**TOPOGRAPHIC DATA DERIVED FROM SCANS OF THE ORIGINAL APOLLO PANORAMIC FLIGHT FILM.** M. R. Rosiek[1], S. J. Lawrence[2], M. S. Robinson[2], W. Close[3], J. Grunsfeld[3], R. Ingram[3], L. Jefferson[3], S. Locke[3], R. Mitchell[3], T. Scarsella[3], M. White[3], B. A. Archinal[1], T. Hare[1], B. L. Redding[1], D. M. Galuszka[1], and M. Hopkins[1], [1]U.S.Geological Survey, (2255 N. Gemini Dr., Flagstaff, Arizona 86001, mrosiek@usgs.gov), [2]School of Earth and Space Exploration, Arizona State University, Tempe, AZ, [3]NASA Lyndon B. Johnson Space Center, Houston, TX

**Introduction:** Apollo 15, 16, and 17 combined to photograph ~20% of the Moon immediately under and adjacent to their orbital tracks using both a frame mapping camera and a panoramic camera. The frame camera was a Fairchild metric camera with a 4.5″ x 4.5″ film format. Stereo models are obtained by overlapping photographs along the flight line and between flight lines. When digitized at 5-μm, a metric camera photograph provides a useful resolution of about 7-m/pixel. The panoramic camera was an Itek panoramic camera with 45.24″ x 4.5″ film format. Stereo models are obtained by using forward and aft looking photographs acquired along the same flight line. When digitized at 5-μm, a panoramic photograph has a resolution at image center of about 1-m/pixel and at the edge of the image the resolution is about 2-m/pixel. Johnson Space Center and Arizona State University are scanning and creating an online digital archive of all the original Apollo flight films [1]. The scanned images and information about the scanning process are available at http://apollo.sese.asu.edu/.

The Lunar Mapping and Modeling Project (LMMP) [1] has been charged with doing high resolution topographic mapping of Constellation "regions of interest" (ROI) [2]. This mapping will be used to assist in the design of Constellation hardware, and possibly in the actual navigation of landers and planning of future lunar surface operations. Although generally this mapping will likely be done using Lunar Reconnaissance Orbiter data, the Apollo images can also be used to do such mapping and still meet the Constellation program requirements. We describe here our mapping of three of the ROIs and demonstrate that similar mapping can be already done in any of the (~20%) area of the Moon with such image coverage.

**Interior orientation:** Interior orientation is the reconstruction of the location of the scanned pixels within the sensor. For panoramic images the timing marks on the edge of the film are used to determine the scan angle from the center of the scan. Because the panoramic image film length is too large for the scanner, the panoramic image was scanned in eight segments. The midpoint between the center timing marks is used as the origin for image coordinates. The Y coordinates for the two timing marks are set to zero and the X coordinates are set to the distance from the origin, based on pixels and the scan size of 5 μm. Timing marks at

the edge of the scan segment are picked that are in common with the next scan segment. The midpoint between these timing marks is located, and the distance from the origin midpoint and this midpoint is computed, again based on the number of pixels and scan size of 5 μm, and is used as the Y coordinate for these timing marks. The X coordinate is the distance from the midpoint to the timing marks on the edge of the film. The timing marks are located every 2.5° (Y direction), with an additional timing mark at the center of the scan [3]. We did not find any information on the nominal location of the timing marks in the X direction.

**Expected Precision:** The expected precision is based on the flight geometry shown in Figure 1. A stereo pair is formed by combining a forward and an aft image. The panoramic camera is pointed forward and aft by 12.5° and the images usually overlap 100%. A flying height of 123 km was used to compute the expected precision. Shown in Figure 2 is the change in the expected precision from the center to the edge of the panoramic image. The expected precision is 0.5 m at the center of the panoramic image and 1.3 m at the edge of the image.
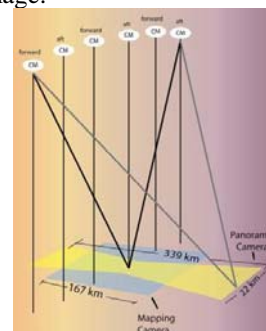


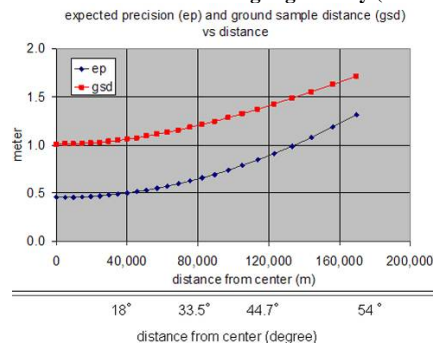**Figure 1 - Panoramic camera flight geometry (not to scale)**
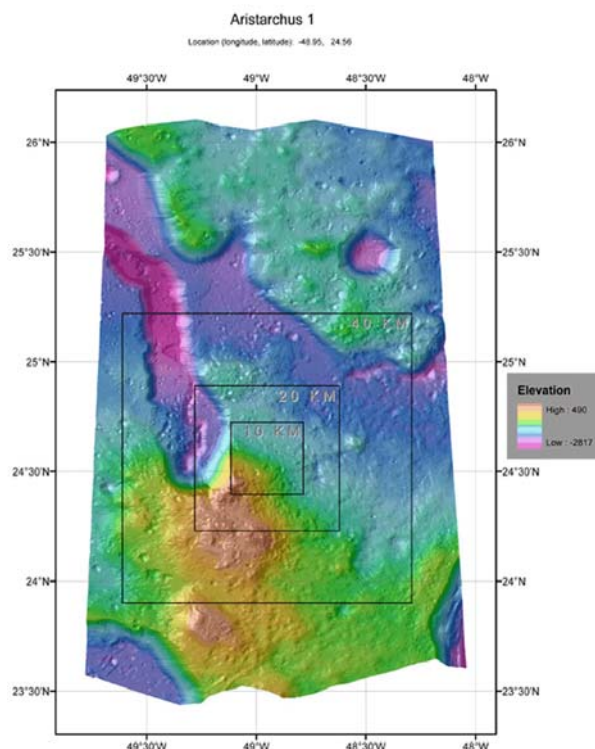


**Figure 2 - Expected precision**

Aristarchus 1
Location (longitude, latitude) -48.95, 24.56



**Figure 3 - Color-coded Hillshade Topography for the Aristarchus 1 site**
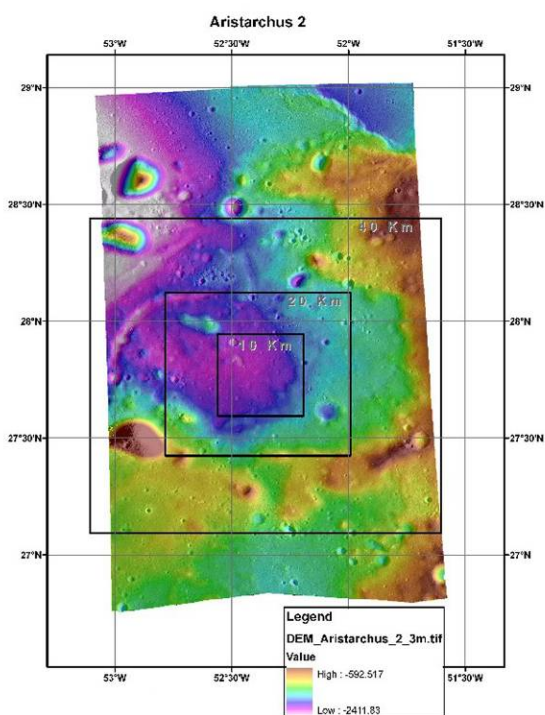
Aristarchus 2



**Figure 4 - Color-coded Hillshade Topography for the Aristarchus 2 site**

Tsiolkovskiy Crater
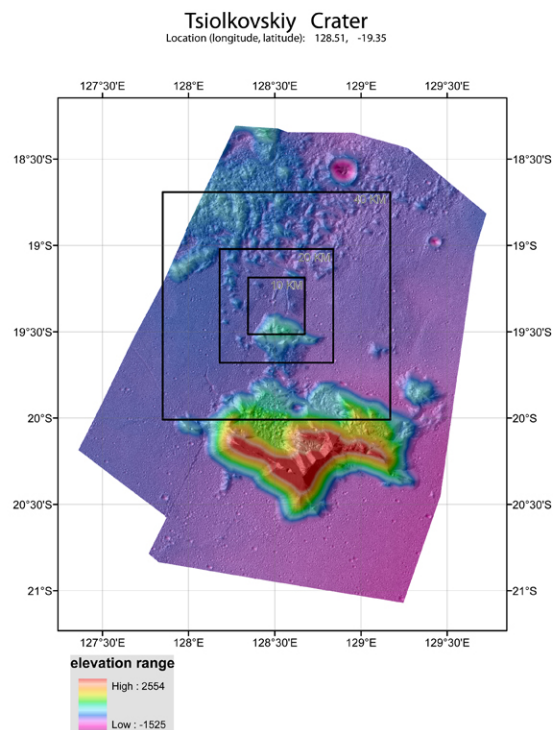Location (longitude, latitude): 128.51, -19.35



**Figure 5 - Color-coded Hillshade Topography for the Tsiolkovskiy crater site**

**Topography:** Topographic data was derived from the scanned image segments. The sites were selected from the list of Constellation ROIs. The images were controlled to the ULCN 2005 control network [4]. Clementine and Apollo metric images were used to help transfer the ULCN 2005 control points to the Apollo panoramic images. Figures 3, 4, and 5 show the topographic data as color-coded hillshaded images, with elevations in meters above the IAU reference sphere of radius 1737.4 km. The 10, 20 and 40 km boxes in the figures show the different priorities in the regions of interest to the Constellation Program.

**Future Work:** Preliminary versions of the topographic data can be downloaded from USGS Astrogeology Science Center ftp site:
 ftp://pdsimage2.wr.usgs.gov/pub/pigpen/moon/topo/Apollo.
The coordinate frame of the topographic data will be updated in March 2011 to be consistent with the data being collected by the Lunar Orbiter Laser Altimeter (LOLA) instrument on board NASA's LRO spacecraft.

**References:** [1] Robinson M. S., et al. (2008), LPS XXXIX, #1515. [2] Cohen B. A., et al. (2008), LPS XXXIX, #1640; Noble S. et al. (2009), 2009 Annual Meeting of LEAG, #2014. [3] Jolliff B. L. et al. (2009) *LPS XV,* Abstract #2343; Gruener J. E. & Joosten B. K. (2009), LRO Science Targeting Meeting, #6036. [4] NASA (1971) Apollo 15 Sim Bay Photographic Equipment and Mission Summary, Mapping Sciences Branch, Houston Texas. [5] Archinal B. A. et al. (2006) USGS Open File Report 2006-1367.