UK Space Agency "Mars Utah Rover Field Investigation 2016" (MURFI 2016): overview of mission, aims and progress

Conference or Workshop Item

UK SPACE AGENCY "MARS UTAH ROVER FIELD INVESTIGATION 2016" (MURFI 2016): OVERVIEW OF MISSION, AIMS AND PROGRESS

M.R. Balme[1], M.C. Curtis-Rouse[2], S. Banham[3], D. Barnes[4], R. Barnes[3], A. Bauer[5], C. Bedford[1], J. Bridges[6], F.E.G. Butcher[1], P. Caballo[5], A. Caldwell[2], A. Coates[7], C. Cousins[8], J. Davis[9], J. Dequaire[4], P. Edwards[6], P. Fawdon[10], K. Furuya[5], M. Gadd[4], P. Get[4], A. Griffiths[7], P.M. Grindrod[10], M. Gunn[11], S. Gupta[3], R. Hansen[12], J.K. Harris[10], J. Holt[6], B. Huber[5], C. Huntly[11], I. Hutchinson[6], L. Jackson[3], S. Kay[2], S. Kyberd[4], H.N. Lerman[6], M. McHugh[6], W. McMahon[13], J-P. Muller[7], G. Paar[5], L.J. Preston[10], S. Schwenzer[1], R. Stabbins[7], Y. Tao[7], C. Traxler[14], S. Turner[6], L. Tyler[11], S. Venn[4], H. Walker[2], J. Wright[1], B. Yeomans[5]. [1]School of Physical Sciences, Open University, UK (matt.balme@open.ac.uk), [2]Science & Technology Facilities Council, UK, [3]Imperial College London, UK, [4]University of Oxford, UK, [5]Joanneum Research, Austria, [6]University of Leicester, UK, [7]Mullard Space Science Laboratory, UK, [8]University of St Andrews, UK, [9]University College London, UK, [10]Birkbeck, University of London, UK, [11]Aberystwyth University, UK, [12]Natural History Museum, London, UK, [13]University of Cambridge, UK, [14]VRVis, Austria.

Introduction: The Mars Utah Rover Field Investigation "MURFI 2016" is a Mars Rover field analogue mission run by the UK Space Agency (UKSA) in collaboration with the Canadian Space Agency (CSA). MURFI 2016 took place between 22nd October and 13th November 2016 and consisted of a field team including an instrumented Rover platform (Fig. 1), at the field site near Hanksville (Utah, USA), and an 'Operations Team' based in the Mission Control Centre (MOC) at the Harwell Campus near Oxford in the UK.

The field site was chosen based on the collaboration with the CSA and its Mars-like local geology. It was used by the CSA in 2015 for Mars Rover trials [1], and in 2016, several teams used the site, each with their own designated working areas.

Fig. 1. MURFI 2016 Rover. The large "eyes" contain the PanCam filter wheels.

The two main aims of MURFI 2016 were (i) to develop logistical and leadership experience in running field trials within the UKSA, and (ii) to provide members of the Mars Science community with Rover Operations experience, and hence to build expertise that could be used in the 2020 ExoMars Rover mission, or other future Rover missions. Because MURFI 2016 was the first solely UKSA-led Rover analogue trial, the most important objective was to learn how to best implement Rover trials in general. This included aspects of planning, logistics, field safety, MOC setup and support, communications, person management and science team development. Some aspects were based on past experience from previous trials [e.g., 1,2,3] but the focus was on 'learning through experience' - especially in terms of the Operations Team, who each took on a variety of roles during the mission.

Mission Philosophy: (i) It was decided early in the mission planning to simulate the first ~ 10 Sols of a Mars Rover mission "as a whole", rather than testing specific instruments or methods. The mission profile was therefore created to be "ExoMars Rover-like", with the instruments and Rover capabilities selected to be as close as possible to those of the ESA ExoMars 2020 Rover [4]. (ii) MURFI 2016 was run as a "blind" mission from the perspective of the MOC science team: they were not permitted to see any information other than Mars-equivalent remote sensing data, or data returned by the Rover itself. For the MOC team, this also meant blocking the social media accounts of the field team members, and disallowing access to online remote sensing services such as GoogleEarth. (iii) Tactical Operations were performed on a daily basis, with a limited time allowed to analyze data returned from the previous Sol's operations and to create the plan for that Sol's commands. The aim was to provide training for real missions, where efficient and rapid tactical planning is essential.

ExoMars Rover-like Mission Science Goal: The primary science objective of the ExoMars Rover mission is "to search for signs of past and present life on Mars" [4]. The MURFI ExoMars Rover-like mission goal, designed to mirror that of ExoMars Rover, was therefore: *"to locate suitable areas in the field site that* *have sedimentary geology indicative of an ancient habitable environment, then to drill into the surface to acquire a sample from those materials, and, finally to examine these samples with the analytical instruments available onboard the Rover."* Strict adherence to such a goal is challenging, as it requires the identification and sampling of sedimentary bedrock, rather than the acquisition of fines of less well-known provenance.

Platform and instruments: The ARC Q14 Rover (Fig. 1) used in the field was a four-wheeled, holonomic platform supplied by Oxford University Robotics Institute. The Rover was instrumented with (i) the Aberystwyth University PanCam Emulator (AUPE, [5]) to simulate the ExoMars PanCam instrument [6], including the full array of filters [7] and the High Resolution Camera (HRC) emulator, (ii) a Digital SLR camera with macro lens, mounted to simulate the ExoMars Close-up Imager (CLUPI, [8]) range of motion and field of view, (iii) an ASD Inc. FieldSpec4 field reflectance spectrometer to simulate the Infrared Spectrometer for Mars Instrument (ISEM, [9]), and (iv) a Raman Spectrometer, the use of which on the final drill-samples acquired would signify 'mission success'. The Raman instrument is similar to that in the ExoMars Rover Analytical laboratory Drawer [10] and can provide information on the molecular composition of the drill core. In addition, to simulate the ExoMars Rover's ability to drill to depths of up to 2m and obtain a core sample, the field team were equipped with a hand-held core drill and hand tools to extract an ExoMars-like core from depth.

The main ExoMars instruments lacking from the MURFI payload included the Ground Penetrating RADAR, WISDOM [11], and the fuller suite of instruments within the drill package and in the Analytical Laboratory Drawer. We hope to include emulators for these instruments in the future.

Mission Operations Centre (MOC): The MOC contained eight workstation PCs, each with space for two workers, configured in a two-tiered "control room" style. The main focus of the MOC was a large multi-panel video-wall, comprising 18 large HD monitors. Multiple outputs from the MOC workstations could be presented at various sizes on the main display, allowing easy comparison of the different datasets, or the display of single panoramas in very large format and very high definition.

Operations and Results: Week 1 of the mission was dedicated to field setup and testing, and, at the MOC, 'landing site' mapping from remote sensing data [12]. The ExoMars-like portion of the mission extended over 9 Sols in weeks 2 and 3 (two days at the start of week 1 were used for tactical operations rehearsals). The Rover was positioned by the Field Team on Sol 0, and from that point on a new tactical plan was generated each Sol by the MOC team. The daily planning deadline was midday UK time, which, aided by the timezone difference between the UK and Utah, allowed the field team to receive the commands early in the morning and execute the command plan.

The first 5 Sols of the mission consisted of characterizing the local geology and planning drives towards possible outcrops. Waypoint files for the planned drives were generated by the MOC and uploaded to the rover, which then executed each drive autonomously using visual odometry techniques [12] derived from onboard stereo "Navcams".

The geological interpretations from MURFI, based on working hypotheses drawn from remote sensing analyses [13] and the first 5 sols of Rover observations, are presented in [14]. The next 3 sols were devoted to characterizing a possible drill target, with the command to drill being given on Sol 8. Post-drilling observations and CLUPI/Raman analyses of the drill sample were returned on Sol 9 for later analysis.

Conclusion: While primarily a 'trial for future trials', MURFI 2016 was also a vital training activity for the science team and produced some important operations insights. An important learning outcome for many in the MOC team was having to perform tactical operations under a tight deadline, rather than having time to examine the data in full. Also, the complexity and difficulty of targeting a Rover-mounted drill, on a Rover with mainly stand-off instruments as opposed to an instrument suite on a Robotic Arm, became apparent during the last few Sols of MURFI 2016. This will present a challenge for ExoMars Rover operations.

We plan to perform another MURFI mission in 2017/2018, and hope to include a fuller instrument suite. The current plan is to begin at the same location that MURFI2016 ended, thus simulating the next 10-15 Sols of an ongoing mission.

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