MASS PRODUCTION OF DEMS FROM MOC STEREO PAIRS

M. Caplinger
Malin Space Science Systems, Inc.
San Diego, California

Introduction: In its extended mission, the MGS spacecraft has been operated in so-called "R16" mode, in which a 16-degree pitch is introduced to minimize fuel usage by reducing torque on the spacecraft. This allows repeat coverage of previous nadir-looking Mars Orbiter Camera (MOC) narrow angle images to obtain stereo. Additionally, MSSS is able to specify "Roll-Only Targeted Observations", or ROTOs, which roll the spacecraft as much as 30 degrees from nadir to image selected targets. This also provides stereo of areas previously imaged.

In 2001, MSSS selected Harris Corporation Government Communications Systems Division to process NA stereo pairs and extract DEMs from them on a "mass production" basis. This effort was completed in late 2002 and yielded 153 DEMs.

Data Interchange: Image pairs to process were selected manually on the basis of overlap, stereo angle, general image quality, and lack of major changes in surface shading or lighting. To simplify interface issues, MSSS preprocessed the MOC images and supporting spacecraft position and orientation data into an agreed-upon interchange format. The images were translated to TIFF format after standard level 1 processing and removal, to the extent feasible, of the effects of data drops. Spacecraft position and orientation were interpolated from the SPICE kernels at regular time intervals, and a text file containing these data and other instrument parameters (start time, line clocking rate, summing mode) was generated.

DEM generation: The Harris algorithms use a model-based stereo extraction technique, with parametric sensor adjustments, to derive relative height differences from a stereo image pair. A seed DEM produced from gridded MOLA data was used as an initial height estimate to reduce the search area over which image matching was done. The use of a seed DEM did not affect the quality of the computed height measurements, but substantially reduced CPU time for the algorithm, especially for areas where terrain heights varied greatly. DEM resolution was typically about 16 meters/pixel. Manual quality control techniques were used to remove spurious matches.

Artifact removal: Vibration and oscillation of the MGS spacecraft at frequencies too high to be captured in the spacecraft attitude telemetry leads to errors in the DEM. The most common of these is an along-track quasi-sinusoidal pattern we call "washboarding." We considered three possible solutions to correct these artifacts: the use of MOLA data (shots or gridded) to provide a low-frequency reference surface (as described in [1]), simple "boxcar" spatial filters, and frequency-domain removal. We found that while the use of MOLA data would have insured accuracy, it was labor-intensive to produce a suitably high-resolution MOLA DEM, and in many areas not feasible because of sparse MOLA coverage. We instead employed simple boxcar filtering to cosmetically remove artifacts from the DEMs; see Figure 1. Experimenting in the frequency domain, Harris found that a notch filter with manually-adjustable footprint and amplitude was most successful at removing the washboarding without introducing further artifacts. Harris applied their algorithm to about 60% of the DEMs, but we have not yet reviewed the results.

Data assessment and availability: Comparison with raw MOLA shot data shows absolute vertical offsets of between 10 and 50 meters, sometimes slowly varying in the downtrack direction, but otherwise good agreement. Figure 2 shows a comparison between MOLA shots and a DEM.

The DEM data will soon be available in PDS standard format on the Web at http://www.msss.com/mapping/

Conclusions: This attempt to adapt a stereo mass production flow developed for processing of terrestrial images to a planetary dataset has proven both successful and cost-effective. A similar approach should be fruitful for future missions, such as the 2005 Mars Reconnaissance Orbiter.

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References: [1] Kirk, R.L., ISPRS-ET Workshop, 2001.

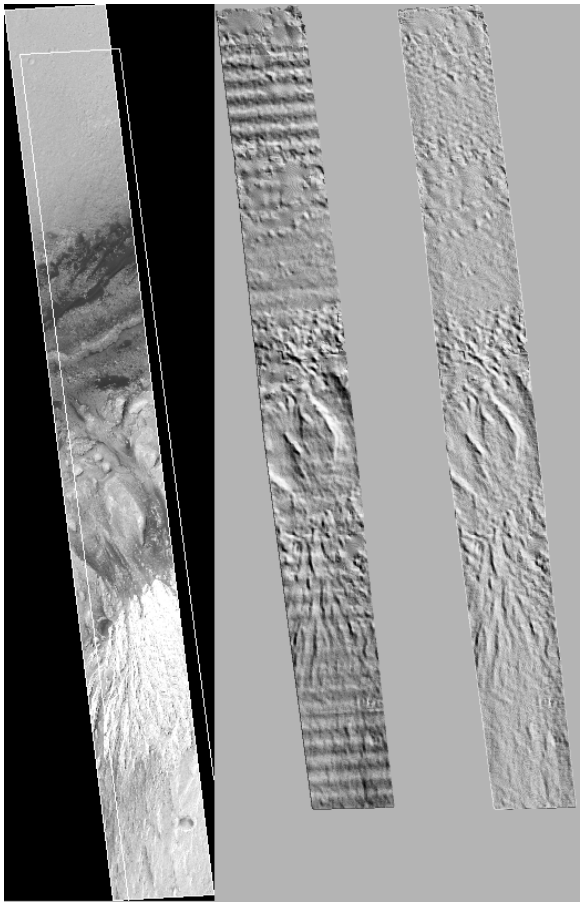

Figure 1: (left to right) Footprints of stereo pair E01-01026, M03-01521; DEM with washboarding; DEM with washboarding removed via filtering.

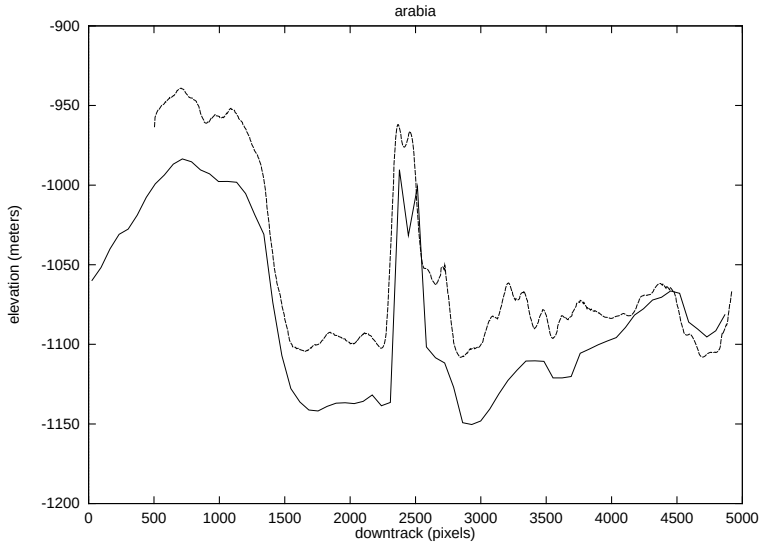

Figure 2: MOLA-DEM comparison for pair M20-01357, E04-01109; the dashed line is the average DEM height at the location of the MOLA shot, and the solid line connects the MOLA shots.