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Scientific calibration and analysis of calibration data for the CaSSIS instrument of the ExoMars Trace Gas Orbiter

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Abstract

The Colour and Stereo Surface Imaging System (CaSSIS) is a camera, the development of which is led by the University of Bern (CH), with hardware contributions from the University of Padova (I) and the Space Research Center of Warsaw (Pl). It will take high resolution stereo images in 4 colours of the Martian surface, from on board the ExoMars Trace Gas Orbiter. Our calibration facility stands ready to perform the required measurements. We are currently testing the procedures on a dummy system and we will report on calibration results of the CaSSIS instrument.

1. Introduction

The ESA-lead ExoMars Trace Gas Orbiter (TGO), to be launched in 2016, will demonstrate key flight and in-situ enabling technologies by searching for signs of past and present life on Mars, and, investigate the geochemical environment and atmospheric trace gases and their sources [1]. The TGO will carry 4 scientific instruments: the atmospheric spectrometers NOMAD and ACS, the neutron detector FREND, and the camera CaSSIS (Colour and Stereo Surface Imaging System). The development of CaSSIS is led by the University of Bern (CH), with hardware contributions from the University of Padova (I) and the Space Research Center of Warsaw (Pl).

2. CaSSIS

CaSSIS will characterise sites which have been identified as potential sources of trace gases, investigate dynamic surface processes, and thus certify potential future landing sites. The instrument comprises two major units: Camera Rotation Unit (CRU) and Electronics Unit (ELU). The CRU is composed of the telescope (including focal plane and associated electronics), the rotation system, cable management system and some structure to support all of the above and mount the CRU to the spacecraft. The ELU contains the boards with the electronics required to operate the camera.

The CaSSIS telescope is a three-mirror astigmatic system (off-axis) and fold mirror, with power on all 4 reflecting surfaces. The detector is a Raytheon Osprey 2k CMOS hybrid comprising 2k×2k pixels with 10 μm pitch, which allows snapshot operation at a readout rate of 5 MPixel/s with 14 bit resolution. CaSSIS will operate in the push-frame mode with this system, with a focal plane consisting of the detector mounted with 4 colour filters: PAN 550–800 nm; Red 790–910 nm; Blue-Green 435–565 nm; and IR 875–1025 nm.

It will observe a 9 km-wide swath width, with a surface resolution of <5 m/pixel, capable of producing 1 full-resolution stereo image pair of the Martian surface per orbit. The imager has been designed to look 10° ahead of the spacecraft as the first image is taken. After the instrument rotates by 180° passing over a desired target, the imager is consequently pointing backwards by 10° for the second image. It is this process and mechanism that allows for the quasi-simultaneous stereo image acquisition.

3. Calibration Facility

A room at the University of Bern has been converted to a Class 100 (ISO 5) clean room (Figure 1). It includes a laminar flow system, calibration/integration room, and an optical bench. Our facility is complete and stands ready to perform the calibration of CaSSIS.

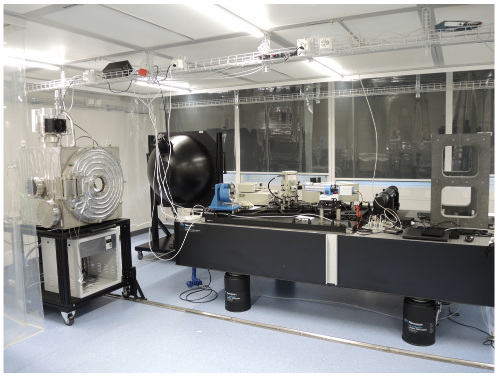

Figure 1: The class 100 (ISO 5) clean room, including laminar flow system and calibration/integration room. Left: the vacuum chamber, with the black integrating sphere distant centre-left. Right: dark grey optical bench on which stands the collimator, off-axis parabola, monochromator, and vertical stand.

4. Procedures

The calibration procedures of CaSSIS have been inspired by that of HiRISE and OSIRIS [2]. In order to correct for various types of noise and distortion, to characterise, and therefore optimise the performance of CaSSIS, we are to perform the following tests:

- *Flat-field, linearity, and absolute response*. For corrections caused by differences in pixel-to-pixel sensitivity and detector response.
- *Bias levels and dark current of the detector*. Needed to correct for the randomly-generated noise within the detector, and also its variance with temperature.
- *Point spread function (PSF)*. To measure the response of the system when observing a point source, and how this response varies with temperature.
- *In-field straylight*. Light from scattered or diffuse reflections impairs ability to reach and maintain required signal-to-noise ratio. With measurements of the PSF, straylight may be corrected.
- *Relative spectral response*. Gives the combined system efficiency including filter transmission and detector sensitivity. Measured at ambient temperature, and under thermal load, it is important to determine the correct colour ratio in observations.
- *Focal length and angular scale*. Required to determine the scale of each image.
- *Geometric distortion*. Critical measurement for reconstructing the digital terrain models from the stereo images.
- *Performance of the rotation mechanism*. Ensuring the efficiency of its performance and to foresee potential problems.
- *Performance of the digital processing module in a flight data acquisition simulation*.

At the time of writing, we are testing the procedures listed on a dummy CaSSIS system. Figure 2, as an example, displays the results obtained testing the linearity of the system. The presentation will show some of the results.

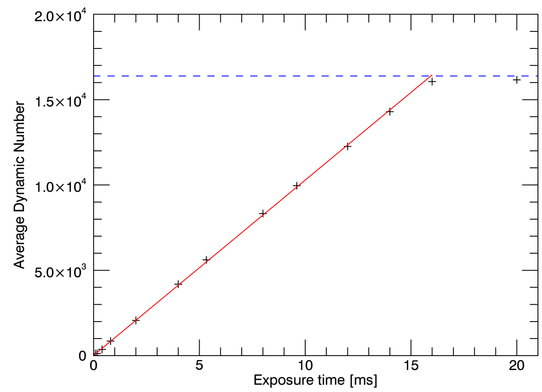

Figure 2: Linear response of the dummy CaSSIS system, from images of different exposure times.

Acknowledgements

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References

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