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Identification and Analysis of Landing sites for the ESA ExoMars Rover (2018)

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The exploration and search for life on Mars forms a cornerstone of international solar system exploration. In 2018, the European Space agency will launch the ExoMars Rover and Lander to further this exploration. The key science objectives of the ExoMars Rover are to: 1) search for signs of past and present life on Mars; 2) investigate the water/geochemical environment as a function of depth in the shallow subsurface; and 3) to characterise the surface environment. To meet these objectives ExoMars will drill into the sub-surface to look for indicators of past life using a range of complementary techniques, including assessment of morphology (potential fossil organisms), mineralogy (past environments) and a search for organic molecules and their chirality (biomarkers).

The choice of landing site is vital if ExoMars' scientific objectives are to be met. The landing site must: (i) be ancient ($\geq$3.6 Ga); (ii) show abundant morphological and mineral evidence for long-term, or frequently reoccurring, aqueous activity; (iii) include numerous sedimentary outcrops that (iv) are distributed over the landing region (the typical Rover traverse range is only a few km, but the uncertainty in the location of the landing site forms an elliptical of size $\sim$ 100 by 15 km); and (v) have little dust coverage. In addition, in order to land and operate safely, various 'engineering constraints' apply, including: (i) latitude limited to 5º S to 25º N; (ii) maximum altitude of the landing site 2 km below Mars's datum, (iii) few steep slopes within the uncertainty ellipse. These constraints are onerous. In particular, the objective to drill into sediments, the requirement for distributed targets within the ellipse, and the ellipse size, make ExoMars site selection extremely challenging.

To meet these challenges, we have begun an intensive study of the martian landscape to identify as many possible ExoMars landing sites as possible. We have converted the current engineering constraints into spatial filters in a GIS (Geographical Information systems) to define regions of Mars where landing could be possible. We have used published geological maps of Mars to define areas that are of the appropriate age and integrated published catalogues of morphological indicators of standing water (e.g. delta-like landforms) and of layered terrains, and of the locations and spectral characteristics of minerals indicative of the action of water. Using this GIS we identified $\sim$25 study areas that held promise scientifically, and into which one or more landing 'uncertainty ellipses' could be fitted without breaching the engineering constraints. For each of these, we obtained and processed imaging data (from the NASA Mars Reconnaissance Orbiter 'CTX' instrument and the ESA Mars Express Orbiter 'HRSC' instrument), high resolution topographic data (again, from ESA's HRSC), and mineralogical data (based on infrared spectrometry data obtained by ESA's OMEGA instrument and NASA's CRISM instrument. Using these data we down-selected to five sites that had the highest potential and which, in some cases, had not been well-described previously in the peer-reviewed literature. At the time of writing, we are undertaking further geomorphological and mineralogical mapping of these sites, with the expectation of submitting 1-3 sites to ESA's ExoMars Landing Site Selection Working Group by the deadline set at end of February 2014.

In this presentation we detail the GIS and terrain analysis element of the work we have done, and describe how the diverse data types and team abilities were harnessed to solve the challenging problem created by ExoMars' stringent scientific and engineering constraints.