Calibration, Shipment and Initial Spacecraft Integration of the Moon Mineralogy Mapper (M3) Imaging Spectrometer for the Chandrayaan-1 Mission. Robert O. Green[1], Carle Pieters[2], Pantazis Mouroulis[1], Glenn. Sellar[1], Michael Eastwood[1], Sven Geier[1], and James Shea[3]. [1]Jet Propulsion Laboratory California Institue of Technlogy, 4800 Oak Grove Drive, Pasadena, CA 91109 (rog@jpl.nasa.gov), [2]Brown University, [3]Swales Inc.

Introduction: The Moon Mineralogy Mapper (M3) is a high uniformity and high signal-to-noise ratio imaging spectrometer of the pushbroom type [1,2,3] and a NASA Discovery Mission of Opportunity. M3 measures images of 600 cross-track spatial elements and 260 contiguous spectral channels nominally from 430 to 3000 nm at 10 nm sampling. The basis for the use of imaging spectroscopy for mapping the mineralogy of the moon [4,5] is shown in Figure 1. M3 is scheduled to be launched as a guest instrument on the Chandrayaan 1 mission of the Indian Space Research Organization (ISRO). We present here the calibration, shipment, and intitial spacecraft integration results of M3 in the year 2007.

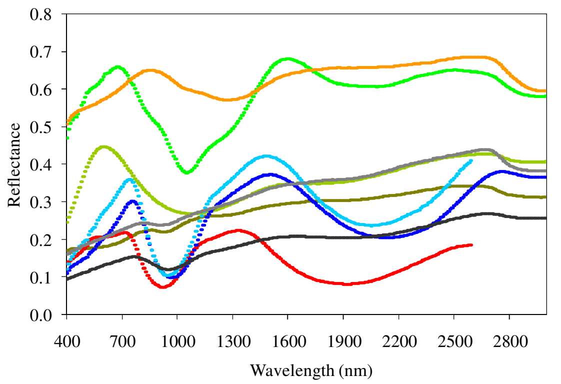

Figure 1. Laboratory spectra of lunar materials and analogs show a diversity of spectral features.

M3 was selected in early 2005. The first spectrum was acquired in the laboratory on the 15th of December 2006. Calibration took place during the month of April 2007. A complete set of spectral, radiometric, spatial and uniformity calibration measurements were acquired. Figure 2 shows an M3 image of a laser-illuminated integrating sphere with wavelengths of 532, 1064, 2065 nm across the field-of-view (FOV). The calibrated spectral range is from 403.9 to 2982.8 nm. Spectral sampling was measured as 9.995 nm (constant through the entire band). A scanning monochromator was used to establish the spectral response functions over the entire spectral range. Figure 3 shows a set of M3 measured spectral response functions in the range from 2000 to 2200 nm.

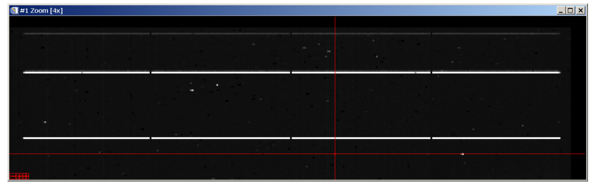

Figure 2. M3 FOV measurement of three laser lines for determination of spectral range and sampling (600 cross-track samples by 260 spectral channels.

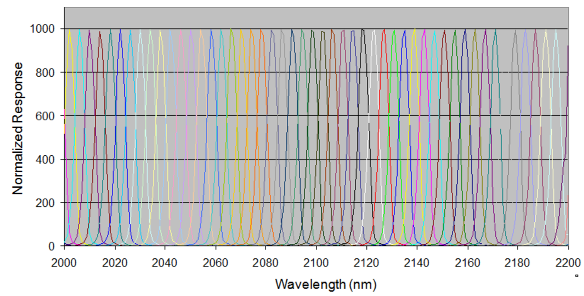

Figure 3. M3 spectral response function subset from 2000 to 2200 nm.

Radiometric calibration was traced to a National Institute of Standards and Technology (NIST) irradiance lamp and a reflectance panel standard. Figure 4 shows an M3 calibrated measurement of the radiometric calibration source. With radiometric calibration and instrument noise measurement, the signal-to-noise ratio of M3 was calculated for the polar and equatorial reference radiances and is shown in Figure 5.

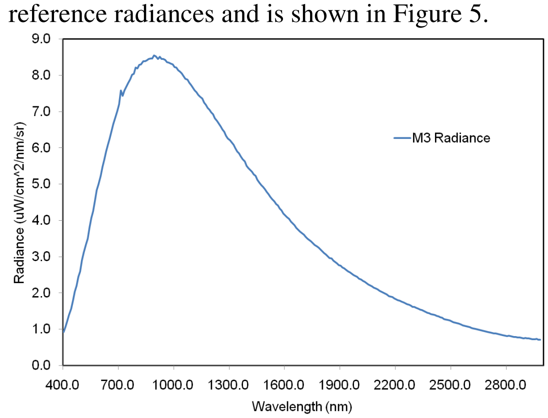

Figure 4. Radiometrically calibrated M3 measurements from laboratory radiance standard.

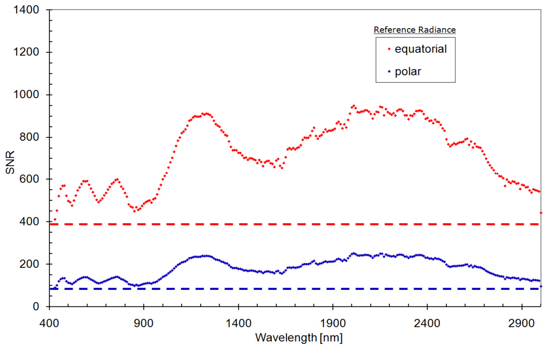

Figure 5. M3 calculated signal-to-noise ratio based on laboratory measured instrument throughput and noise and signal from Apollo 16 soil at 0 and 80 degrees zenith.

The spatial field-of-view (FOV), sampling, and response function were measured as well. The image FOV of M3 is 24 degree with a cross-track sampling of 0.7 milliradians. The full-width-at-half-maximum (FWHM) for the spatial response function was measured as ~1 milliradian with a non-Gaussian shape.

The imaging spectrometer uniformity of M3 was specified at > 90% for both the spectral cross-track uniformity and spectral-IFOV uniformity. Figure 6 shows the spectral cross-track uniformity measured from a Neodymium spectral target. Figure 7 shows the spectral-instantaneous-FOV uniformity measured from a cross-track scanning white-light slit through a collimator.

Figure 6. M3 spectral cross-track uniformity. There is less than 0.5 nm cross-track spectral variation with respect to 10 nm spectral sampling

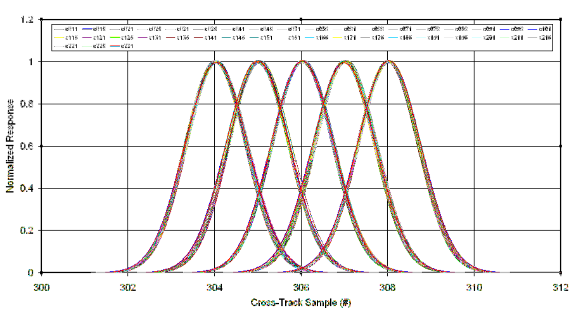

Figure 7. Derived M3 spectral-IFOV uniformity over the spectral range. The blue spatial response curve is from the visible and the red in from 2800 nm.

Following laboratory calibration M3 completed a pre-ship review on the 3rd of May 2007. Figure 8 shows a picture of M3 at the Jet Propulsion Laboratory prior to shipment. In early August M3 was shipped to Bangalore, India. Figure 9 shows M3 at the ISRO cleanroom. Initial integration was completed on the 10th of August with M3 successfully commanded from the Chandrayaan-1 spacecraft system. Spacecraft integration will continue and launch is planned in 2008.

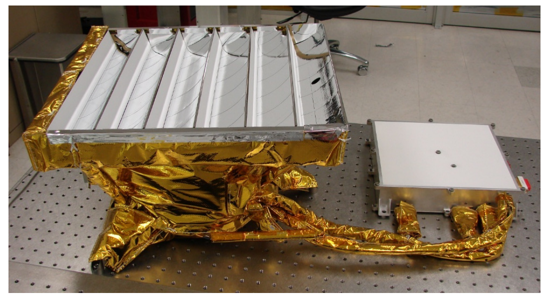

Figure 8 M3 instrument prior to shipment.

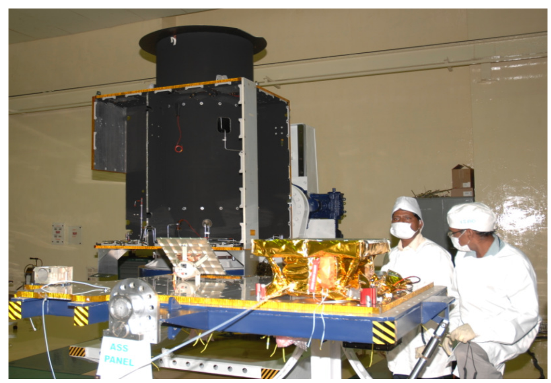

Figure 9. M3 at the ISRO facilities in Bangalore, India.

References: [1] Mouroulis et al., "Design of push-broom imaging spectrometers for optimum recovery of spectroscopic and spatial information," APPLIED OPTICS (2000). [2] Green R. O. (2007) LPSC XXXVIII #2354, [3] Mouroulis, et al., Opt. Eng. (2007) [4] Pieters, C.M., "Compositional diversity and stratigraphy of the lunar crust derived from reflectance spectroscopy," in Remote Geochemical Analysis: Elemental and Mineralogical Composition, Cambridge University Press, Cambridge (1993). [5] Pieters, C.M., et al. (2006) LPSCXXXVII #1630; (2007) LPSC XXXVIII #1295.

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