HIGH-RESOLUTION BASEMAPS FOR LOCALIZATION, MISSION PLANNING, AND GEOLOGIC MAPPING AT MERIDIANI PLANUM AND GALE CRATER.
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Introduction: We recently updated the Opportunity location map to include Endeavour crater, using CTX and HiRISE images at 25 cm/pixel (http://goo.gl/pSuFZ, http://goo.gl/ydjT2). A similar base mosaic is nearing completion for the Gale crater landing site. Accurate placement of Mars rover vehicles is essential for localization and traverse planning, as well as placing science results into local and regional geologic context. The Gale crater map will include all of the landing ellipse and much of the western half of the mound.

Method: We approach our rover basemap generation in a manner similar to [1], using a pyramidal georegistration of lower to higher resolution imagery with respect to the MOLA global and local HRSC DEMs. First, CTX images are ordered such that those with lowest emission angles appear on top and are georeferenced first. Subsequent, increasing emission angle images are georeferenced to the previous CTX and the surrounding HRSC and MOLA, until the area within the basemap is complete. The “final” basemap product for these sites is an image mosaic exported at 25cm/pixel consisting of all available HiRISE images georeferenced to this CTX mosaic background.

Spirit and Opportunity had already landed and were well into surface operations when we began using ArcGIS to place all our successful landers, from Viking 1 through Phoenix, as accurately as possible with respect to the Mars control net. The Opportunity basemap (fig 1) has been incorporated into our mission planning software and is used for daily localization updates and traverse planning. The Gale basemap will be used to provide data for entry, descent, and landing (EDL) Monte Carlo simulations, in addition to traverse analysis, and tactical and strategic planning after Curiosity touches down this August.

Basemaps: This section will describe the compilation of the Gale crater basemap (fig 2). Compilation of the Opportunity map was similar, but less complex, since the planning tool uses a 2-dimensional map, and so does not include the DEMs that are now available, whereas inclusion of topography will be critical for localization and route planning onto the Gale crater mound with Curiosity. Using ArcGIS, DEMs and visible imagery were georectified and mosaiced from four sources: the MGS Mars Orbiter Laser Altimeter (MOLA) [2], Mars Express High Resolution Stereo Camera (HRSC), Mars Reconnaissance Orbiter (MRO) Context (CTX) 6 m/pixel imagery [3], and the MRO High Resolution Imaging Science Experiment (HIRISE) [4]. MOLA served as the base reference elevation dataset at ~0.5 km/pixel. The gridded MOLA elevation product is the current Mars cartographic control and provides an easy translation to inertial space for spacecraft pointing in EDL simulations [5]. HRSC DEMs, at 50 m/pixel [6], provide the first transition from MOLA to the higher resolution image datasets. HRSC enables excellent three-dimensional registration to MOLA. In addition, most HRSC DEMs are accompanied with an orthorectified 12.5-25 m/pixel panchromatic visible image.

These orthorectified HRSC images allowed a second step of georegistering of select 6 m/pixel, low-emission angle CTX images. We selected one base CTX to cover most of the landing ellipse, and then added four overlapping images to fill the box we had designated to provide complete coverage of the landing ellipse, as well as any terrain likely to be visited or visible from Curiosity during and beyond its nominal mission. Finally, each HiRISE orthophoto was georeferenced to the CTX rectified image base. All CTX and HiRISE images were co-registered via manual selection of a horizontally homogenous collection of 20-100 tie points per image. These tie points were used to rectify each image via a spline transformation to an Equirectangular (aka Equidistant Cylindrical) projection to 0°N, 0°E (MOLA 2000 Areocentric), with units in meters relative to the Mars central meridian, on a sphere with radius 3,396,190 m. Because the landing site is relatively close to the equator the amount of distortion introduced is minimal. Where subsequent HiRISE orthophotos overlapped, extra tie points in intersecting areas were captured to ensure horizontal registration and edge matching between the highest resolution images.

References: [1] Kim J.R. and Muller J.P. (2009) *Planet. & Space Sci*. 57, 2095-2112. [2] Zuber M.T. et al. (1992) *JGR* 97, E5, 7781-7797. [3] Malin M. C. et al. (2007) *JGR* 112, E05S04. [4] McEwen A. S. et al. (2007) *JGR* 112, E05S04. [5] Golombek M. P. et al. (2003) JGR 108, E12, 8072. [6] Gwinner K. J. et al. *LPS* 41, 2727.

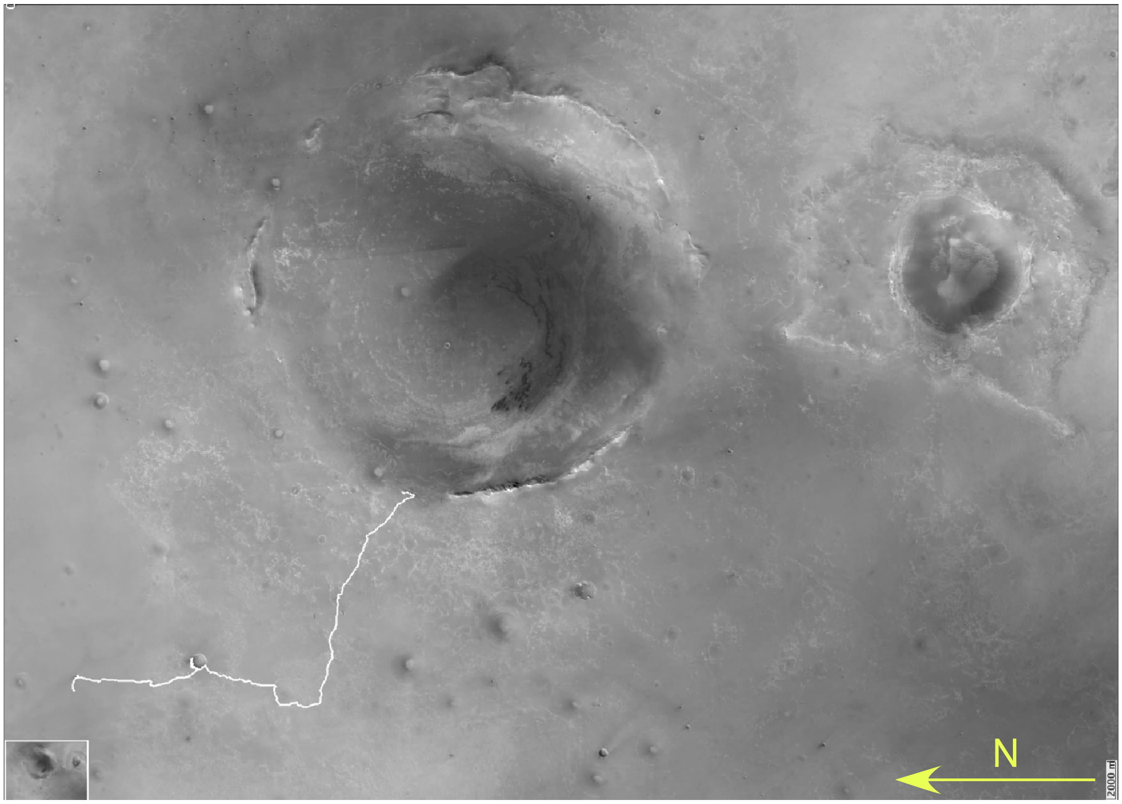

Figure 1: Opportunity planning map, with rover path from Eagle crater to Greeley Haven. Mosaic of georeferenced CTX and HiRISE images, with shading correction in Photoshop to minimize image boundaries. North at left. Full-resolution, 25 cm/pixel file available for download at: http://goo.gl/ydjT2

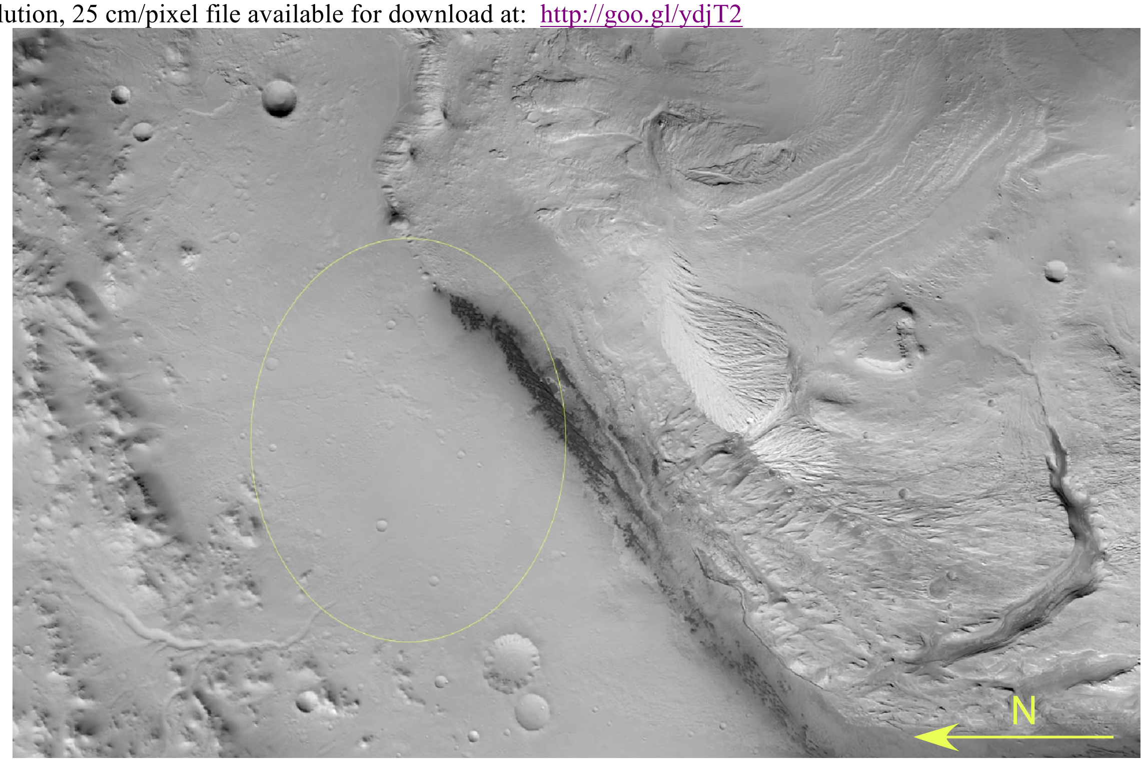

Figure 2: Curiosity planning map, with 20x25km landing ellipse in yellow. Mosaic of georeferenced and shading corrected CTX images (HiRISE georeferencing and shading correction in progress at time of this writing). North at left.