2015 CANMARS MSR ANALOGUE MISSION: MISSION CONTROL TEAM STRUCTURE AND OPERATIONS.

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Introduction: The 2015 CanMars MSR Analogue Mission is a Mars Sample Return Analogue Mission carried out in partnership between the Canadian Space Agency (CSA), MacDonald, Dettwiler and Associates Ltd. (MDA), and the Centre for Planetary Science and Exploration (CPSX) at the University of Western Ontario (UWO), as part of the NSERC CREATE project "Technologies and Techniques for Earth and Space Exploration" (create.uwo.ca) [1].

Over 50 participants from 6 institutions divided into 3 teams worked on this analogue mission. The Mission Control (MC) team, responsible for the science planning, processing, and interpretion, was based at UWO in London Ontario. The CSA team, with responsibility for the Mars Exploration Science Rover (MESR) operations was based at CSA headquarters in Montreal. The MESR was deployed at a remote Mars analogue location in Utah, USA, with a Field team comprising CSA engineers and geologists from UWO.

Pre-deployment team planning: This analogue mission was the third in a series of four CREATE analogue missions. CPSX was also previously involved in a series of analogue missions with the CSA in 2010-2011 [2]. The lessons learned from previous missions were reviewed as a way to ensure their application into the planning of this mission. The main recurring lessons noted were the need for mission goals made clear to all participants (detailed in [1]), and clear team organisation and training prior to the deployment operations. The structure of the MC team for this mission was based on these past analogue missions, and in particular on a mission architecture as detailed in [3, 4].

The MC team was organized into three sub-teams; Science, Planning, and Tactical. Each sub-team had a Team Lead to manage the activities of the team and lead discussions, a documentarian to record all activities, and decisions made, and various other assigned roles. Also part of the MC team was the Education and Public Outreach (EPO) lead and the Mission Operations Manager (MOM). The EPO lead had responsibility for all media contact, social media presense, and outreach activities [5]. The MOM – the first author on this abstract – was responsible for the pre-deployment team planning, overseeing the MC team activities during the deployment, ensuring all roles were staffed, and acting as the main point of contact between the MC, CSA, and Field teams.

Science team. The Science team was the largest sub-team with 18 members. Each instrument (see [1] for payload details) was assigned two team members to share the work load of creating the daily instrument sequence, verifying the health of all expected and received data products, creating accessible data products for use in Science and Planning discussions, and providing preliminary scientific interpretations and hypotheses for recent results and overall mission results (see [6] for science results). There were also four GIS team members responsible for the processing of all remote sensing data products, mapping of proposed and actual traverses, annotated images of target locations, and localization of all activities.

Planning team. This team had 5 members. In addition to the planning lead and documentarian, there were two daily activity planners [7], and one long-term planner. The Planning team was responsible for developing the daily and strategic plan with Science while ensuring the planned operations were in line with the time, power, and data budgets, and within the engineering constraints [8].

Tactical team. There were 4 members of the Tactical Team including the lead and documentarian [9]. The Uplink role integrated all instrument sequences received from Science to be uplinked to the rover. The Downlink and Data Management role reviewed all data products received from the rover, managed file structures and ensured proper archiving of all mission data.

Software training and ORT. Symphony is a environmental simulation software package designed by the CSA [7]. It was used during a previous analogue mission by many of the participants but had been further developed and changed that hands-on training with Symphony for the MC team prior to the 2015 deployment was essential. This was carried out at UWO with access for remote participants, in October 2015, followed by an operational readiness test (ORT). This involved the MC team planning and sequencing a day of rover operations and the CSA team validating and executing this plan. This was repeated for two additional days. The Symphony software was available to all participants and participants also organized peer-to-peer training before the start of the deployment.

Pre-deployment science planning. Six weeks before the deployment the MC team received remote sensing data products covering the landing ellipse and larger regional area [10]. Four weeks before deployment the MC team had a science planning meeting held over three days. This allowed the team to begin to get familiar with the mission goals, discuss potential investigations, start developing science hypotheses, and identifing areas of interest in the landing ellipse.

Daily operational workflow: The deployment took place between Nov 15th and Nov 27th 2015. During this period the MC team worked morning (7 am–10 am) and evening (7 pm–10 pm) shifts every day. The following briefly outlines the daily operational workflow for the MC team. More detailed descriptions on this can be found in [8], [9], and [11].

Evening shift. 1) Downlink: the evening shift began with receiving the Sol N-1 downlink from the Field team. This included all the science data, as well as a report from the Field team detailing any anomolies or deviations from the Sol N-1 plan. 2) Science processing and interpretation: preliminary work on the science data was carried out while the Science team began discussing the priorities for Sol N. 3) Planning: when the Science team had come to a consensus on the science prioroties for Sol N the Planning and Tactical teams would join the discussion to provide input and finalise the plan. 4) Sequencing: with a plan agreed to the team members with instrument activities on Sol N began sequencing. All necessary sequences, annotated images, FOI coordinates, and other information were then intergreted to a final spreadsheet to be uplinked in the morning.

Morning shift. 5) Refinement: the morning began with a run through of the Sol N plan noting any changes that would need to be made. 6) Uplink: the plan would be adjusted accordingly and at 8am uplinked to the CSA team for a final check. 7) Plan Review Telecon: at 8:30am the MC team and CSA team would review the plan together and clarify any remaining issues. The plan was then passed to the Field team and Sol N rover operations began. 8) Sol N+1 Pre Planning: the MC team would spend the rest of the morning pre-planning Sol N+1 based on the expected Sol N downlink. The Science team would also review the Sol N-1 data again with further science interpretation discussion.

Troubleshooting and Evaluation. During the evening and morning shifts the MOM was on hand at Mission Control to make note of and evaluate the mission activities, the efficiency of the workflow, and the team dynamics. As the point of contact between the MC, CSA, and Field teams, the MOM was also in a position to pass questions and relevant information between the teams and troubleshoot any issues that arose.

Evolution of team structure: The MC team roles were assigned, with the input of the participants themselves, based on their expertise and interest. It was anticipated that during the deployment roles may be expanded or combined. This did indeed happen and was most evident among the Planning and Tactical teams. By the second week of the deployment these teams had effectively combined. Planning and Tactical team members worked very closely together and were able to efficiently adjust their workflow and cover for each other if needed.

Evaluation and lessons learned: The pre-deployment Symphony training and ORTs were invaluable in helping the teams better understand and refine the operational workflow. However, the team roles were defined long before this. In the future a well defined workflow needs to be in place earlier to feed into the team structure itself. This may also allow a rearranging of the shifts the MC team work. Early mornings and late nights every day for two weeks is as long as participants should be expected to efficiently and effectively work. As future analogue missions will have longer deployments, team and workflow organization will need to account for shifts and/or roles being covered by multiple different teams.

As future analogue missions are also expected to have more remote participants on the MC team an effective line of communication is needed. During this analogue mission the MC team used the online team collaboration tool Slack for messaging and file sharing. It proved to be very useful and intuitive and in the future teams should become familiar with all its features to use it full capabilities.

The best way to carry forward lessons learned to future missions is to do so with the participants themselves. The MC team was made up of undergraduates, graduate students, and post doctoral fellows with varying mission experience and expections and so all participants provided full reports on their role within two weeks of the end of the deployment. With comments and recommendations from all we will be able to make any organizational and operational changes necessary to ensure the success of future analogue missions.

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