EU-FP7-iMars: Analysis of Mars Multi-Resolution Images using Auto-Coregistration, Data Mining and Crowd Source Techniques: One year on with a focus on auto-DTM, auto-coregistration and citizen science.

Jan-Peter Muller (1), Panagiotis Sidiropoulos (1), Vladimir Yershov (1), Klaus Gwinner (2), Stephan van Gasselt (3), Sebastian Walter (3), Anton Ivanov (4), Jeremy Morley (5), James Sprinks (5), Robert Houghton (6), Stephen Bamford (7), and Jung-Rack Kim (8)

(1) University College London, Mullard Space Science Laboratory, Space and Climate Physics, Holmbury St Mary, United Kingdom (j.muller@ucl.ac.uk), (2) DLR, Deutsches Zentrum für Luft und Raumfahrt EV, Rutherfordstrasse, 2 Berlin - 12489 Germany, (3) Freie Universitaet Berlin, Malteserstrasse, 74-100 Berlin – 12249 Germany, (4) École Polytechnique Féderale De Lausanne, ELD 014, Station 11 Lausanne – 1015 Switzerland, (5) The University Of Nottingham, The Nottingham Geospatial Building, Triumph Road Nottingham, NG7 2TU UK, (6) Human Factors Research Group, Faculty of Engineering, University of Nottingham, University Park Nottingham NG7 2RD UK, (7) School of Physics and Astronomy University of Nottingham, University Park Nottingham, NG7 2RD UK, (8) University of Seoul, Jeonnong Dong 90, Dongdaemun Gu, Seoul 130 743 Republic of Korea

Understanding the role of different planetary surface formation processes within our Solar System is one of the fundamental goals of planetary science research. There has been a revolution in planetary surface observations over the last 8 years, especially in 3D imaging of surface shape (down to resolutions of 10cm) and subsequent terrain correction of imagery from orbiting spacecraft. This has led to the ability to be able to overlay different epochs back to the mid-1970s, examine time-varying changes (such as impact craters, RSLs, CO_2 geysers, gullies, boulder movements and a host of ice-related phenomena). Consequently we are seeing a dramatic improvement in our understanding of surface formation processes.

Since January 2004 the ESA Mars Express has been acquiring global data, especially HRSC stereo (12.5-25m nadir images) with 98% coverage with images ≤100m and more than 70% useful for stereo mapping (e.g. atmosphere sufficiently clear). It has been demonstrated [Gwinner et al., 2010] that HRSC has the highest possible planimetric accuracy of ≤25m and is well co-registered with MOLA, which represents the global 3D reference frame. HRSC 3D and terrain-corrected image products therefore represent the best available 3D reference data for Mars. Recently [Gwinner et al., 2015] have shown the ability to generate mosaiced DTM and BRDF-corrected surface reflectance maps.

NASA began imaging the surface of Mars, initially from flybys in the 1960s with the first orbiter with images ≤100m in the late 1970s from Viking Orbiter. The most recent orbiter to begin imaging in November 2006 is the NASA MRO which has acquired surface imagery of around 1% of the Martian surface from HiRISE (at ≈25cm) and ≈5% from CTX (≈6m) in stereo. Unfortunately, for most of these NASA images, especially MGS, MO, VO and HiRISE their accuracy of georeferencing is often worse than the quality of Mars reference data from HRSC. This reduces their value for analysing changes in time series.

Within the iMars project (http://i-Mars.eu), a fully automated large-scale processing ("Big Data") solution has been developed to generate the best possible multi-resolution DTM of Mars co-registered to the DLR HRSC (50-100m grid) products with those from CTX (6-20m grid, loc.cit.) and HiRISE (1-3m grids) on a large-scale linux cluster based at MSSL with 224 cores and 0.25 Pb of storage. The HRSC products are employed to provide a geographic reference for all current, future and historical NASA products using automated co-registration based on feature points. Results of this automated co-registration and subsequent automated DTM will be shown. The metadata already available for all orbital imagery acquired to date, with poor georeferencing information, has been employed to determine the "sweet spots" which have long time series of measurements with different spatial resolution ranges over the last ≈50 years of observations and these will be shown. Starting in July 2015, as much of the entire NASA and ESA record of orbital images will be co-registered and the updated georeferencing information employed to generate a time series of terrain relief corrected orthorectified images (ORIs) back to 1977. Web-GIS using OGC protocols will be employed to allow exploration visually of changes of the surface. An

example of this will be shown for the latest DLR HRSC DTMs at 100m and BRDF-corrected surface reflectance at 1km. Data mining processing algorithms are being developed to search for changes in the Martian surface from 1971-2015 and the output of this data mining will be compared against the results from citizen scientists' measurements in a specialised Zooniverse implementation. The results of an analysis of existing citizen science projects and lessons learnt for iMars will be shown. Final co-registered data sets will be distributed through both European and US channels in a manner to be decided towards the end of the project. The resultant co-registered image datasets will represent the best possible capture of changes and evolutions in the Martian surface. A workshop is planned to be held during the EPSC time period to demonstrate the first science results on these different types of changes based on initial results .

References: Gwinner, K., F. et al. (2010) Topography of Mars from global mapping by HRSC high-resolution digital terrain models and orthoimages: characteristics and performance. Earth and Planetary Science Letters 294, 506-519, doi:10.1016/j.epsl.2009.11.007, 2010; Gwinner, K., F. et al. (2015) MarsExpress High Resolution Stereo Camera (HRSC) Multi-orbit Data Products: Methodology, Mapping Concepts and Performance for the first Quadrangle (MC-11E). This conference.