THE PHOENIX SURFACE STEREO IMAGER (SSI) INVESTIGATION. M.T. Lemmon[1], P. Smith[2], C. Shinohara[2], R. Tanner[2], P. Woida[2], A. Shaw[2], J. Hughes[2], R. Reynolds[2], R. Woida[2], J. Penegor[2], C. Oquest[2], S.F. Hviid[3], M.B. Madsen[4], M. Olsen[4], K. Leer[4], L. Drube[4], R.V. Morris[5], D. Britt[6]. [1]Texas A&M University, USA, [2]University of Arizona, USA, [3] Max-Planck-Institut für Sonnensystemforschung, Germany, [4]University of Copenhagen, Denmark, [5]NASA Johnson Space Center, USA, [6]The University of Central Florida, USA.

Introduction: The Phoenix Mars Lander will begin a 90-sol mission in Mars' north polar terrain on 25 May 2007. A Robotic Arm (RA) on the lander will dig one or more trenches, providing soil and ice samples to two deck chemistry instruments. Through the mission, a meteorology station (MET) and Lidar will measure pressure, temperature, and boundary layer properties. This abstract describes the multispectral science camera on Phoenix, the Surface Stereo Imager (SSI).

The capabilities of the SSI respond to a number of constraints, both scientific and operational. SSI will be used to derive digital terrain maps used to guide the RA in digging and sampling operations; thus it requires stereo viewing capabilities. Selection of scientific targets for digging and sampling will be guided by images of the RA workspace: a Robotic Arm camera offers close-up detail views and SSI adds multispectral imaging. Documentation of sample material around the on-deck instruments requires special diopter filters for maximum resolution. SSI will monitor atmospheric optical depths both for studying polar weather and for understanding spacecraft performance in combination with solar panel data; thus neutral density filters capable of direct solar imaging are included. Phoenix includes a tell-tale for wind measurements, and SSI is used to monitor the tell-tale.

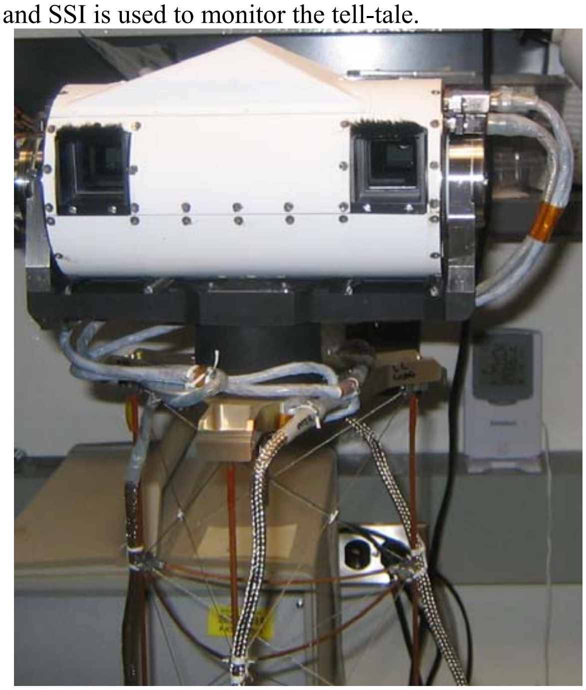

Figure 1. The SSI camera head.

Instrument design: SSI is mechanically similar to the Imager for Mars Pathfinder (IMP) [1] and to Mars Polar Lander's SSI [2]. The cylindrical camera head (Fig. 1) is set on a one-time deployable mast, 84 cm above the lander deck. The camera has two apertures, each protected from dust accumulation while in the stowed position. The eyes are separated by 15 cm to simulate human stereo vision. Stereo overlap is optimized for the RA workspace at 3 m from the camera head. Azimuth and elevation motors allow imaging from the zenith to -60º elevation through 360º of azimuth. Mirrors direct light through a dual-filter wheel with 12 positions for each eye. Fold mirrors then direct the light to the electronics assembly.

The detectors are Mars Exploration Rover (MER) flight spare Charge Coupled Devices (CCDs), similar to those in Pancam [3] and the MER engineering cameras [4]. The arrays are 1024×1024 pixels, with an instantaneous field of view (IFOV) of 0.24 mrad per pixel and a FOV of 14º. Spatial resolution in the RA workspace is ~1.5-2 mm.

The filter wheel contains red and blue matched stereo pairs, 6 neutral density filters for atmospheric dust and water vapor measurements, a total of 13 unique multispectral bands, infrared and blue diopters for deck images, and an infrared linear polarizer. Color and diopter filters are held in the right eye; infrared filters are in the left. Table 1 shows the SSI filter set. Most filters are in best focus near 3 m, with good focus from 2 m to infinity; the deck filters are in focus at 1-1.4 m.

Instrument calibration: Standard radiometric and geometric calibrations were performed with the SSI prior to launch. Dark current is low at expected operating temperatures, although it is high for room temperature tests, as is typical for MER CCDs. The camera response to light is comparable to Pancam performance, except that the solar filters were designed with less extinction to work with shorter exposures. Response across the detector is fairly uniform except for moderate vignetting around the fold mirrors. The nonuniformities can be well-corrected with filter and temperature dependent flat-field images.

The SSI supports calibration on the surface similar to IMP and Pancam. The lander deck has 3 reflectance calibration targets (RCTs). Each RCT has 6 sweep magnets [5] designed to protect the interior surface from magnetic dust accumulation (Fig. 2). Within these 6 magnets are 6 color samples: 20%, 40% and 60% gray scales and blue, green and goerthite pigments. In addition, there are 6 color samples without magnetic protection, and 4 samples with an experimental anti-static coating. The color samples are IMP and MER heritage materials, and have been calibrated for relfectance over a range of incidence, emission, and phase angles.

In addition, the SSI will acquire peridodic dark current calibration, using the solar filters and protected stowed position. Sky flat-field images will be used to monitor any dust accumulation. Four surveyed geometric fiducial targets on the lander deck will be used (with the surveyed RCTs) to monitor accurate range calibration and pointing refinement.

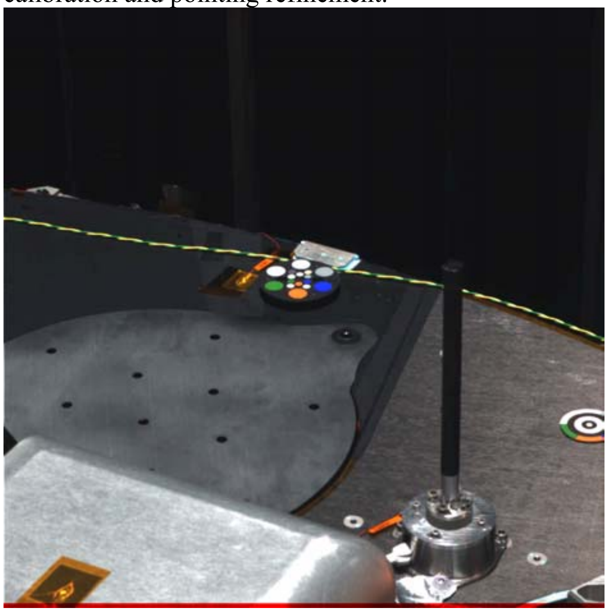

Figure 2. SSI color full-frame image (RGB = RA, RB, RC) of RCT nearest RA workspace during spacecraft tests. A geometric fiducial (right), UHF monopole antenna, and the mass spectrometer housing are also visible, as are a non-flight bracket and cables beyond the RCT.

The SSI investigation: SSI supports a variety of scientific investigations. Initial monochrome and color surveys of the site, especially the RA workspace, will allow identification of targets for further investigation. Stereo surveys of the workspace and beyond will be used to determine sizes, shapes, and angles (*e.g.,* for angle of repose or to estimate insolation on a trench wall). Sample site documentation can include 13-band photometry in addition to stereo imaging. Documentation of the delivered sample can include 2-color imaging at up to 0.25 mm/pixel. Solar imaging at 451, 671, 887, and 991 nm can be used to monitor aerosol optical depth and to separate dust and ice contributions [6]; while adding 935 nm imaging can be used to derive water vapor column abundance [7]. Sky imaging in various bands, including polarization can be used to monitor aerosol properties [8]. Images of lander targets support a magnetic properties experiment and wind measurements.

Table 1. SSI filters.

Filter #	Center wavelength (nm)	Bandwidth (nm)	Application
L1	673	19	Red stereo
L2	447	23	Blue stereo
L3	450.8	4.1	Solar/dust
L4	990.7	4.9	Solar/dust+water
L5	887.0	5.8	Solar/dust+water
L6	833	28	Surface
L7	802	22	Surface
L8	864	37	Surface
L9	900	45	Surface
LA	931	25	Surface
LB	1002	26	Surface
LC	968	30	Surface
R1	673	19	Red stereo
R2	447	23	Blue stereo
R3	671.1	4.9	Solar/dust
R4	935.5	5.2	Solar/water
R5	935.7	5.2	Solar/water
R6	450	29	Deck/blue diopter
R7	753	20	Deck/red diopter
R8	754	21	Surface
R9	753	17	Linear polarization
RA	604	15	Surface—red
RB	532	28	Surface—green
RC	485	21	Surface—blue

Notes: Left and right filters are always paired by the dual filter wheel. R9 is matched to R8, but with a linear polarizer. The solar filters have neutral density coatings with 3 orders of maginitude extinction.

References: [1] Smith, P.H., *et al*. (1997) *J. Geophys Res* **102**, 4003. [2] Smith, P.H., *et al*. (2001) *J. Geophys Res* **106**, 17589. [3] Bell *et al*. (2003) *J. Geophys Res* **108**, 8063. [4] Maki *et al.* (2003) *J. Geophys Res* **108**, 8071. [5] Madsen, M.B., (2003) *J. Geophys Res* **108**, 8069. [6] Smith, P.H. and M.T. Lemmon (1999) *J. Geophys Res* **104**, 8975. [7] Titov, D.V. *et al.* (1999) *J. Geophys Res* **104**, 9019. [8] Lemmon *et al.* (2004) Science **306**, 1753.