THE COLOUR AND STEREO SURFACE IMAGING SYSTEM FOR ESA'S TRACE GAS ORBITER. N. Thomas[1], G. Cremonese[2], A.S. McEwen[10], R. Ziethe[1], M. Gerber[1], M. Brändli[1], M. Erismann[1], L. Gambicorti[1], T. Gerber[3], K. Ghose[1], M. Gruber[1], P. Gubler[1], H. Mischler[1], J. Jost[1], D. Piazza[1], A. Pommerol[1], M. Rieder[1], V. Roloff[1], A. Servonet[1], W. Trottmann[1], T. Uthaicharoenpong[1], C. Zimmermann[1], D. Vernani[4], M. Johnson[4], E. Pelò[4], T. Weigel[4], J. Viertl[4], N. De Roux[4], P. Lochmatter[4], G. Sutter[4], A. Casciello[4], T. Hausner[4], I. Ficai Veltroni[5], V. Da Deppo[6], P. Orleanski[7], W. Nowosielski[7], T. Zawistowski[7], S. Szalai[8], B. Sodor[8], G. Troznai[8], M. Banaskiewicz[7], J.C. Bridges[9], S. Byrne[10], S. Debei[11], M.R. El-Maarry[1], E. Hauber[12], C.J. Hansen[13], A. Ivanov[14], L. Keszthelyi[15], R. Kirk[15], R. Kuzmin[16], N. Mangold[17], L. Marinangeli[18], W.J. Markiewicz[19], M. Massironi[20], C. Okubo[15], L.L. Tornabene[21], P. Wajer[7], J.J. Wray[22]
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Introduction: The Colour and Stereo Surface Imaging System (CaSSIS) is an 11 µrad/px imaging system ready to launch on the European Space Agency's (ESA) ExoMars Trace Gas Orbiter (TGO) on 14 March 2016 from Baikonur. The instrument concept is derived from the HiSCI instrument originally proposed for TGO in 2010 [1] as a response to requirements in a NASA Announcement of Opportunity which drew on a NASA-ESA Joint Instrument Definition Team report [2]. This report foresaw a High Resolution Stereo Color Camera that would provide ~1 m/pixel, near-simultaneous colour stereo to discriminate water ice, and surface variations related to potential trace gas sources and detection of surface changes.

Although similar in scope to HiSCI, CaSSIS has important differences forced by the need to meet a highly accelerated schedule and reduced mass and volume allocations [3]. We describe the basic instrument specifications and the expected scientific return.

Instrument Description: CaSSIS is based around an 880 mm focal length carbon-fibre reinforced polymer (CFRP) telescope with a 135 mm primary mirror and a 2k x 2k CMOS hybrid detector with 10 micron pixel pitch providing 4.6 m/px imaging from the nominal 400 km circular orbit. The telescope is a slightly modified three mirror anastigmat optical configuration with no central obscuration. The instrument is designed to operate in "push-frame" mode where 2048 x 256 images are acquired at a repetition rate which matches the ground-track velocity (~3 km/s) allowing sufficient overlap for co-registration thereby building image strips along the surface.

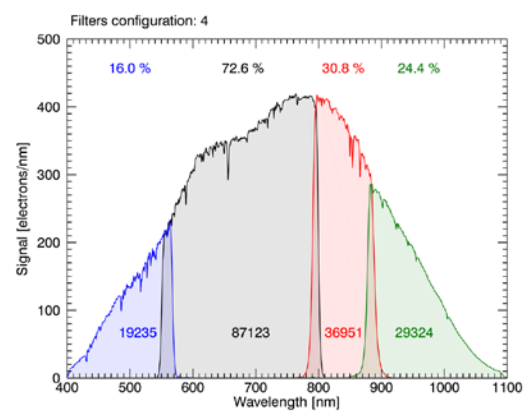

Figure 1. The CaSSIS filter response curves giving the expected signal levels (e-) for a dark Mars surface at a solar incidence angle of 60 degrees with an acquisition time of 1.5 ms. Percent of full well given at the top.

A filter strip assembly (FSA) is mounted directly above the detector providing images in 4 wavelength bands. Two of these (480.5nm and 676.5nm prior to convolution with the rest of the instrument) correspond closely to bands used by the HiRISE instrument on the Mars Reconnaissance Orbiter [4]. Two other filters split the NIR wavelengths with centres at 838 nm and close to 985 nm. The expected signal levels are shown in Figure 1. Analyses show that the filters provide good differentiation between expected surface minerals, particularly Fe-bearing phases [5].

CaSSIS is designed to produce stereo from images acquired ~30 s apart by using a rotation drive (Figure 2). The telescope points 10 degrees off-nadir. The drive aligns the telescope with the ground-track direction so that the telescope is pointing forward. After image acquisition, the telescope is rapidly rotated by 180 degrees to point in the opposite direction and the second image of the stereo pair is acquired.

The instrument has flexibility in image acquisition (swath width, swath length, binning, compression, etc.) but is restricted to a total data volume of 2.9 Gbit/day. This would typically allow 4-6 stereo pairs plus several additional non-stereo targets per Mars day. Coverage will be of ~3% of the Martian surface per Mars year.

The instrument is shown in Figure 3 and comprises two units. The Camera Rotation Unit (CRU) consists of the telescope, the detector and the rotation drive. The instrument is controlled from the second unit, the Electronics Unit (ELU), which houses the power supply, the onboard computer, and the rotation control electronics. CaSSIS weighs 18 kg and its volume can be gauged from Figure 3.

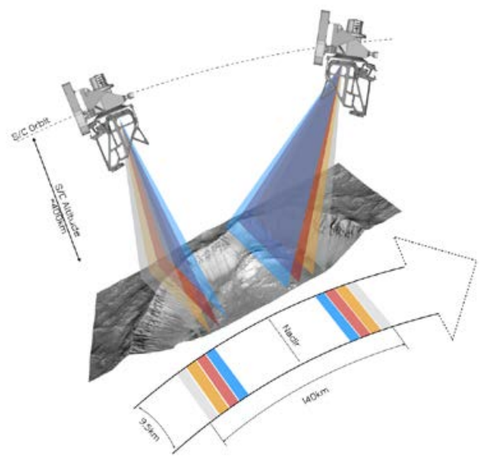

Figure 2. The stereo concept of CaSSIS. The instrument points 10 degrees forward to acquire the first image. After completing the image, a rotation drive turns the telescope by 180 degrees to point backward and the second image is acquired, with a total convergence angle of 22.4 degrees.

Science: The concept of CaSSIS has been constructed to complement previous imagers. CaSSIS will extend the monitoring of past missions to future years allowing the tracking of longer-term changes. It will also provide contemporaneous imaging of regions that may produce unique signatures detected by other instruments such as localized trace gases. The additional coverage provided will complement the moderate to high resolution coverage provided by HiRISE and CTX and will significantly improve upon the colour coverage and photometry of previous missions.

The orbit of TGO also provides another major scientific opportunity. The 74 degree inclination, circular orbit is not Sun-synchronous. Hence, imaging at different local times will be possible, allowing searches for diurnal effects. This may be of major importance for the investigation of, for example, RSL [6] and sublimation processes in the 55-75 degree latitude range. The diurnal variation of other dynamic phenomena, for example those associated with weather, can also be investigated.

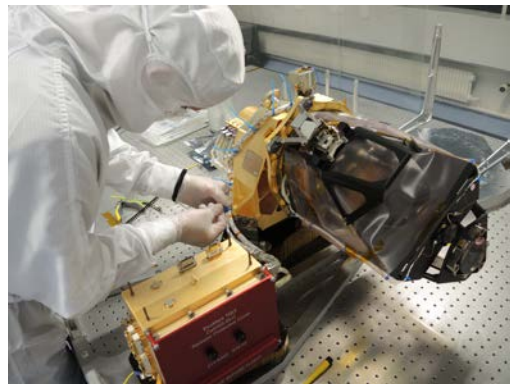

Figure 3. The CaSSIS instrument on the bench (with the senior electronics engineer for scale). The electronics box is to the left. The camera rotation unit is to the right. The telescope is the mostly black structure cantilvered off the golden structure which includes the rotation drive.

Acknowledgements: The authors wish to thank the spacecraft and instrument engineering teams for the successful completion of the instrument. CaSSIS is a project of the University of Bern and funded through the Swiss Space Office via ESA's PRODEX programme. The instrument hardware development was also supported by the Italian Space Agency (ASI) (ASI-INAF agreement no.I/018/12/0), INAF/Astronomical Observatory of Padova, and the Space Research Center (CBK) in Warsaw. Support from SGF (Budapest), the University of Arizona (Lunar and Planetary Lab.) and NASA are also gratefully acknowledged.

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Additional Information:
http://space.unibe.ch/pig/science/projects/cassis.html