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The Small Bodies Thermal Mapper: An Instrument for Future Missions to Study the Compositional and Thermal Properties of Phobos

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The surface of Phobos holds many keys for understanding its formation and evolution as well as the history and dynamics of the Mars-Phobos system. Phobos has been the target for numerous flyby and sample return missions in the past (e.g. Rosetta [Pajola et al., 2012] and Phobos Grunt [Kuzmin et al., 2003]). Previous telescopic and spacecraft observations have revealed a surface that is compositionally heterogeneous [e.g. Pang et al., 1978; Pollack et al., 1978, Lunine et al., 1982; Murchie and Erard, 1996; Roush and Hogan, 2001; Rivkin et al., 2002; Giuranna et al., 2011; Fraeman et al., 2014] and with large variations in surface topography [e.g. Shi et al., 2011; 2012; Willner et al., 2014]. For any future sample return mission, remote sensing observations, in particular thermal infrared observations, will be key in characterising possible landing/sampling sites and placing returned samples into their geological context.

The European Space Agency has identified Phootprint, a European sample return mission to Phobos, as a candidate mission of the Mars Robotic Exploration Preparation Programme 2 (MREP-2). Using this mission concept as a baseline, we have studied the options for a simple multichannel radiometer to provide thermal mapping and compositional remote sensing data. By mapping Phobos' diurnal thermal response, a thermal imaging instrument will provide key information on the nature of the surface and near sub-surface (the thermal inertia) and composition. These measurements will support visible imaging observations to determine landing sites that are compatible with the spacecraft's sampling mechanisms. Remotely sensed thermal maps of the surface will also prevent otherwise unpredictable thermal loads on the spacecraft due to variations in local topography and albedo.

The instrument design resulting from this study, the Small Bodies Thermal Mapper (SBTM), is a compact multichannel radiometer and thermal imager. The SBTM is based on the Compact Modular Sounder (CMS) instrument currently flying on the UK's TechDemoSat-1 spacecraft in low Earth orbit. This gives a significant level of flight heritage with optimisations for the expected Phobos environment. The SBTM instrument uses a two-dimensional uncooled thermal detector array to provide imaging of Phobos. In addition, ten narrow-band infrared filters located around diagnostic mineral spectral features provide additional compositional discrimination.

For the SBTM, the optimisations studied include options for the detector and filters required to cover the wide range of diurnal temperatures expected at Phobos (e.g. 130 to > 300 K) [e.g. Kuzmin et al., 2003]. Options studied include the use of a broadband micro bolometer array (e.g. http://www.ulis-ir.com/uploads/Products/PICO640E-041-BroadBand.pdf) or a thermopile detector [Foote et al., 1998] array. Optimisation of filter band passes for remote measurement of composition is also considered, based on mineral spectra measured under simulated Phobos environment [e.g. Glotch et al., 2014].