EUROPEAN GEOSPATIAL IMAGE UNDERSTANDING TOOLS FOR MARS EXPLORATION

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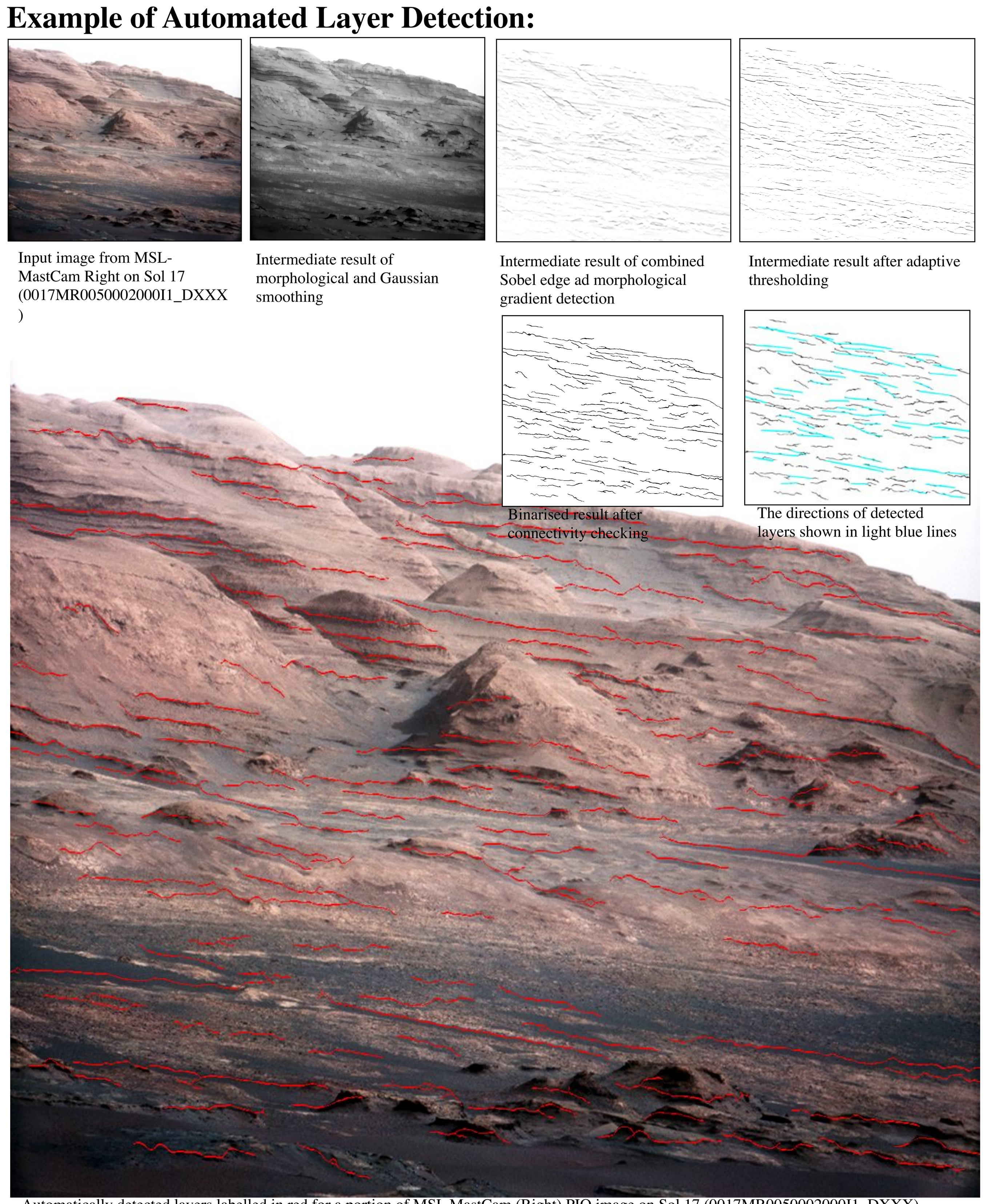
www.provide-space.eu

i-Mars.eu

Introduction:
Several European Union Seventh Framework funded projects http://provisg.eu, http://proviscout.eu, http://provide-space.eu [1], http://i-Mars.eu [2] have and are developing tools for Mars exploration in preparation for the ESA-Roscosmos ExoMars Trace Gas Orbiter 2016 and rover mission in 2018. This is driven by the fact that ESA & Roscosmos scientists have less experience collectively than their colleagues and collaborators in the US but also because of the necessity to try to learn lessons based on this previous US experience. Fortunately, this has been recently recognised by the European Union as part of its support for the Aurora long-term goals of landing an European as part of a multi-national mission on the surface of Mars within the next decades. There are several common themes running throughout these developments including: a) the necessity to try to automate as much of the image processing as feasible so that future missions to Mars can be run with small teams of engineers and scientists; b) to provide VR tools to allow geoscientists to focus on the science and not get bogged down with the catalogues and arcane processing steps and; c) to try to ensure that we can exploit the superior geometric qualities of the only photogrammetric instrument (HRSC) to co-register all previous and future Mars orbital imagery including their data fusion with ground-level rover imagery. These developments are aiming to consolidate and spatially unify all of the exploration imagery to date to provide as seamless as possible a virtual exploration of the Martian surface.

Example of Automated Layer Detection:



Input image from MSL-MastCam Right on Sol 17 (0017MR0050002000I1_DXXX)

Intermediate result of morphological and Gaussian smoothing

Intermediate result of combined Sobel edge ad morphological gradient detection

Intermediate result after adaptive thresholding

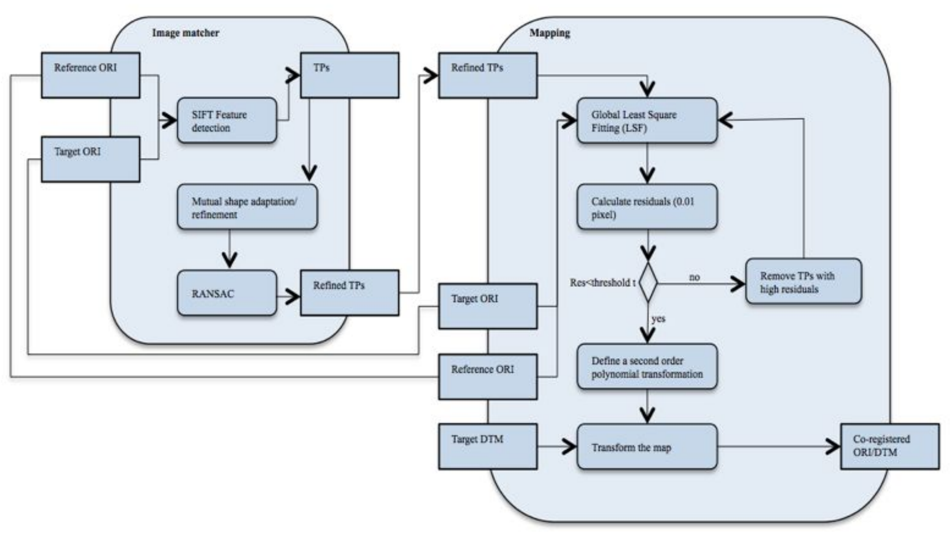
Binarised result after connectivity checking

The directions of detected layers shown in light blue lines

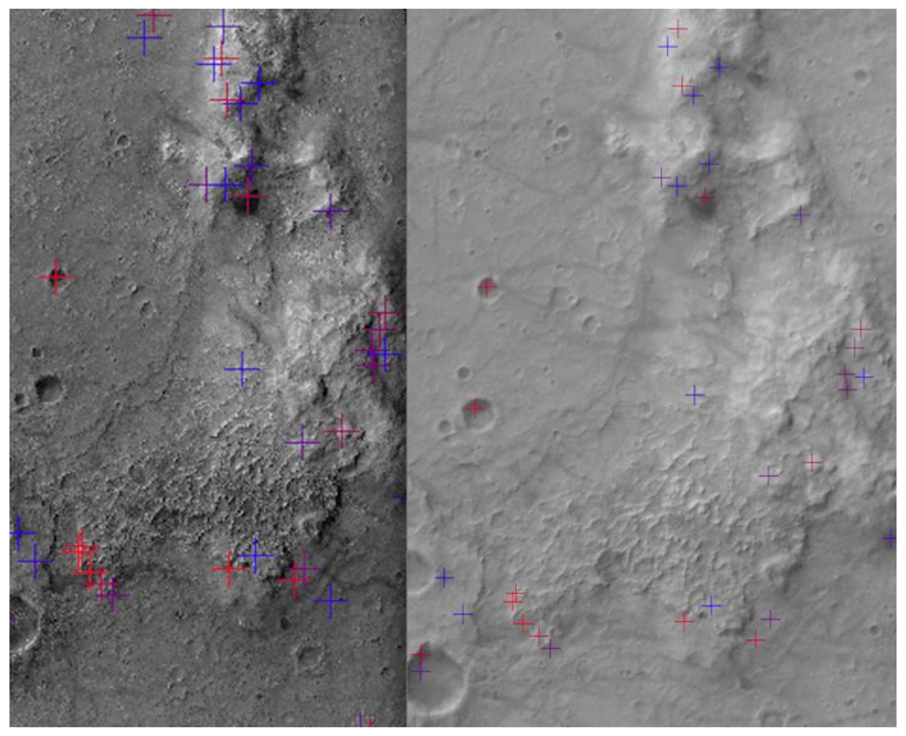
Automatically detected layers labelled in red for a portion of MSL MastCam (Right) PIO image on Sol 17 (0017MR0050002000I1_DXXX)

Automated co-registration of HiRISE-CTX-HRSC:

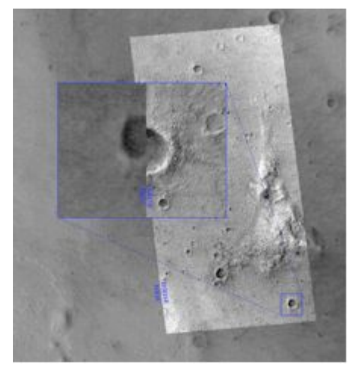
HRSC 3D products have georeferencing accuracy of ≤25m [4] and represent the best available geospatial reference dataset for co-registering all HiRISE, CTX, THEMIS, MOC-NA and Viking Orbiter imagery.



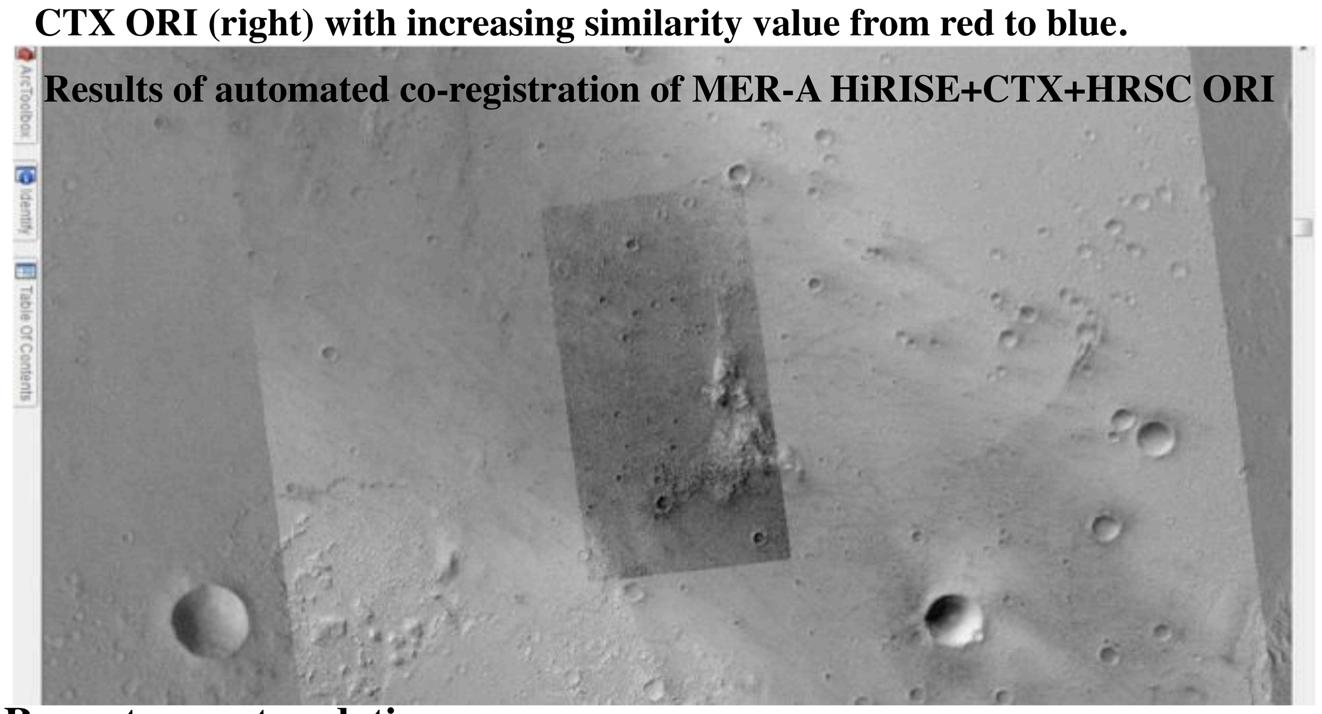
Flow diagram of automated tie-point based HRSC-CTX-HiRISE co-registration



Zoom-in view showing detected TiePoints on HiRISE ORI (left) and CTX ORI (right) with increasing similarity value from red to blue.

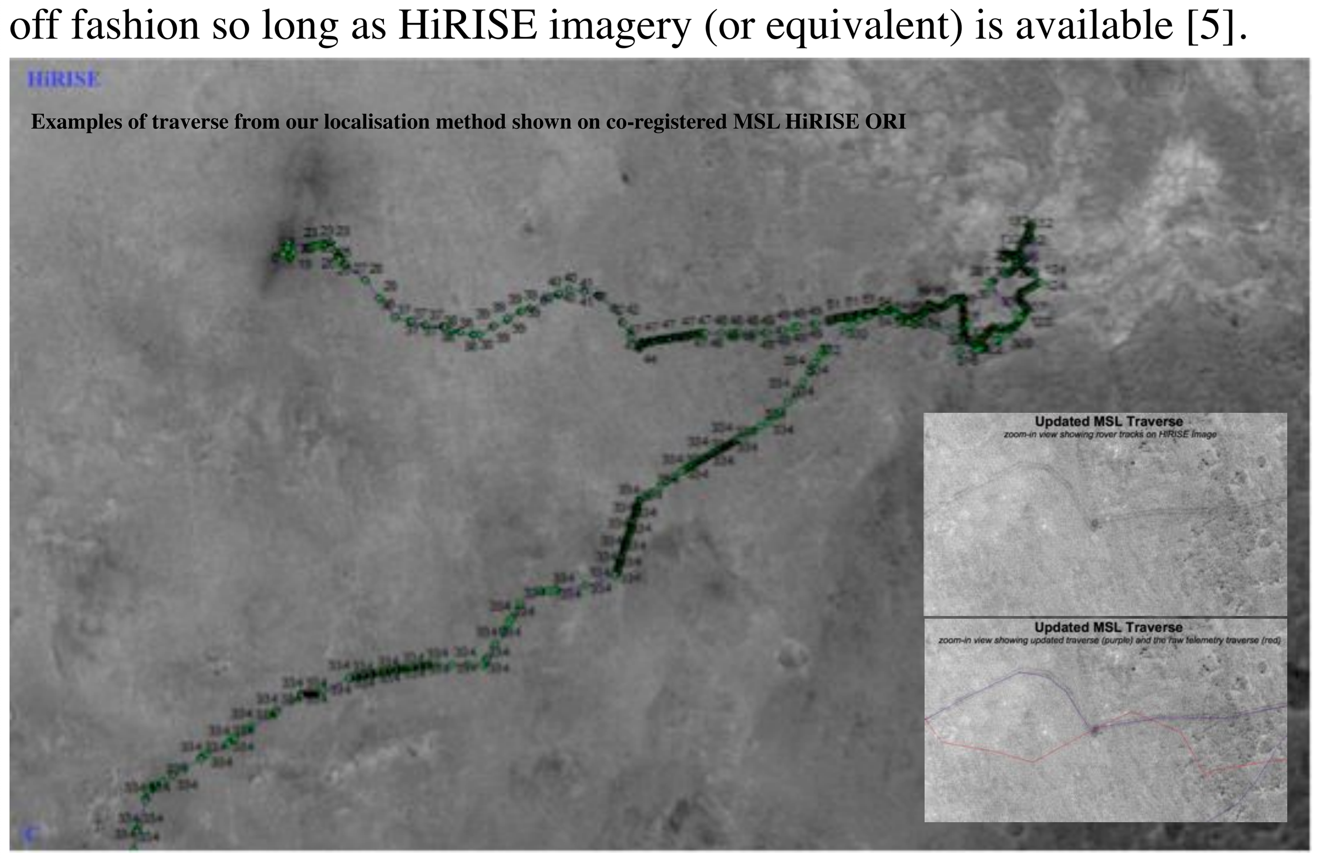


Example swipe view showing misregistration between HiRISE - HRSC ORI (OrthoRectified Image over MER-A



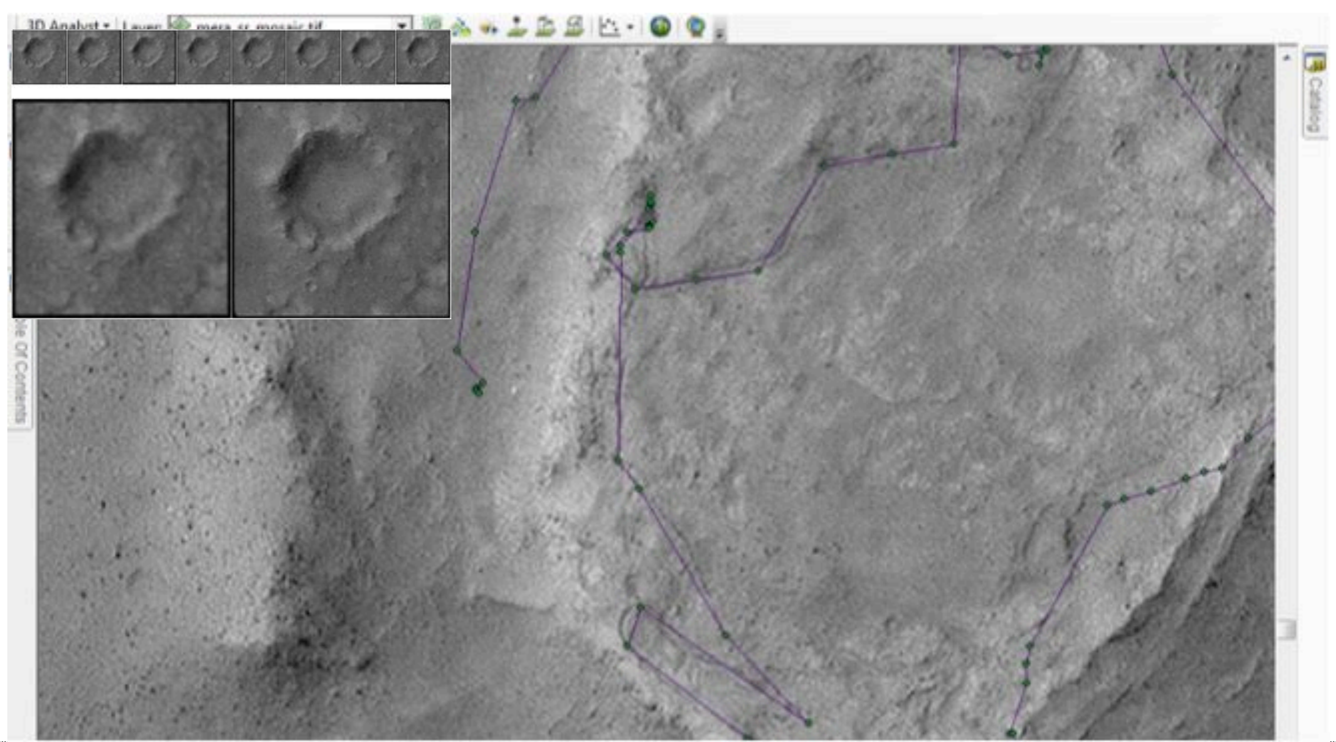
Results of automated co-registration of MER-A HiRISE+CTX+HRSC ORI

Rover transect updating:
Existing systems for placing rover on the surface of Mars use either IBA (Iterative Bundle Adjustment) or manual jiggling of the rover camera stations to best fit ORIs from NavCam to a HiRISE system in some arbitrary co-ordinate system. Within EU-FP7-PRoViDE, a fully automated system has been developed to replace the manual system which can be used in a hands-off fashion so long as HiRISE imagery (or equivalent) is available [5].

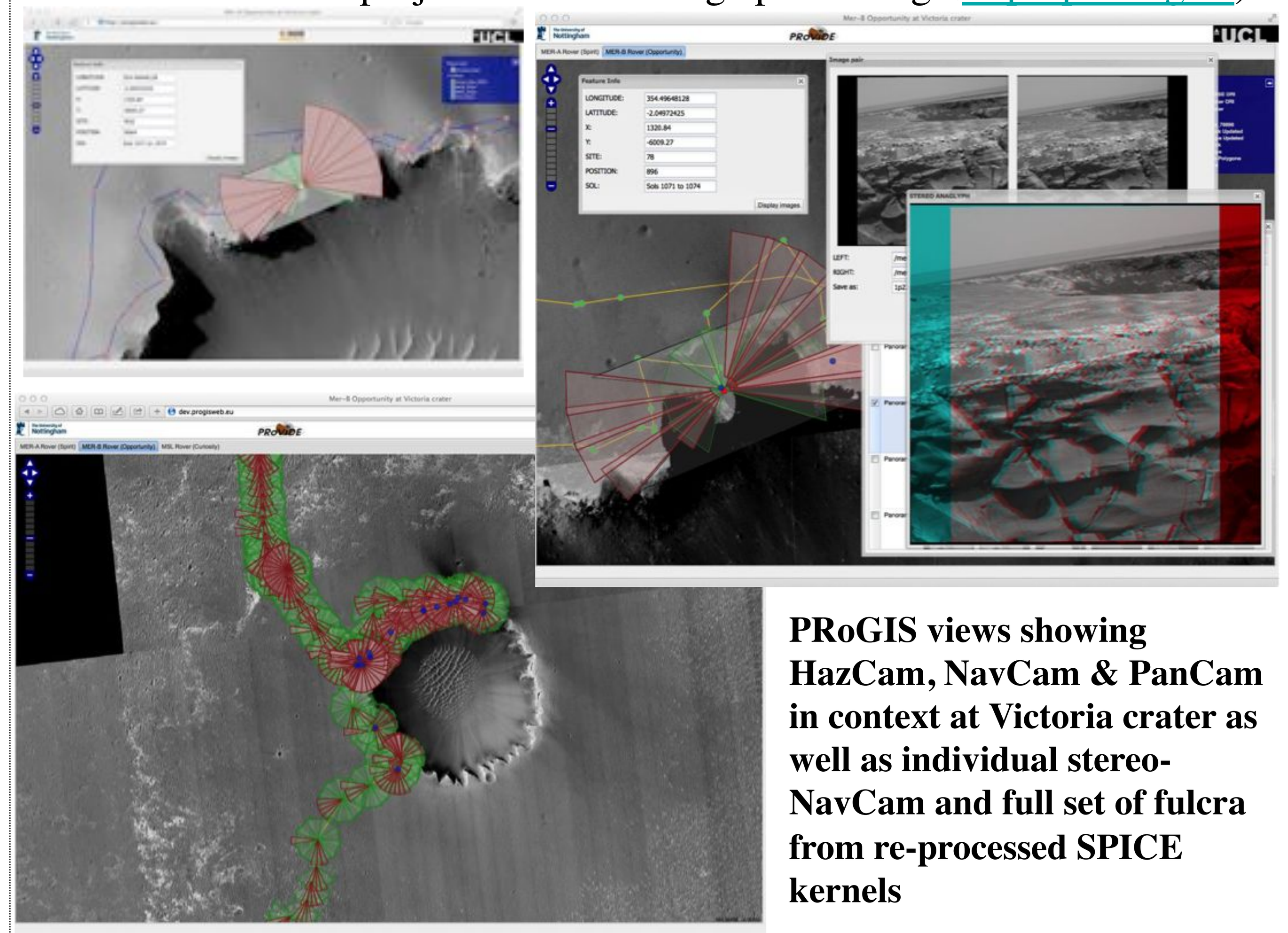


Examples of traverse from our localisation method shown on co-registered MSL HiRISE ORI

Superresolution restoration of multiple HiRISE: For a very limited number of sites, HiRISE has been acquired multiple times. In the example shown below, a 5cm image has been generated from a stack of 8x25cm HiRISE images. This allows an even more accurate refinement of the orbital optical navigation of the rover imagery as well as an opportunity to validate the automatically derived rover traverse.

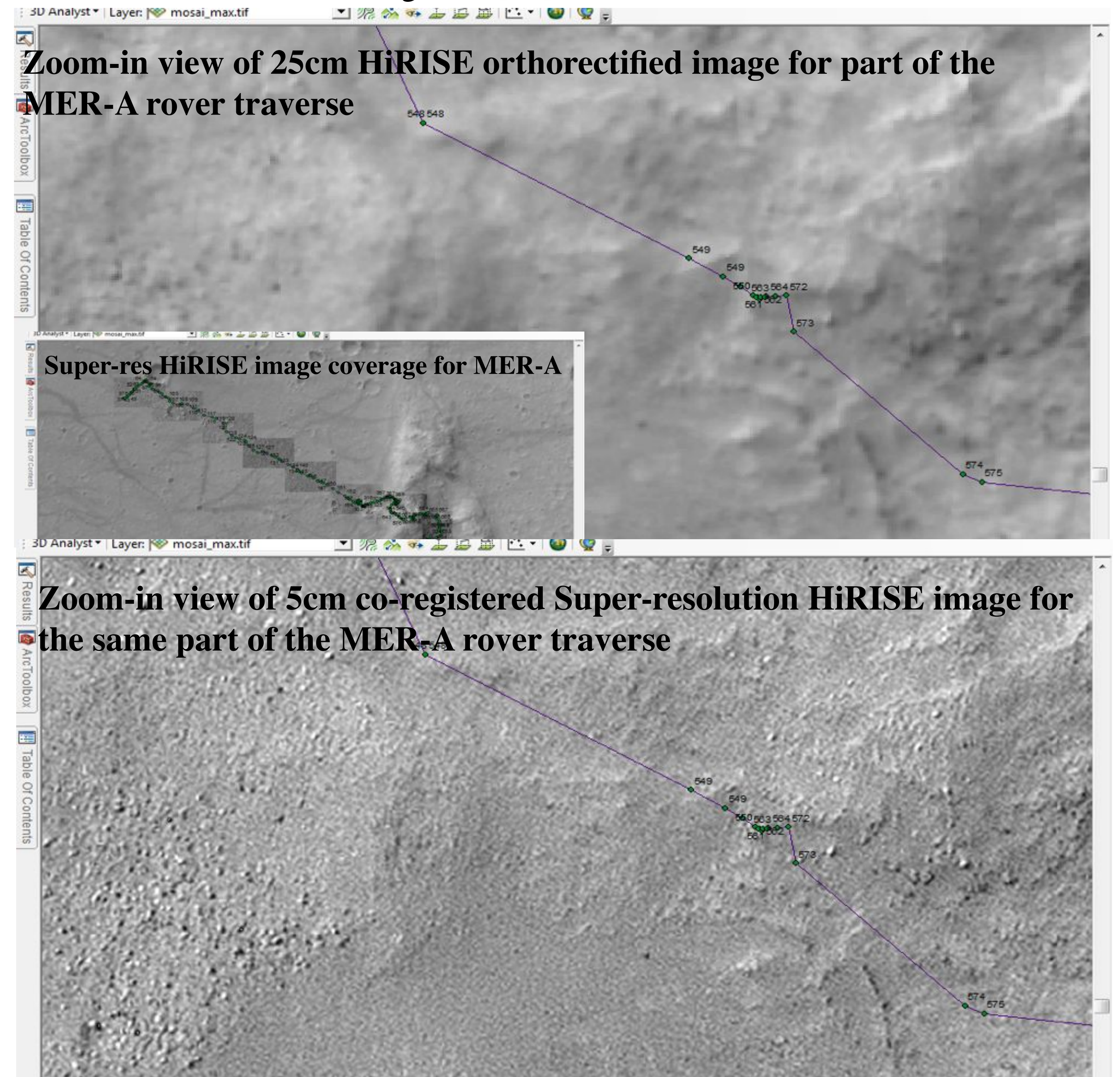


On-demand processing of rover imagery within a web-GIS (PRoGIS): :
PRoGIS [6] is designed to give access to rover image archives in a geographical context, using projected image view cones (fulcra), obtained from updated meta-data as previously described, as a means to interact with and explore the archive. It has also been integrated into a Java based stereo workstation developed for platform independent visulisation of Mars rover imagery [7,8] and PRoViP [9], which is the core software processing engine in the EU-PRoVisG project for MER image processing (http://provisg.eu)



PRoGIS views showing HazCam, NavCam & PanCam in context at Victoria crater as well as individual stereo-NavCam and full set of fulcra from re-processed SPICE kernels

Fusion of super-resolution image using co-registered imagery and rover tracks:
Super-resolution images hav been processed over the entire MER-A rover traverse calculated using the methods described above. This approach is being used to help select ExoMars rover landing sites [10].



Zoom-in view of 25cm HiRISE orthorectified image for part of the MER-A rover traverse

Super-res HiRISE image coverage for MER-A

Zoom-in view of 5cm co-registered Super-resolution HiRISE image for the same part of the MER-A rover traverse

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References: [1] Paar G. et al (2013) EPSC2013-289-2; [2] Muller J.-P. et al (2014) EGU2014-13744; [3] Tao Y. and Muller J.-P. (2013) LPSC2013-1573; [4] Gwinner et al. (2010) Earth and Planetary Letters, 294:506-519; [5] Tao Y. et al. (2014) ISPRS-Archives; Traxler C. et al (2014) EGU2014-12038; [6] Morley J.G. et al (2012) LPSC 43, 2896. [7] Shin D. and Muller J.-P. (2009) EPSC2009-390 [8] Shin D. and Muller J.-P. (2010) EGU2010-10851-1; [9] Paar G. (2009) EGU2009-4473-6. [10] Sidiropoulos P. and Muller J.-P. (2014) ISPRS-Archives;