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The High-resolution Stereo Color Imager (HiSCI) on ExoMars Trace Gas Orbiter (TGO)

A. McEwen[1], N. Thomas[2], J. Bridges[3], S. Byrne[1], G. Cremonese[4], W. Delamere[5], C. Hansen[6], E. Hauber[7], A. Ivanov[8], L. Kestay[9], R. Kirk[9], N. Mangold[10], W.J. Markiewicz[11], M. Massironi[4], S. Mattson[1], C. Okubo[9], J. Wray[12]. [1]Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ, USA (mcewen@lpl.arizona.edu), [2]U. Bern, [3]U. Leicester, [4]INAF, [5]DSS, [6]PSI, [7]DLR, [8]EPFL, [9]USGS, [10]U. Nantes, [11]MPI, [12]Cornell U.

Abstract

HiSCI has been chosen for the payload of the *ExoMars Trace Gas Orbiter (TGO),* a joint ESA/NASA mission scheduled to arrive at Mars in 2016 [1]. There are 3 major HiSCI partners: (1) the telescope assembly will be built in Switzerland overseen by the University of Bern; (2) the overall design, electronics, and integration will be by Ball Aerospace in Colorado; and (3) operations will be joint with *MRO*'s High Resolution Imaging Science Experiment (HiRISE) [2] at the University of Arizona. HiSCI will acquire the best-ever colour and stereo images over significant areas of Mars.

1. Introduction

The chief objective of *TGO* is to search for and map the spatial and temporal distribution of disequilibrium trace gases with high-resolution spectrometers [1]. Once localized, a key question is: What is the nature of the source regions? Spectra obtained in both occultation and nadir modes combined with atmospheric monitoring and modeling will make it possible to determine source locations to ~100 km. HiSCI will then image candidate features within these source regions at 2 m/pixel, in 4 colours, and in stereo, over an 8.5-km swath width. If no sources are identified or confirmed, HiSCI will nevertheless lead to many new results on active (and ancient) Martian processes.

Many viable hypotheses exist for the origin(s) and release of Martian atmospheric trace gases such as methane; all involve active surface processes. Dust deposition homogenizes surface colours over time, but other active processes create spatial and temporal colour variability. To identify colour anomalies and hence active locations, colour imaging at high spatial resolution and high signal to noise ratio (SNR) is essential. Topographic data at similar resolution are also needed to understand physical processes and to orthorectify images for reliable change detection [3].

MRO's HiRISE has revealed spectacular small-scale colour diversity, but suffers from a very narrow colour swath width. HiSCI will exceed by >20x the colour and stereo coverage of Mars per year by HiRISE, and will image at significantly better resolution and SNR than the extensive coverage by the *MRO* Context Camera (CTX) and Mars Express High Resolution Stereo Camera (HRSC) (Figure 1). HiSCI will have excellent stray light rejection and essentially identical photometric angles and atmospheric path lengths for each colour image.

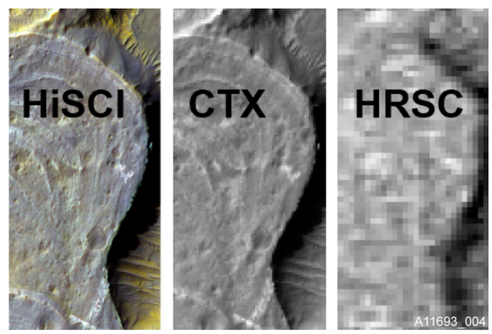

Figure 1: HiSCI (HiRISE reduced to 2 m/pixel), CTX (5.5 m/pixel), and HRSC (12.5 m/pixel) images of fluvial landforms in Eberswalde delta.

2. Science Objectives

HiSCI has 3 main objectives, to: (1) better understand active or potentially active surface processes, (2) map regions known to release trace gases, and (3) complete the certification of new candidate landing sites. For active processes we will focus on better understanding of:

- Seasonal processes (frost, gullies, aeolian)
- Shallow subsurface ice and related processes
- Impact processes
- Tectonic, volcanic, and hydrothermal processes
- Slope and mass wasting processes
- Fluvial processes
- Mineralogy and stratigraphy
- Anomalous clouds

HiSCI may be the only high-resolution orbital imaging available during the joint Mars surface missions of 2018 and beyond. *TGO* trace gas results could lead to surprising new high-priority locations for future surface exploration, but it is highly unlikely that certified landing sites would already lie next to such locations. HiRISE has acquired >19,000 images to identify meter-scale hazards, but only ~2,500 stereo pairs covering <0.2% of the surface. HiSCI will provide the ~6 m (~1 m vertical) scale topographic data needed to complete certification of new candidate landing sites with HiRISE sampling of meter-scale hazards.

3. The HiSCI Experiment

High SNR is essential to mapping subtle colour differences through a dusty atmosphere. A modest-size high-resolution camera can achieve high SNR via time delay integration (TDI), which in turn requires orienting the pixel columns parallel to image motion to prevent smear. *TGO* plans a yaw strategy to keep one side of the spacecraft sun-pointed, so HiSCI must have a yaw rotation drive (YaRD) to align the TDI columns with image motion.

HiSCI also will use the YaRD to acquire along track stereo imaging. The benefit of along-track stereo is that it ensures identical illumination angles for optimal stereo correlations. The telescope will point 10° away from nadir in the direction of TDI motion. A stereo pair is acquired by first rotating the telescope to point ahead 10° to image, then rotating it 180° to point 10° behind for the second stereo view. The build-to-print CCDs feature bidirectional TDI, essential to HiSCI stereo. The 10° look angle increases the pixel scale and atmospheric path length by only 1.5%, yet provides a slightly larger than 20° stereo convergence angle (accounting for planetary curvature).

TGO will have an inclined orbit (~74°) so HiSCI cannot image latitudes greater than 74°, unless the spacecraft adapts a new mode of pointing off-nadir. TGO will enable observations at all times of day to better understand seasonal processes.

4. Synergy with *MRO*'s CRISM

MRO's Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) [4] provides high-SNR data in 545 wavelengths to map a wide range of hydrated minerals, but at no better than 18 m/pixel scale. Co-analysis of HiSCI and CRISM data will be an important part of the HiSCI investigation. The 2 m/pixel colour imaging improves mapping and interpretation of mineral units identified by CRISM, and Digital Terrain Models (DTMs) will enable orthorectification of CRISM and HiSCI data for stratigraphic measurements.

6. Data Products

We will produce a set of data products similar to those from HiRISE, including calibrated and map-projected 4-colour products. Thousands of stereo pairs will be processed into colour anaglyphs, and hundreds of DTMs will be produced at US and European centers. HiSCI will continue the new standard set by HiRISE for rapid release of high-level data products to NASA's Planetary Data System (PDS), and to ESA's Planetary Science Archive (PSA). We will release image products as soon as is practical, typically 1 month after acquisition rather than the required 6 months. There will be a website similar to http://hirise.lpl.arizona.edu and a mirror website at the University of Bern. We also plan an extensive public outreach program including colour flyover movies from HiSCI stereo.

Figure 2: Simulated 2 m/pixel HiSCI image of stratigraphy near Mawrth Vallis.

References

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