THE COLOR CAMERAS ON THE INSIGHT MARS LANDER, J. Maki[1], A. Trebi-Ollennu[1], R. Deen[1], M. Golombek[1], H. Abarca[1], C. Sorice[1], B. Banerdt[1], M. Schwochert[1], [1]Jet Propulsion Laboratory, California Institute of Technology (4800 Oak Grove Drive, Pasadena, CA 91109, Justin.N.Maki@jpl.nasa.gov).

Introduction: The InSight spacecraft is scheduled for launch in May 2018 with a Mars landing six months later in November 2018 [1]. The key objective of the InSight mission is the investigation of the interior structure and processes of Mars using a seismometer (SEIS) [2] and heat flow probe (HP^3) [3]. A robotic arm will lift these instruments off of the top deck of the lander and place them onto the ground at specific locations chosen by the InSight science and engineering teams. To assist in this deployment task, the lander is equipped with two cameras: an Instrument Deployment Camera (IDC) mounted on the robotic arm and an Instrument Context Camera (ICC) mounted on the lander body underneath the top deck (Figure 1).

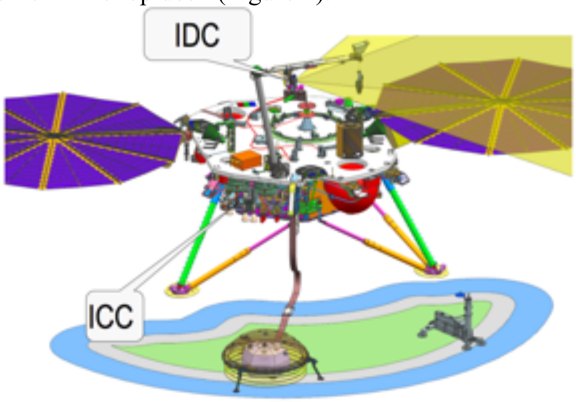

Figure 1: Locations of the IDC and ICC on the InSight lander. The IDC is located on the robotic arm and the ICC is mounted directly to the lander body.

IDC/ICC Instrument Objectives: The primary objectives of the IDC and ICC are to: 1) support terrain assessment for the selection of the SEIS and HP^3 instrument deployment locations, 2) facilitate and document the deployment activities, and 3) monitor the location and state of the instruments post-deployment. In addition, images will be used to investigate the geology and physical properties of the landing site [4]. These objectives are met by the acquisition of images of the lander deck and the deployment workspace, nominally located to the south of the lander. A full panorama as well as surface change detection images are also planned. In addition to single monoscopic images, stereo IDC images are acquired by moving the arm-mounted camera between images.

Instrument Description: Both InSight cameras are flight spare units from MSL [5], which flew build-to-print copies of the Mars Exploration Rover (MER) cameras [7]. The InSight project has converted the MSL cameras from grey-scale to color by replacing the MSL detector with a Bayer color filter array (CFA) version of the same detector. The cameras utilize frame transfer charge-coupled devices (CCDs) (see Table 1 for a summary of CCD properties). The camera electronics and optical assemblies are otherwise unchanged from MSL. Both cameras use identical camera heads and readout electronics, differing only in the type of lens mounted to the camera head. For a more detailed description of the InSight cameras, see [7].

Table 1. ICC and IDC Detector Summary

Detector ADC	12 bits
Pixel Size	12 x 12 microns
Photosensitive area	1024 x 1024 pixels
Fill Factor	100%
CCD readout time	6.3 seconds
Exposure time	0-406 seconds, in steps of 6.2 msec.
Full well (nominal)	170,000 e-

Instrument Deployment Camera (IDC): The IDC is flight spare MSL Navcam Serial Number 210. It has a medium field of view (FOV) f/12 lens. The resulting instantaneous FOV (IFOV) is 0.82 mrad/pixel, identical to the MER/MSL Navcams. Table 2 lists the optical properties of the IDC.

Table 2. IDC Summary

Angular Resolution at the center of the FOV	0.82 mrad/pixel
Focal Length	14.67 mm
f/number	12
Entrance Pupil Diameter	1.25 mm
Field of View	45 x 45 degrees
Diagonal FOV	67 degrees
Depth of Field	0.5 meters – infinity
Best Focus	1.0 m
Bandpass centers (approximate)	R (600 nm) G (550 nm) B (500 nm)

An example IDC image is shown in Figure 2. Spatial resolution in an IDC image depends on the position of the camera relative to the ground; typical values are ~1 mm/pixel. Also shown in Figure 2 are XYZ, range, and slope images.

Because it is attached to the robotic arm near the elbow, the IDC field of regard can cover areas above and below the lander deck, including views of the lander footpads, equipment on top of the lander deck, the sky, and terrain not obscured by the lander. The IDC FOV includes the scoop at the end of the arm and the grapple fixture, as shown in the upper left of the images in Figure 2.

Instrument Context Camera (ICC): The ICC is MSL flight spare Hazcam Serial Number 203. It has a fisheye lens with a focal ratio of f/15. The IFOV of the ICC is 2.1 mrad/pixel, the same as the MER/MSL Hazcam. Table 3 lists the optical properties of the ICC.

Table 3. ICC Summary

Angular Resolution at the center of the FOV	2.1 mrad/pixel
Focal Length	5.58 mm
f/number	15
Entrance Pupil Diameter	0.37 mm
Field of View	124 x 124 degrees
Diagonal FOV	180 degrees
Depth of Field	0.10 m – infinity
Best Focus	0.5 meters
Bandpass centers (approximate)	R (600 nm) G (550 nm) B (500 nm)

Flight Processing of Image Data: All onboard IDC/ICC image processing is done by the lander flight software running on the lander computer. After an image is read out from the camera, a shutter image is also acquired and subtracted from the image of interest; this removes frame transfer readout smear and dark current. The raw Bayer image is then demosaicked into RGB triplets, color balanced onboard using preloaded color correction coefficients, and companded to 8 bits using a 12-to-8 bit square root lookup table (LUT). The resultant images are JPEG-compressed by the lander computer and packetized for downlink. Typical JPEG quality values used for deployment activites are 85, 90, and 95, which correspond approximately to compressed bit rates of 1, 2, and 3 bits/pixel, respectively (the exact relationship between compression quality and bit rate is scene-dependent).

Ground Processing: Once on the ground, images are processed by the JPL Multimission Image Processing Laboratory (MIPL) using heritage image processing software from the MER and MSL missions [8]. The resulting three-dimensional (3D) terrain maps will be scrutinized by the science and engineering teams, and after careful topographical evaluation the operations team will command the robotic arm to place the instruments at the selected locations. The ICC will provide a wide-angle view of the activities during the deployment and will also serve as a partial backup to the IDC.

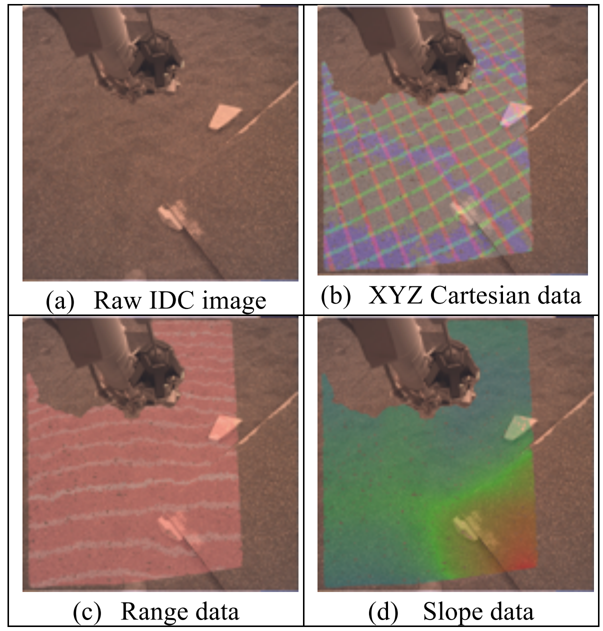

Figure 2. IDC stereo image data acquired in the InSight testbed at JPL. Red, green, and blue contours correspond to X,Y,Z in (b). Contours are spaced 10 cm apart in (b) and (c). Spatial resolution at the center of the image is ~1.4 mm/pixel.

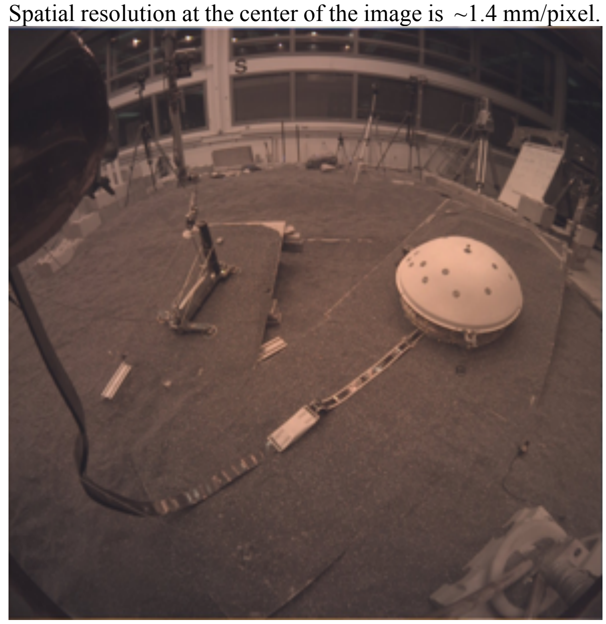

Figure 3. ICC image acquired in the InSight testbed at JPL.

References:

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