INVESTIGATING THE SCIENCE RETURN OF A MICROROVER FOR MARS EXPLORATION.

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Introduction: No nano-rover (2 kg) class vehicle has ever landed on Mars. Such a small vehicle would make it an ideal secondary payload with its own independent mission in a similar manner to Cubesat missions. A nano-rover, approximating the size of an A4 sheet of paper (29.5 X 21 cm) was machined to characterise and evaluate the application of skid steer drive system on such a small vehicle. Previous mobility testing identified that vehicles of this type are able to traverse surfaces found on Mars and negotiate slopes up to 20^o on firm ground [1]. Current work is focusing on testing of the rover's imaging system; part of its science payload. A series of radiometric tests were conducted on materials expected to be found on Mars in order to identify what science data can be gathered for rovers of this class.

Science Testing: The A4 Rover, named the Crab carried a non-contact thermometer, UV sensor and Raspberry Pi (RPi) camera with a pixel resolution of 2592 X 1944. The scientific payload was designed to provide useful data from a diversity of Martian landing sites [2, 3]. The camera was calibrated using a custom target of colour swatches and painted targets to test for accuracy of returned results [4, 5]. This target was photographed by the Crab, and images were processed for dark current and vignette removal using ImageJ, an open source image processor [6]. Areas of interest were used to interrogate pixel values from the corrected image. These areas were a minimum of 20 pixels in size in order to produce meaningful data. Results from these areas were compared with values obtained from an SR-3500 spectro-radiometer [7] on the same materials under controlled conditions.

Results: Figure 1A-C show the empirical regression analysis results between the red (Fig. 1A), green (Fig. 1B) and blue (Fig. 1C) channel of the camera (digital numbers, Y axis) and the SR-3500 (0-1, X axis). The R2 values for all bands were 0.8538 to 0.8662, with the green channel performing slightly better than the red or blue channels. The empirical regression results (0.85-0.87, Fig. 2A-D) showed the Raspberry Pi camera performance was comparable to, or better than that of the Tetracam commercial multispectral camera [8]. The Crab camera results were also comparable to other custom built multispectral cameras [4, 5, 8]. Although not visible in NIR wavelengths due to design limitations the Crab's camera would still be useful at identifying basic geological properties of studied regolith and rocks.

Figure 2 shows a qualitative overview of the performance of the Crab's camera with the SR-3500 on three mineral types that have been discovered on Mars [3]. The green and blue channels of the trialed minerals were in closer agreement than the red channel (Fig. 2A-C). This was particularly the case for the Gypsum sample (Fig. 2C). The Crab camera used the default RPi polycarbonate lens in order to save weight and space. The small size of the lens may be adding biases to the red band. A 12 mm glass lens was trialed for the RPi camera in order to determine the degree to which a higher quality lens increased radiometric accuracy. Following reimaging of the same target, and performing dark subtraction and vignetting corrections it was found that fitted values for all bands increased to 0.97. This lens thus produced better results at the expense of increased size and weight. Future investigations into other cameras able to see into the near-infrared wavelengths will be considered for testing on nano-rovers of this type.

References: [1] Hobbs S.W. Paull D.J. and Clarke J. D. A. (2017) *16th ASRC Proceedings*. [2] Soffen G. A. (1977) *JGR Planets., 82*, 3959-3970. [3] Farrand, W.H. et al. (2008) *Cambridge Univ. Press, NY.* [4] Kelcey, J. and Lucieer A. (2012) *Int. Archives of Photogrammetry*. [5] Aden S.T. et al. (2014) *Int. Archives of Photogrammetry*. [6] Abramoff M.D.. (2004) *Biophotonics International*, 36-42. [6] Spectral Evolution (2017) *spectralevolution.com*, accessed 31 December 2017. [8] Hobbs S.W. Paull D.J. and Clarke J. D. A. (2017) *IJRS.*

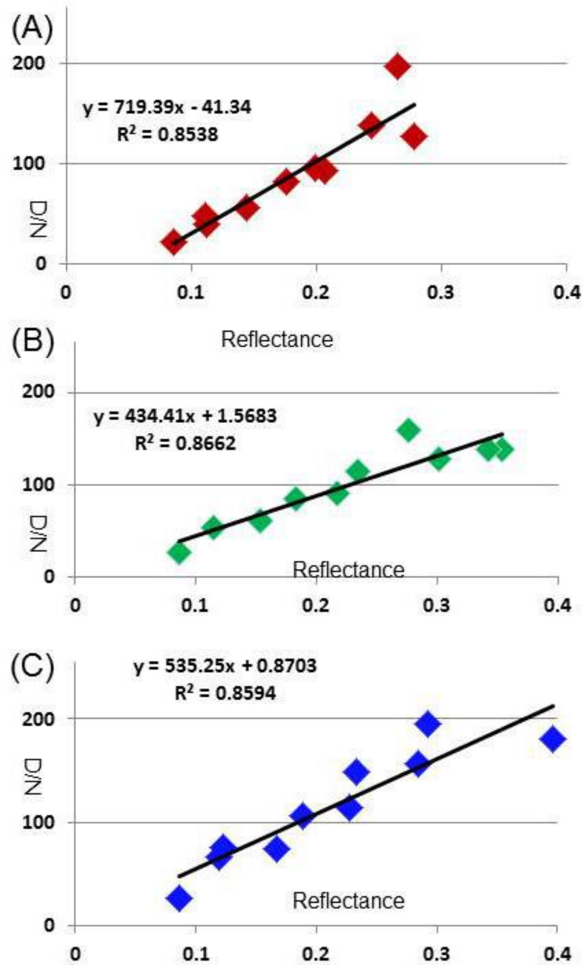

Figure 1. Regression plots of A4 Rover camera with SR-3500 spectro-radiometer. (A) Red band. (B) Green band. (C) Blue band.

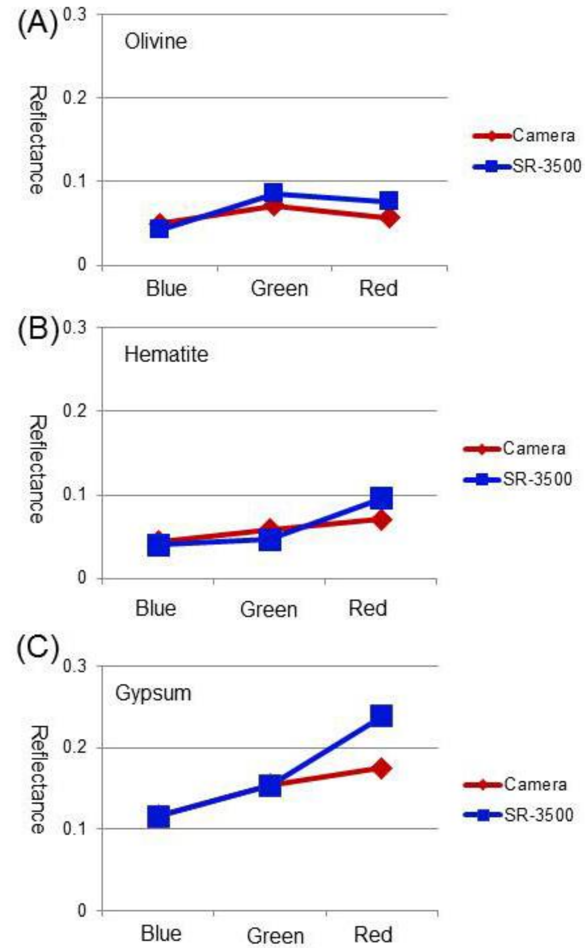

Figure 2. Comparative plots of A4 Rover camera with SR-3500 spectro-radiometer for selected minerals. (A) Olivine. (B) Hematite. (C) Gypsum.