES) would produce compositional images of phyllosilicates, sulfates, chlorides, carbonates and primary igneous minerals with a methodology complementary to CRISM, as well as characterize the surface thermophysical properties (including rock abundance , surface roughness and thermal inertia) at decameter scale to support rover traverse planning and safety.

A Spectral Complement to CRISM, TES and THEMIS: TIR spectroscopy is sensitive to minerals not detectable by NIR spectroscopic instruments, including feldspars and anhydrous silica and sulfate phases. TIR spectroscopy also provides detailed information on the hydration state of polyhydrated sulfates, which are often indistinguishable from each other at NIR wavelengths [7]. While carbonates, sulfates, and phyllosilicates have been difficult to detect with TES and THEMIS due to their relatively low spatial resolution (TES), or sparse spectral sampling (THEMIS), HiTES will be able to provide confirmatory detections, and abundance, of carbonates, sulfates, and phyllosilicates and direct detection of silica phases [8,9]. As thermal alteration affects the TIR and NIR spectra of hydrated phases differently, HiTES will also provide a tool to assess the post-depositional thermal history of (eg. impact bombardment, volcanic interactions, burial) of sedimentary deposits, which may have implications for biosignature preservation [10]. All of these detections would be carried out at TES spectral resolution, but with two times higher spatial resolution than CRISM. For surfaces with particle sizes > ~60 µm, linear spectral mixture analysis can be performed [11] on HiTES data, resulting in mineral modal abundances in addition to detections.

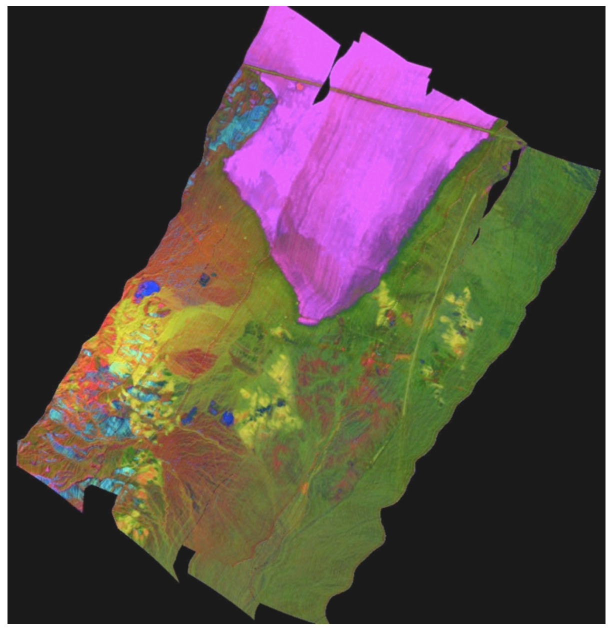

Figure 1. 1-meter resolution thermal IR hyperspectral imaging near Silver Lake CA, where carbonates, silica, phyllosilicates and a variety of other silicates are detected.

Thermophysical Properties at Unprecedented Spatial Resolution: The 10-meter thermal imaging inherent to this technique will allow determination of thermophysical properties at that scale. Planning of rover traverses will be greatly aided by knowledge of the decameter-scale thermal inertia of the local region. Rover safety may also be enhanced. It is possible that Spirit could have avoided its sand trap if thermal inertia measurements at HiTES scales had been available.

Continued atmospheric monitoring: The spectral range of HiTES allows for continued monitoring of atmospheric gases and aerosols, and would extend the Mars climatology measurments made by TES and THEMIS to additional years. Atmospheric monitoring is critical for planning rover EDL.

Technology: The HiTES instrument is an spatial interferometer equipped with a HgCdTe detector array. Because the detector array only views low emissivity surfaces, the interferometer itself is not cooled. The detector array, which operates at 65K, is the only cooled element in the system. Based on terrestrial experiments using a prototype instrument, we have calculated that there is sufficient thermal signal, even during martian night at low- to mid-latitudes, to collect hyperspectral data without image motion compensation, simplifying the instrument and its impact on spacecraft operations. Because only the detector is cooled, the cryocooler is only run just prior to, and during, data collection, which results in minimum in power consumption. The instrument uses a two temperature calibration at an intermediate focal plane allowing very small and low power sources, and a single temperature instrument cover for through-optics calibration.

Instrument and Data Characteristics.	
Spectral Range	3-12 microns
Spectral Resolution	10 wavenumbers
Spatial Resolution	10 meters
Swath Width	3.2 km
Swath Length	arbitrary
Mass	50 kg (scaled from HIRISE)
Power	10 watts (during data collection)

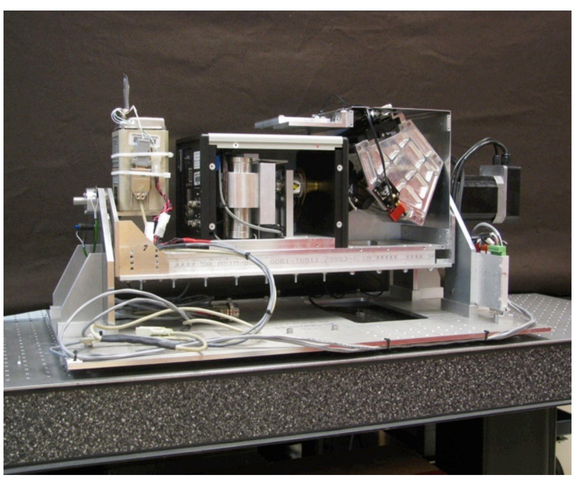

Figure 2. Airborne version of the instrument developed under PIDDP funding.

Demonstration: A HiTES prototype (Fig. 2) has been built and flown for several months verifying the performance predictions in [5]. It has collected thermal hyperspectral data at 35 cm resolution demonstrating the ability to detect major minerals and a variety of gases.

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Acknowledgments: This work was supported by NASA Grant NNX09AN27G under the Planetary Instrument Definition and Development Program (PIDDP).