INTRODUCTION
In the early 1970s, an integrated photogrammetric mapping system (Figure 1) flew on the last three Apollo lunar missions (15, 16, and 17). Included was a Metric (mapping) Camera (MC), a high-resolution Panoramic Camera (PC), and a star camera and laser altimeter to provide support data [1]. Approximately 6,000 MC images of the lunar equatorial region were acquired that are suitable for mapping. Of these, ~3/4 are nadir-pointed, covering ~16% of the lunar surface. The remaining ~1,500 images are oblique, increasing useful coverage to ~25%.

The NASA Johnson Space Center (JSC) and Arizona State University (ASU) recently produced digital scans of the original MC negatives at film-grain resolution and created an digital record of support data (available online at http://apollo.sese.asu.edu) [2,3]. This work enables an ongoing collaboration between USGS Astrogeology, the Intelligent Robotics Group of the NASA Ames Research Center (ARC), and ASU to achieve the most complete cartographic development of Apollo mapping system data into versatile digital map products. These can be integrated easily with other digital lunar data and updated geodetically and cartographically as needed. Scientific/engineering uses of these products including mission planning, geologic mapping, geophysical process modeling, slope dependent correction of spectral data, and change detection.

With the Ames Stereo Pipeline (ASP) [4] and the Integrated Software for imagers and Spectrometers (ISIS) developed by the USGS [5], the ARC has completed our initial joint project to process the nadir images by making a photogrammetrically and geodetically controlled, orthorectified digital image mosaic (DIM) and digital terrain model (DTM) sampled at ~30 m/pixel and tied to a reference frame based on Lunar Orbiter Laser Altimeter (LOLA) data [6]. To complete processing of the MC images, we now focus on the oblique images, beginning with those from Apollo 15. The ~450 Apollo 15 oblique images were acquired in four orbits with the spacecraft oriented so the camera was tilted either 25° forward or 40° north or south (orbits 23, 34, 35, and 71). While oblique geometry may complicate feature recognition and orthorectification, the USGS has previously shown that such images can be rectified and provide valuable topographic information [7,8].

PHOTOMGRAMMETRIC CONTROL OF OBLIQUE APOLLO 15 IMAGES
In the control process, images are registered to each other or the ground by measuring features common to overlapping images (tie points) or common between images and ground (control points). The Apollo images are pre-processed for quality and removal of artifacts (fiducials/reseaux; space hardware; image noise) that may complicate tie-point detection and the matching of tie-points between images. Image measurements are input to the least-squares bundle adjustment (jigsaw in ISIS [9]) which produces improved image position/attitude parameters and ground coordinates for all tie/control points. At this time, the oblique orbits have been controlled separately in ISIS (Table 1) using the Lunar Reconnaissance Orbiter Camera (LROC) Wide Angle Camera (WAC) mosaic [10] and LOLA DTM as ground control. With the improved image parameters we created preliminary DIMs (Figure 2) and updated (smithed) NAIF SPICE position/pointing kernels [11] for each orbit. Using these new kernels and the oblique images, the ARC produced a preliminary DTM for each orbit (Figures 3 and 4).