TO HEL AND BACK – STRATEGIC PLANNING FOR THE CANMARS 2016 MARS SAMPLE RETURN ANALOGUE MISSION. E. A. Pilles[1], R. Francis[2,1], J. Newman[1], M. Cross[1,4], M. Battler[1], and G. R. Osinski[1,3]. [1]Centre for Planetary Science and Exploration / Dept. Earth Sciences, University of Western Ontario, London, ON. [2]Jet Propulsion Laboratory, California Institute of Technology, [3]Dept. of Physics and Astronomy, University of Western Ontario, London ON, [4]Dept. of Electrical and Computer Engineering, University of Western Ontario, London, ON.

Introduction: In 2015, the Centre for Planetary Science and Exploration (CPSX) at the University of Western Ontario, in partnership with the Canadian Space Agency (CSA), executed a high-fidelity Mars Sample Return (MSR) Analogue Mission at the University of Western Ontario, as part of the of the NSERC CREATE project "Technologies and Techniques for Earth and Space Exploration" (create.uwo.ca) [1]. The Mars Exploration Science Rover (MESR), developed by MDA, "landed" in Utah, USA in an unknown location, and 11 command-cycles (each consisting of 1 sol's worth of activities) were planned by the science operations team located at the University of Western Ontario, Canada. These plans were executed by the field team in Utah using MESR and handheld instruments with the goal of testing the science instruments and rover in a realistic way.

In November 2016, the analogue mission continued in two parts [2]. During part 1 of the mission (Sols 12–21) 10 command-cycles were planned, each corresponding to 1 sols worth of activities, executed using MESR. Two Strategic Traverse Days [3] were preplanned with activities involving long rover traverses and post-drive imaging. These 'strategically-developed plans', largely pre-developed, were included to allow the science team more time for longer-range planning and data analysis/synthesis, by reducing effort spent on tactical planning.

During part 2 of the mission (Sols 22–39), 6 command-cycles were planned, each corresponding to 3 sols worth of activities, executed by a human field team but under the same constraints as the rover. This part of the mission was called the Fast Motion Field Test (FMFT), and was implemented in order to increase the amount of scientific data and samples received during the mission. During the FMFT, two new simulated capabilities were included: *(1) Autonomous geological classification* [4], which allowed the "rover" to autonomously classify units in an image and target them with remote measurements, and; *(2) Conditional sequencing*, which allowed the "rover" to carry out a different plan if certain conditions were met [5].

Pre-planning for 3-sol command-cycles: The original plan conceived for executing 6 3-sol command-cycles in a row relied heavily on the rover's ability to precisely return to a point it had previously been [5]. This allowed the rover to return to a previous waypoint and use images acquired from that point to target specific features with remote measurements. This idea lead to the concept of the "walkabout" which was an essential part of planning 3-sol command-cycles.

The walkabout (Sols 22–24): The first command-cycle consisted of the walkabout (yellow in Fig. 1), during which the rover would traverse to 3 different locations in the Ragnarok region. At each of these locations an image was acquired of one or more features of interest. Each of these images was classified using autonomous geological classification, and remote measurements were taken from the centroid of two different units visible in the image. This process acquired scientific data without requiring the science operations team to target specific points, and also generated 3 reusable waypoints that the rover could return to and perform targeted remote measurements using the images obtained during the walkabout. Each command cycle afterwords consisted of some combination of contact science/sampling, returning to a previous waypoint for remote science, and traversing to a new waypoint and performing autonomous science.

Targeted science and sampling set-up (Sols 25–27): The second command-cycle (blue in Fig. 1) began with a short traverse towards Hel, "saving" a new waypoint for future targeted science. The rover then returned to two waypoints where targets were selected for remote science. The traverse ended at the slopes of Ragnarok with a workspace lidar scan and zoom image, in order to set-up the next command-cycle for sampling.

Sampling, targeted science and set-up for sampling (Sols 28–30 and Sols 31–33): The following two command-cycles (pink and red in Fig. 1) progressed in a very similar way. They began with contact science (using the instruments mounted on the "arm" of the rover) and sampling. Then, the rover drove towards Hel, carrying out targeted remote science on the first Hel waypoint, and "saving" a new waypoint for future targeted science. Then the rover returned to the previous waypoints for targeted remote science, and ended the traverse with a workspace lidar scan and zoom image, in order to set-up the subsequent command-cycle for sampling. This 3-sol template (sampling, targeted science, autonomous science, and set-up for sampling) was used for each remaining command-cycle with new waypoints being added with each cycle.

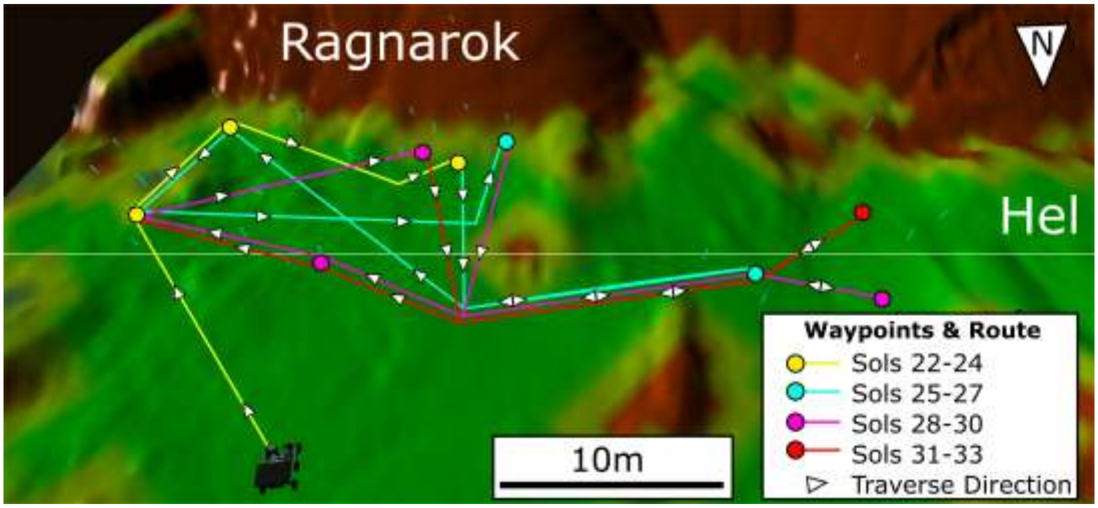

Figure 1. Digital elevation model of the landing site, overlain with a slope map. Green indicates slopes from 0–10°, yellow indicates slopes from 10–15°, and red indicates slopes >15°. The rover's route taken during 4 com-mand cycles is represented by the different coloured lines and circles.

Implications of the Fast Motion Field Test: The FMFT allowed the science operations team to plan the rover activities in a novel way that made efficient use of the 3-sol plans. In most cases, a rover will follow a straight path, only moving on from a particular waypoint or region when there is no longer any significant science to be done at that location. During the FMFT, the rover followed a route that was very much analogous to a field geologist. The rover did an initial pass of the Ragnarok region (yellow line, Fig. 1) in order to identify the major lithologies present. It then returned to these locations to complete targeted remote science on each lithologic unit visible. Once it had acquired sufficient contextual information on each unit, it began sampling each unit. If the mission were to continue, the rover would have collected a representative suite of samples from the Ragnarok region, and would have traversed to a new location, where it would repeat the process again.

Integrating 3-sol command cycles with strategic traverse days: Two major problems associated with the 3-sol command-cycles involved fatigue. In the most basic sense, the team became tired after 3 weeks of mission operations, and additional days off would be valuable. Additionally, the data return from 3-sols of activities was so high it resulted in "data fatigue", where measurements were received faster than they could be interpreted. Many details in the images or other data were missed because the science operations team did not have sufficient time to analyse the data *and* create plan for the following 3-sol plan.

To remedy the data fatigue problem, it is recommended that future analogue missions simulating the execution of 3-sol plans allow time afterwards for analysis (i.e., a science discussion day). For example, one week of operations could proceed as follows:

Monday – sols 1 – 3: 3-sol plan executed by a human field team. Data would be returned to the science operations team by the end of the day. This would be a day off for the rover operations team.

Tuesday – science discussion day: The science operations team would have the entire day to review the data and create a plan for sol 4. The human field team and rover operations team would have this day off.

Wednesday to Sunday – sols 4 – 8: Five command-cycles each corresponding to one sols worth of activities executed by the rover.

A sequence of plans such as this would be beneficial for the science operations team and the rover operations team. This would provide the science operations team with an extra day dedicated longer-range planning and data analysis/synthesis. This would also provide the rover operations team with two days off per week to address any technical difficulties or run their own tests.

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