**CANADIAN SPACE AGENCY ANALOGUE MISSIONS – APPROACH TO EVALUATION AND LESSONS LEARNED.** V. Hipkin[1], G. Dubreuil-Laniel[1], Y. Gonthier[1], T. Haltigin[1], R. Leveille[1], E. Martin[1] and A. Monarque[1], Canadian Space Agency, 6767 Route de l'Aeroport, St. Hubert, QC, J3Y 8Y9, Canada (victoria.hipkin@asc-csa.gc.ca, timothy.haltigin@asc-csa.gc.ca, richard.leveille@asc-csa.gc.ca).

**Introduction:** In 2010, the Canadian Space Agency initiated support for a set of four Analogue Missions, building upon earlier investments in analogue activities [1]. The overarching objective of these projects was to advance science and operational readiness for future Canadian space mission contributions through mission simulations at Canadian analogue sites. End-to-end simulations of science and operations were desired, with validation of field results through laboratory analyses or other methods.

While technology testing was encouraged where prototypes or commercial technologies already existed, the intent of these projects was not technology development, but rather to demonstrate a proof of concept with lessons learned and mission requirements that could be used as a basis for future technology and mission development.

Eligible categories of target mission scenarios for the Mars and the Moon are shown in Table 1. These were derived from the 2009 Canadian Scientific Priorities for the Global Exploration Strategy community document [2]. Each of the four contracts were awarded for a two year duration with a total value of around $800k, with the intent of a preliminary deployment in the first year to familiarise teams with site logistics, and a second full deployment in the second year. Brief summaries of each project are provided below.

**Table 1: Categories of target mission scenarios for Mars and the Moon.**

| Category | Description |
|---|---|
| Mars: an in situ search for microbial biosignatures in a Mars analogue environment | |
| A* | Asceptic drilling in an ice-rich (eg ground ice, permafrost) environment |
| B* | Search for methane: discriminating abiotic from biotic origin |
| C* | Search for life in rocks |
| Moon: an in situ investigation of geology in a lunar analogue environment | |
| D* | Map the distribution and age of bedrock |
| E* | In situ drilling and sampling to assess hydrogen and oxygen content of rock and regolith targets for lunar ISRU |
| F* | Investigation of the formation processes and resource potential of impact crater(s) |

**"MARSLIFE":** The Mars Analogue Research: Signatures of Life in Freshwater Environments (MARSLIFE) project was led by the University of British Columbia with important scientific contributions from NASA Ames/SETI Institute, McMaster University and University of Delaware. This project targeted SubCategory C: Search for life in rocks. Fieldwork included in situ scientific investigations and sampling of microbialites, including with humans and autonomous underwater vehicles, in Pavilion and Kelly lakes, British Columbia. This work successfully integrated a multi-platform exploration program of a novel analog environment that included elements of robotic and human exploration, as well as novel imaging and communication technologies.

**"Mars Methane Mission":** The Mars Methane Mission project was led by MPB Communications with important scientific contributions from the University of Winnipeg and several other collaborators. The project targeted Category B: Search for methane: discriminating abiogenic from biogenic sources, and used a novel robotic micro-rover and imaging system, along with hand-held portable instruments to search for and measure sources of methane (as well as characterize the geology) in an area of serpentinization, near Asbestos, Quebec. Elevated methane concentrations and carbon isotope compositions were measured in situ using a portable cavity ring down spectrometer, notably from boreholes in serpentinite-like rocks. Methane concentrations were found to decrease very rapidly with 1-2m from localized sources suggesting that rover-based search strategies for methane source could be challenging.

**"Genesis of Methane on Mars":** Also targeting SubCategory B was the "Genesis of Methane on Mars", led by York University with support from the University of Toronto and contributions from Western University. This project used both passive and active spectroscopic techniques to detect and localize a natural methane seep on Axel Heiberg Island in the Canadian High Arctic, with follow-on robotic operations simulations at the CSA Mars Emulation Terrain. Both techniques were able to detect above-background methane concentrations from a distance of tens of meters, suggesting that both approaches could potentially be utilized in a mission scenario.

**"Lunar Sample Return":** Led by University of Western Ontario with support from the University of Toronto, the lone project addressing a lunar mission scenario was the "Lunar Sample Return from South Pole Aitken Basin", targeting SubCategory F. Here, the team developed two mission scenarios: (i) a robotic precursor mission with a combined human/robot follow-on mission, and; (ii) a purely robotic sample return. Scenario (i) was conducted over two deploy ments to Mistastin Crater in northern Labrador, while Scenario (ii) was performed in Sudbury, ON. Certainly, benefits and drawbacks to both approaches were evident, with either one being considered feasible for future efforts.

**Agency Approach to Lessons Learned / Evaluation:** From an Agency perspective, these projects were designed around a strategy to capture lessons learned, to allow for direct flow of both technical and operational lessons to future development and flight programs. This approach provides a path forward within space agencies to link analogue lessons to flight activities.

The primary deliverable from these contracts were standard reporting forms for a generic set of tasks (Table 2) designed to capture scientific, technical and management lessons learned. A feature of these forms was to capture *a priori* expectations by including mission requirements and personnel roles as planned before the deployments, and update these as a result of activities.

The results and deliverable are still being analysed, but are expected to draw out interesting results especially in the case of the methane category where two teams took different approaches to the same scenario.

**Summary of Findings:** Preliminary conclusions from this approach:

[1] Effectively capturing lessons learned and formulating recommendations requires considerable work. The effort needed to complete end-to-end analysis in teams, and analysis of lessons learned at the agency, was significantly greater than planned and needs to be anticipated if this approach is pursued.

[2] Freestyle reporting, or oral reporting in a workshop is preferred by teams, but a means is needed to make lessons accessible to other programs, and searchable within an archive, if benefits of analogue activities are to have impact beyond the team. Publications on science operations are often not valued as research contributions. Acceptence in peer reviewed journals would encourage write up and distribution.

[3] Analogue missions become logistically complex in short field seasons if early technology testing and science fieldwork are combined with significant science operations simulations. There should also be alternate avenues for early field testing of technology and for analogue science field work, in addition to more integrated mission-related activities.

**Table 2: Tasks and Reporting Forms**

| | |
|---|---|
| 1 | Personnel Assignment |
| | Mars: Simulation of a remote science team tactical operations process with limited Mars-like windows for uplink and downlink. |
| | Moon: Simulation of a tactical decision making process with two field team members taking the role of "astronauts" supported by a robotic assistant during EVAs. A back room science team provides remote support. |
| | Moon: In situ monitoring of human health and performance |
| 2 | Site Selection |
| 3 | In Situ Survey and targeting of samples/analyses |
| 4 | Sample acquisition for in situ analyses |
| 5 | In situ analysis & validation by laboratory analyses |
| 6 | Investigation of local geological and environmental context |

**References:** [1] Hipkin, V. et al. (2007) *LPS XXXVIII*, Abstract #2052. [2] CSEW6 steering committee, (2009), *Proc. 6th Canadian Space Exploration Workshop*, Dec 1-3 2008, Canada