MARS_NEST ORBITAL IMAGE CO-REGISTRATION AND MAPPING. T. L. Logan, M. M. Smyth, F. J. Calef, M. R. Trautman, *Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA (Thomas.L.Logan@jpl.nasa.gov).*

Abstract: One of the core technologies for conducting Mars geographic, geologic, and general planetary science is the co-registration of orbital imagery. "Mars_Nest" is a georeferencing pipeline that automatically co-registers most two map-projected Mars images to each other. The software has been tested on Mars images acquired from six distinct instruments: Viking VIS, Mars Reconnaissance Orbiter (MRO) Context (CTX) and High Resolution Science Experiment (HiRISE), Mars Odyssey THEMIS-VIS and -IR, and the Mars Express High Resolution Stereo Camera (HRSC). The software handles images varying in resolution, projection, and pointing, while adjusting them to the resolution and projection of the input image, reference image, or to a different projection. Metrics on co-registration quality are collected for later evaluation or to adjust the input parameters for a better solution. For ungeoreferenced images, we are developing a sub-program called "Mars_Nest_Map" to generate a Replacement Sensor Model (RSM) for the image to map-project it before running the core Mars_Nest pipeline.

Introduction: After 40+ years of international Mars orbital survey missions, a large library of image data now exists with varying pixel scales, resolution, band wavelengths, sensor types, viewing angles, seasonal effects, and imaging quality. All of these data need to be fused, stacked, and co-registered to perform the core science analyses. Unfortunately, imperfections in the spacecraft SPICE and Navigation data often result in significant ground positional errors that prevent the simple overlay of mapped imagery. Thus, many current Mars co-registration techniques must rely upon some form of manual tiepoint collection to fuse multiple images together and update the Georeference. This laborious process can be time consuming, expensive, and can often result in a sub-optimal product.

Approach: One approach to the Mars image co-registration problem is to consider existing Earth image registration software. However, a requirements study highlighted significant differences between the functional Earth and Mars registration cases that limit the utility of some Earth-focused software. For example with Mars, there is a common need to co-register images with very different pixels scales like 12-100m HRSC imagery with 6-20m CTX imagery, or CTX imagery with 0.25m HiRISE imagery, or merging a Red wavelength image with a THEMIS visual or infrared image. With Earth imagery, almost all registration is between images of the same sensor with similar pixel resolution, like Landsat with Landsat, and Worldview with Worldview, but rarely registering Landsat 30m imagery with Worldview half-meter imagery. Most Earth-based registration software does not directly support the large pixel scale differences and weak georeferencing associated with the typical Mars registration application.

Our solution is to leverage the Jet Propulsion Laboratory's (JPL) AFIDS and Geocal software for planetary applications. The Automated Fusion of Image Data System (AFIDS) has a long history of subpixel co-registration of NASA and Commercial Earth imagery across a range of different resolution systems from MODIS (1-5KM) to Worldview (0.5m). The AFIDS advantage is the use of Fast Fourier Transforms (FFTs) that can be automatically adjusted in geographic size to match diverse terrain and differing image scales to create precise tiepoints. Funded through the NASA AMMOS (Advanced Multi-Mission Operations System) Instrument Data Systems (IDS) programs, the Mars_Nest version of AFIDS/Geocal was developed for Mars specific requirements and extensively tested over a variety of Mars imaging systems. Figure 1 shows seven image pairs co-registered (nested) using thousands of FFT tiepoints automatically generated in just a few minutes with less than ½ pixel error. The Geocal mapping component of Mars_Nest insures support for the Mars projections and datums used by the various orbital missions.

Technical Summary: The Mars_Nest algorithm involves seven automated steps: 1) "fix_projection" corrects for known errors in a mission's map metadata; 2) "check_intersection" looks for sufficient overlap between the two images; 3) "resample_proj" matches the reference image's scale to the secondary image; 4) "accck1" provides initial offset accuracy metrics between the original two input images; 5) "gtpwarp" performs the FFT tiepoint generation and polynomial-based warping; 6) "resample_proj" resizes the inputs and outputs as necessary to provide matching pairs at the two input scales; and 7) "accck2" which calculates Root-Mean-Square (RMS) error metrics between the original and output registered products.

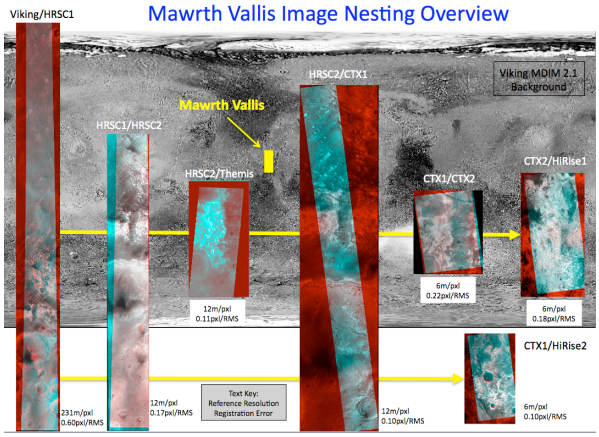

Figure 1: Mars_Nest Sub-pixel Co-Registration Examples.