IMPLEMENTATION OF STRATEGIC TRAVERSE DAYS DURING THE CANMARS 2016 MARS SAMPLE RETURN ANALOGUE MISSION. E. A. Pilles[1], C. M. Caudill[1], R. Francis[3,1], M. Battler[1] and G. R. Osinski[1,2]. [1]Centre for Planetary Science and Exploration / Dept. of Earth Sciences, University of Western Ontario, London ON. [2]Dept. of Physics and Astronomy, University of Western Ontario, London ON. [3]Jet Propulsion Laboratory, California Institute of Technology.

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 a location which was not revealed to the remote operations team. Eleven command-cycles (one command cycle was equivalent to one sol of operations) were planned by the science team located at the University of Western Ontario, Canada. These plans were executed by field team in Utah using the MESR rover and hand-held instruments with the goal of testing the instrument suite, rover handware and software capabilities, and operational workflows to best meet mission goals.

The 2016 mission cycle continued from the previous year[2]. During the 2016 mission cycle, strategic traverse days were implemented, where pre-planned tractical sequences were implemented with activities involving long rover traverses and post-drive imagery. These pre-planned command cycles were included for two main reasons: 1) to eliminate the need for tactical planning for that sol, thus enabling the science team to process and interpret the immense data return with an extended science discussion;2) to vet workflows for active and future rover missions, which are increasingly making use of strategic planning.

Planning for Strategic Traverse Days: The mission began on Sol 12, where the 2015 CanMars mission left off. During the previous year's mission, the Jotunheim region (Fig. 1) was thoroughly investigated and sampled to characterize the geologic setting of the site [3]. This year, the primary objective was to obtain a sample with highest organic carbon [4]. The regions Horik, Ragnarok, and Hel (Fig. 1) were of particular interest, having well-exposed lacustrine and fluvial deposits; furthermore they had not been visited during the 2015 mission.

The first strategic traverse day was scheduled for sol 15, and this provided some limitations to the activities that could be completed on the sols before and after the strategic traverse. The strategic traverse day was intended as a long driving day, which was the best use of the mission time and rover resources with little autonomy in play. Prior to this traverse, we had to ensure that we had completed any necessary science at our current location (the base of Jotunheim) before Sol 15. This was difficult to accomplish, as the southern slopes of Jotunheim had not been imaged until sol 14. Had the strategic traverse day not been included, the mission operations team would have possibly spent additional time examining the southern slopes of Jotunheim before moving on. In the end, the mission operations team decided that sols 12, 13, and 14 were best spent collecting a few final measurements and images in the Jotunheim region before traversing towards Horik.

Strategic Traverse Day 1 (Sol 15): The primary objective of Sol 15 was to get as close as possible to the feature of interest Horik (Fig. 1). Horik was chosen as a region of interest because of its potential to preserve in-situ materials. Based on best available imagery, Horik appeared to consist of an intact sandstone capping unit underlain by layers of siltstone similar to that of Jotunheim. This appeared to be the only location seen thus far where there rover may be able to reach the contact between the lenticular sandstone units and the underlying material. It was believed that this capping sandstone may have protected and preserved clays, sulfates, and other material in-situ.

The strategic traverse day consisted of a 30m traverse towards Horik with a post-drive panorama and 360° lidar scan. A zoom image was also acquired of the capping rock material. This image was used to autonomously target two different rock types visible in the image with SuperCam measurements. Novel autonomous capabilities for the rover operations were implemented in the 2016 analogue mission cycle [5, 6] in part to facilitate the strategic traverse days. This strategic traverse set up the science team to perform targeted science and sampling in the Horik region over the next few sols.

Strategic Traverse Day 2 (Sol 20): After sampling the cap-rock material from Horik, Sol 20 was spent traversing towards the Ragnarok region (Fig. 1). Originally, the intent was to travel directly south from Horik towards Ragnarok, however the terrain was difficult to traverse – something that was not apparent from the 0.5m/pixel digital elevation model integrated into the MESR rover software. Because of this, the rover was

forced to backtrack around the difficult terrain on its way towards Ragnarok.

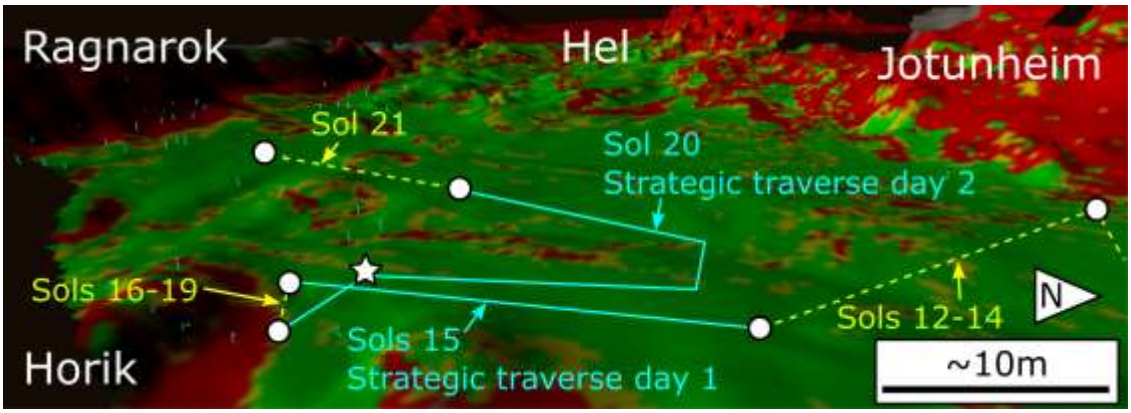

Figure 1. Digital elevation model of the landing site, overlain with a slope map. Green indicates slopes from 0–10°, yellow indicates slopes from 10–15°, and red indicates slopes >15°. The rover's route taken during the strategic traverse days is shown in blue.

The rover made one stop after ~15m (indicated by the star in Figure 1) where it acquired a single zoom image and autonomously targeted two rock types with SuperCam measurements. After this, the rover was given a command to traverse towards the feature Ragnarok, using MESR's autonavigation to drive as close as it could to the feature of interest (a drive of ~60m). After this drive it acquired a zoom image to the left of the rover and autonomously targeted the dominant rock type in the image with SuperCam measurements. This strategic traverse got the rover closer to the Ragnarok region, in preparation for part 2 of the mission [7].

Science Discussion: Strategic planning days were used in the CanMars mission to give the science team a break from tactical planning to focus on the huge volume of data return and develop and strengthen depositional models. During these strategic days, pre-planned sequences were uplinked to the rover. We found that these days were essential for the team to refine depositional models which would determine lithologies for sample targeting.

Strategic Traverse Day Implementaiton and Science Outcomes: The strategic traverse days allowed the science team to break from normal mission roles and collaborate broadly to expand on a stratigraphic sequence initially created during CanMars 2015. From this effort, we developed a predictive model for the field site. A depositional model is imperative in predicting and finding features of interest, advanced planning of rover sequencing, and long-term planning to meet science goals. This model was in active development during the mission, and was tested and updated as new data was acquired.

The highest priority mission goals for the 2016 CanMars mission were focused on paleoenvironmental habitability potential and preservation of ancient biosignatures from organic-rich carbon. The predictive stratigraphic model gave us the tools to indicate lithologies and specific outcrops likely to have preserved biosignatures many sols in advance of acquiring data on the targets of interest. Using this information, we were able to make a long-term strategic mission plan which was very focused on rich data return and sample acquistition.

Implications: The inclusion of pre-planned command cycles had both benefits and drawbacks. It allowed the science team to focus on the development – and improvement – of a depositional model for the landing site, which guided sampling strategies for the remainder of the mission. However, it limited the activites available to the mission operations team prior to – and immediately after – the strategic traverse days. This high fidelity analogue mission allowed our team to experiment with novel mission approaches and operational workflows. We propose that a combination of strategic planning days with multi-sol rover autonomy represents the best use of human and rover resources [4].

Acknowledgements: We thank the CSA and international guests (from NASA, UKSA, and DLR) whose dedication and guidance made this a very closely simulated analogue mission. This work was funded by the Natural Sciences and Engineering Research Council of Canada's CREATE program and the Canadian Space Agency.

References: [1] Osinski G. R. et al. (2016) *LPSC XLVII*, Abstract #2616. [2] Osinski G. R. et al. (2017) LPS XLVIII, *this conference*. [3] Pontrefact, et al., (2016) *LPSC XLVII*, 2117. [4] Caudill, C. M. et al. (2017) LPSC *XLVIII, this conference.* [5] Francis R. et al (2017) LPSC XLVIII, *this conference*. [6] Kissi, J. et al. (2017) LPSC *XLVIII, this conference.* [7] Pilles, E. A. et al (2017) LPSC *XLVIII, this conference.*