PLANETARY CARTOGRAPHY AT MSSS

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Introduction: Though the primary focus at Malin Space Science Systems (MSSS) is on building and operating instruments through the archiving of raw data, we have also pursued research interests in planetary cartography. This abstract describes three of these efforts using data from the Mars Orbiter Camera on MGS.

Outreach: In 2000 MSSS was approached by National Geographic Maps (NG Maps) to produce a map of Mars for an insert to accompany an article about the MGS mission. A rendering based on MGS data and showing both topography and surface shading was desired. After consultation with the MOLA team, they graciously provided a prerelease version of the global MOLA Digital Terrain Model at 16 pixels per degree (ppd) resolution. For surface albedo, we assembled a mosaic of MOC red Wide Angle (WA) images taken during the "geodesy campaign" in May-June 1999 (mapping cycle M01, [1]) and "Science Campaign C" in December 1999 (mapping cycle M10). Brightness matching between images was controlled by using lower-resolution daily global map images, built by hand, as base maps. This global image mosaic was also processed to a resolution of 16 ppd. Extensive filtering and edge matching was performed at this stage, by hand, to remove visible flaws caused by transmission errors and remaining brightness mismatches.

The MOLA DTM was converted into two shaded relief maps: one using a physical shading model, and another using the normalized gradient mode of the Generic Mapping Tools (GMT) software. The latter helped to emphasize the subtle topography visible in the MOLA data. The physical and non-physical shaded relief and the image mosaic were combined by a linear function; the Winkel-Tripel and polar stereographic projections requested by NG Maps were generated using GMT.

Although the MOC WA did acquire two-color (red and blue) images of the entire planet, clouds obscured many areas in the blue images. To create a color image without clouds, only the red part of the MOC images was used. Color images of the planet, previously assembled from Viking data by the United States Geological Survey, were used to create a function that mapped red brightness to color, and this function was then applied to the MOC images. Figure 1 shows the resulting image.

NG Maps applied labeling and a latitude-longitude grid to the image and it was integrated into the sheet titled "Mars Revealed", which appeared in the February 2001 issue of NATIONAL GEOGRAPHIC magazine. In October 2001, NG Maps received the John Bartholomew Award for excellence in small-scale thematic cartography from the British Cartographic Society for this product.

Global WA Orthophoto Mosaic: The map described above was produced by projection to a spheroid. At its low resolution, no further correction was needed for adequate seam matching, but at the intrinsic resolution of the geodesy campaign images (about 240 m/pxl), topography can cause as much as 20 pixels of disparity shift, which becomes objectionable. Starting in mid-2001, we modified our map-projection software to apply the topographic correction, using the MOLA 16 ppd dataset. Use of the MOC geometric model derived at USGS [2] (with the red camera's C05 term corrected; C05 = -0.**1**539636) leads in principle to subpixel edge matching. In most cases this is borne out, though we have noted some periods of poor or missing spacecraft ephemeris and/or orientation data. While the spacecraft position and orientation information and the camera geometry model appear to be sufficient for the production of good uncontrolled mosaics, the wide range of photometric and atmospheric conditions makes shading correction problematic. We are addressing this in our current products by again using a hand-corrected base map to normalize brightness. While not preserving of absolute photometry, this approach provides qualitative albedo information and does not enhance detector pixel-to-pixel variation as high-pass filtering might. Derivation of a photometric model capable of truly removing edges remains work for the future. Figure 2 shows an area of a mosaic constructed at 64 ppd with and without topographic color overlay.

Narrow Angle Stereo Processing: starting in February 2001 the MGS spacecraft has been executing Roll-Only Targeted Observations (ROTOs) based

on planning done by MSSS. ROTOs have been used both to image high-priority targets (such as landing sites) more quickly than the orbit track of MGS would otherwise allow, and to acquire stereo coverage of selected targets. The stereo attributes of these images are well-described by others [3]. MSSS has recently contracted with Harris Corporation's Government Communications Systems Division to process 150 such stereo pairs using Harris' automated photogrammetry tools and manual editing. DTM post spacing will be 3 NA pixels, and MOLA altimetry will be used to validate the product. Figure 3 shows a shaded relief version of an early processing test, prior to manual editing. Initial data products are expected by mid-2002.

References: [1] Caplinger, M. and M. Malin, The Mars Orbiter Camera Geodesy Campaign, *JGR*, in press. [2] Kirk, R.L., T.L. Becker, E.M. Eliason, J. Anderson, and L.A. Soderblom, Geometric Calibration of the Mars Orbiter Cameras and Coalignment with Mars Orbiter Laser Altimeter (abstract), LPSC XXXII, 2001. [3] Kirk, R.L., E. Howington-Kraus, and B.A. Archinal, High Resolution Digital Elevation Models of Mars from MOC Narrow Angle Stereoimages, ISPRS Extraterrestrial Mapping Workshop (this workshop), 2001.

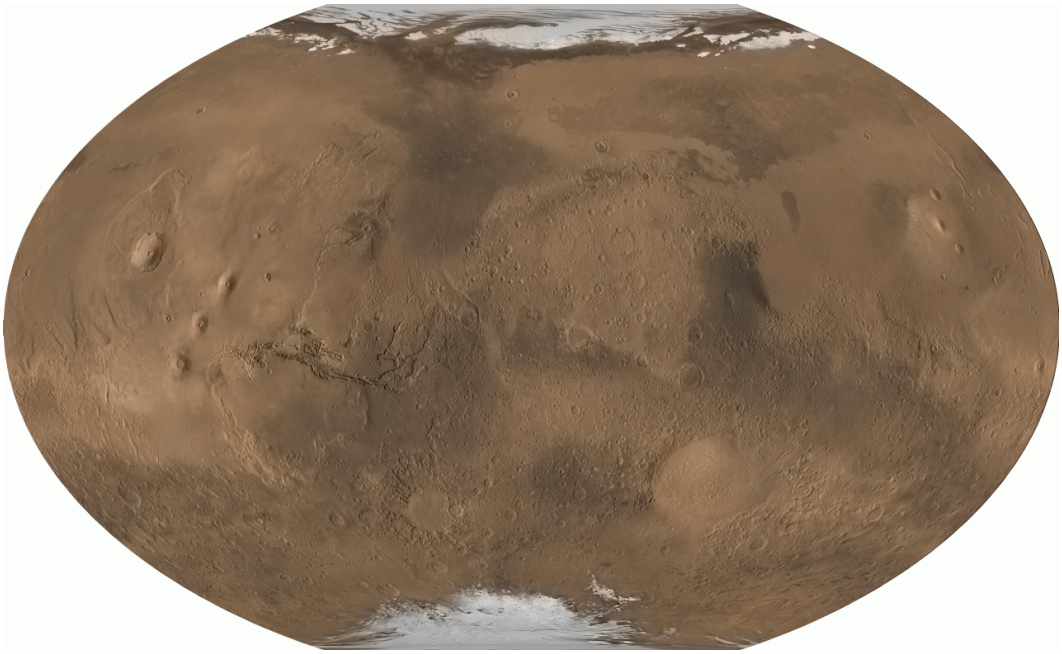

Figure 1: MOC/MOLA NGS global mosaic

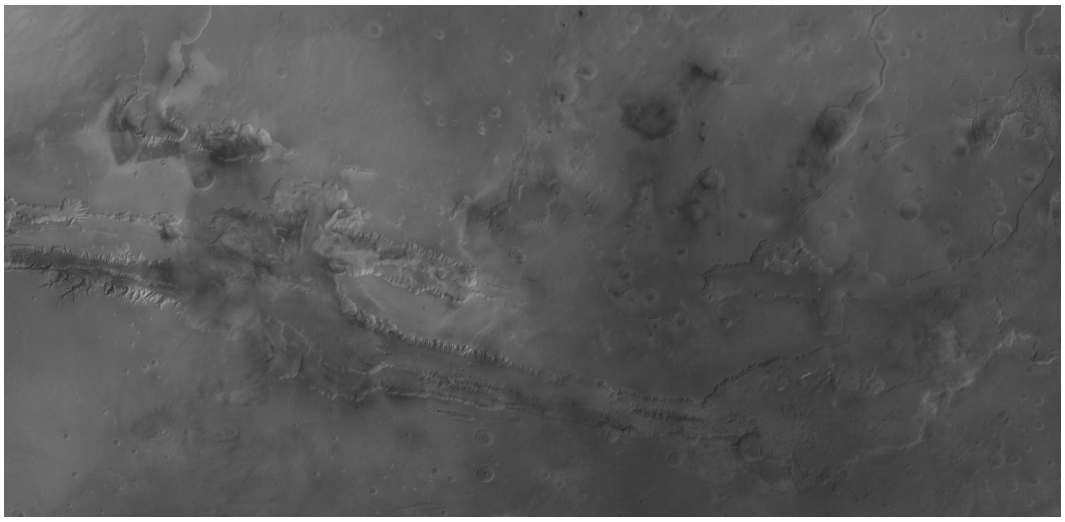

Figure 2A: MOC WA global mosaic, eastern Valles Marineris

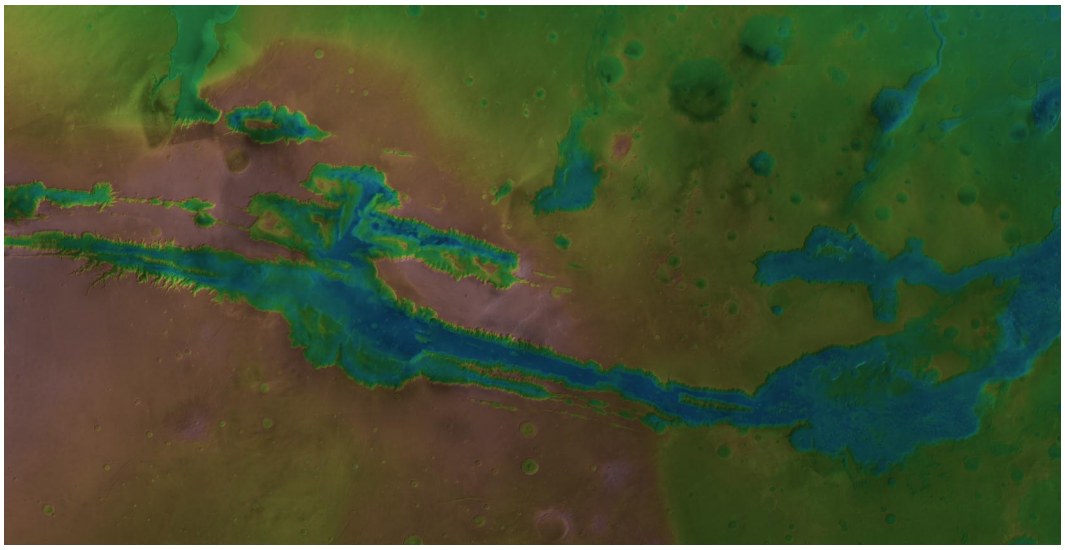

Figure 2B: MOC WA global mosaic with MOLA topography color overlay

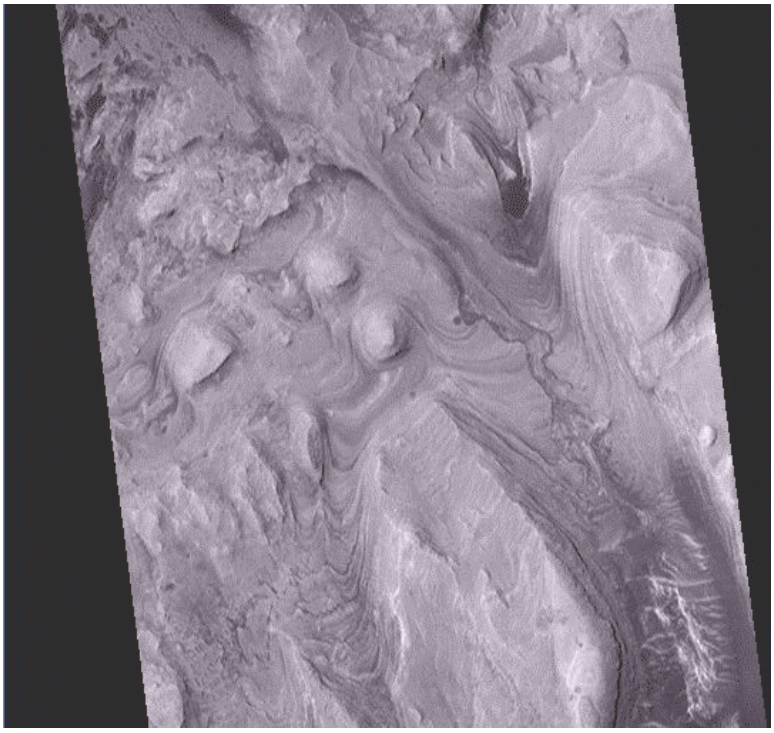

Figure 3A: MOC NA image M03-01521 (Gale Crater)

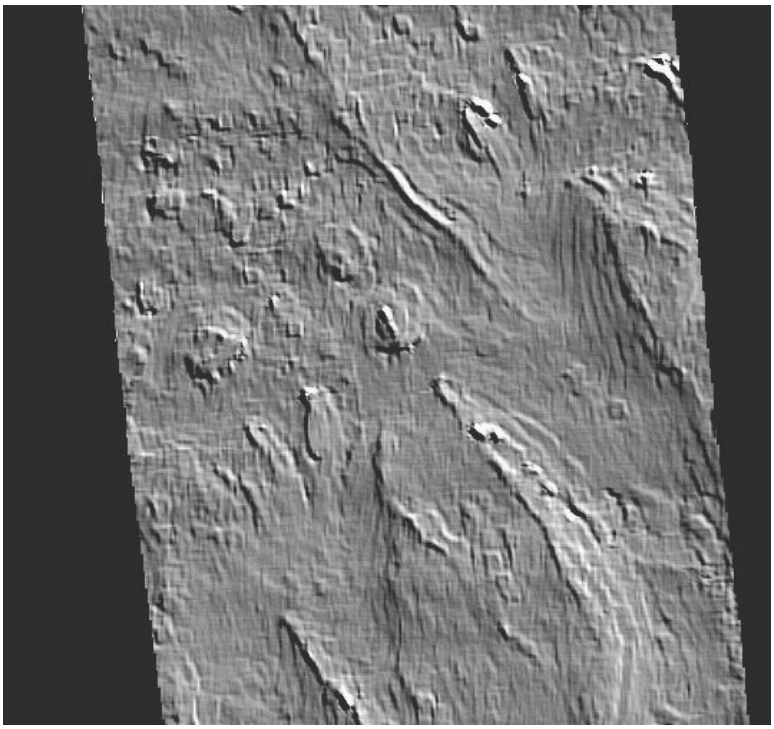

Figure 3B: shaded relief of topography extracted from M03-01521 and E01-01026