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The ExoMars Rover Inspection Mirror (RIM): New opportunities for Mars surface science

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With the current baseline ExoMars rover design and the positioning of the cameras - PanCam, NavCams, and HazCams [The Rover Team 06, Griffiths 06], there are several regions of the rover that cannot be imaged. These regions include the front, sides, and underside of the rover. The inability to image these regions is also the case for the two NASA MER rovers [Squires 04]. From both engineering and planetary science standpoints, to be able to image these regions would be highly desirable. To address this imaging inability, UWA is proposing that a Rover Inspection Mirror (RIM) be introduced into the ExoMars rover design. To investigate the new Mars science opportunities that the RIM would facilitate, studies have been performed both in simulation and with a real rover chassis, robotics arm, RIM and UWA PanCam system in the UWA Planetary Analogue Terrain (PAT) Laboratory.

During the studies the RIM has been placed towards the end of the ExoMars robotic ARM. This means that it can be imaged by the PanCam High Resolution Camera (HRC). The HRC provides a zoom-in capability (FOV $>$ 5 degrees), and with a motor drive mechanism providing object focus from 1 metre to infinity, it means that close-up images of the RIM can be obtained. When mounted for example on the ARM lower wrist motor gearbox housing, the distance from RIM to HRC is approximately 1600 mm (when the ARM and the rover mast are in their nominal deployed operating configuration).

A spherical convex mirror with a FOV of 106 degrees has been used for both the simulation and real RIM studies. HRC captured RIM images can be 'unwrapped' from a spherical to a planar projection, and 'flipped' horizontally as they are mirror-images. We propose that the RIM is not a separate component; rather it is machined as in integral part of the ExoMars robotic ARM (or similar) structure, and hence negligible additional mass. The resultant surface would require polishing, and a reflective metallic coating applied (e.g. via spluttering). This surface would require a coating of a transparent material so as to protect the mirror. Any protective coating would need properties so as to minimise any surface micro-structures, and hence minimise the aggregation of dust particles on its surface. All materials used would have to be fully compliant with planetary protection, not out-gas, and UV tolerant etc.

Our studies have shown that using the RIM it is possible to image the ExoMars rover together with its surrounding terrain. The front, sides and underside of the rover can be seen, and by moving the rover ARM (and hence the attached RIM) it is possible to generate views of the rover hitherto not seen during any other Mars missions (for example MER). The engineering benefits of the RIM are most evident, and examples include for the ExoMars rover images of the drill which can be obtained during drill deployment, rather that only being able to image the top of the drill housing box.

We argue that the RIM will provide new science opportunities for the ExoMars rover. Our studies have shown that the rover wheels can be imaged in their entirety using the RIM with a clarity that has not been achieved during (for example) the MER mission. Such image data would allow advances in planetary soil mechanics to be made. By imaging the RIM with the HRC whilst the RIM is positioned over the Martian surface, in-situ bidirectional reflectance distribution functions (BRDF) can be measured in the RGB wavelengths. Such experiments have not been performed to date on Mars, and the data would allow advances to be made in areas such as orbital imaging and Mars photogrammetry.

More speculative RIM science possibilities include the use of dielectric coatings to create a multilayer mirror as opposed to the metallic coated mirror studied so far. An ultra broadband dielectric mirror could be used that would have more durable properties than a metallic coating. Conversely it may be possible to use a selective bandwidth multi-layer mirror that could be used to image the Martian surface for evidence of intrinsic fluorescence [Pane 05] signatures amongst the Martian rocks. Likewise polarising [Sparks 05] RIM coatings could offer new exobiology discovery opportunities.

This paper presents the results we have obtained from our simulated and real RIM studies, and the new Mars surface science opportunities are described.

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