THE MANITOBA LUNAR AND PLANETARY STEM NETWORK (MLaPS): A K-12 STEM INITIATIVE.

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Introduction: This project, entitled the Manitoba Lunar and Planetary STEM Network (MLaPS) is designed to engage K-12 students in STEM via a wide-ranging series of diverse engagement materials focusing on lunar exploration, particularly Canadian efforts.

This proposal takes advantage of Canadian planetary and lunar exploration activities being undertaken in Manitoba at the University of Winnipeg and University of Manitoba. It also capitalizes on a range of nascent and existing interest in lunar and planetary exploration present in Manitoba, as exemplified by the Manitoba Association of Physics Teachers (MAPT).

We are developing educational materials and hands-on engagement projects for K-12 students that cover a gamut of planetary/lunar missions ranging from Phase 0 to Phase F, ATLO mission phases, as well as Science Readiness Levels and Technology Readiness Levels ranging from SRL1 and TRL1 to SRL9 and TRL9, by incorporating ongoing research and development activities related to upcoming lunar missions and instruments [e.g., 1 – 5].

The engagement materials and activities developed in the course of this project will be hosted by the University of Winnipeg, ensuring long-term access, and will be freely available to other jurisdictions.

Goals: The goals of this endeavor include:

- *Increase **interest** in STEM using space-related disciplines among youth and educators:* planned activities relevant to this include "ride along" participation in upcoming planetary missions such as the UW/University of Manitoba (UM) Earth-orbiting Iris CubeSat mission, which is part of the CSA University Cubesat Program, as well as planned annual rover analogue deployments at two Mars analogue sites in Manitoba.
- *Increase **knowledge** in STEM using space-related disciplines among youth and educators:* planned activities include "paper-based" studies of lunar mission and instrument concepts that fall within the lower levels of mission Phases (Phase 0, A, B) and instrument development: SRL and TRL (<4).
- *Increase **experience** in STEM using space-related disciplines among youth and educators:* planned activities include hands-on lab and field-based activities that address fabrication and testing of mission and instrument hardware/software and analogue site field deployments (Phases C-F, ATLO), SRL>4, and TRL >4).
- *Development and delivery of information, materials, products, activities, and events that use the context of the Canadian Space Program to expand the scientific literacy of Canadian youth and/or educators:* Planned "products" involve development and delivery of a wide range of materials (e.g., in-class and in-field exercises), encompassing the end-to-end stages of mission and instrument development. Disciplines that will be addressed include biology, engineering, chemistry, geology, physics, mathematics, and sociology. Soft skills such as teamwork, project management, interdisciplinarity, and public speaking will also be important aspects of this project.
- *Development of activity and promotion to increase reach and impact:* Our main K-12 partner, MAPT (https://mapteachers.wordpress.com/) is a highly-engaged and active group, involved with, and in contact with, additional teachers that will enable us to engage disadvantaged communities (e.g., inner city), visible minorities, northern communities, First Nations, girls, and other traditionally underrepresented groups in science and engineering.
- *Production, distribution and presentation of Canadian space-related information, products and materials in written, audiovisual, and multi formats for awareness purposes:* the range of materials we are producing cover all of these format. Multiple formats are essential for robustly engaging different age groups and disciplines.
- *Design and delivery of Canadian space-focused youth or educator workshops and hands-on activities:* in the preparation of this proposal, we have verified the feasibility of teacher Professional Development days as a venue for delivery, and also identified areas within various curricula where the developed materials can be integrated.

This project is responsive to the Canadian Space Agency's commitment to inspiring young Canadians through space as highlighted in the Government of Canada's Space Strategy for Canada.

Overview: This STEM initiative focuses on a number of "themes" related to lunar and planetary exploration as follows:

Major theme 1: Lunar rovers/landers. Subthemes:

- Lunar rover trafficability.
- Effects of regolith on surface operations and assets
- Landing systems
- Lander workspace and sample triage
- Rover workspace triage

Major theme 2: Moon base (living on the Moon and Gateway).

Major theme 3: Lunar sample return

Building on past knowledge transfer and K-12 student engagement: This initiative builds on prior activities that we have successfully undertaken with K-12 students in the past. These include the ManitobaSat-1 (Iris) 3-U cubesat mission to investigate space weathering of geological materials in low-Earth orbit [6]. K-12 students were engaged in naming of the mission (Figure 1), design of the mission logo (Figure 2), and design of a gnomon that will be mounted on the payload plate (Figure 3). It will be used by the students to determine satellite orientation and solar illumination direction. Students will be involved in calculating sun angles from the gnomon's shadow angle and length.

Figure 1. ManitobaSat-1 mission naming contest winner.

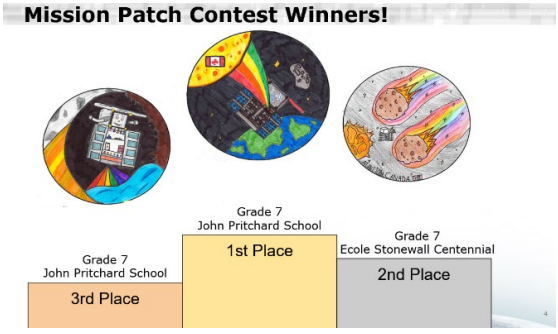

Figure 2: Mission patch design contest winners.

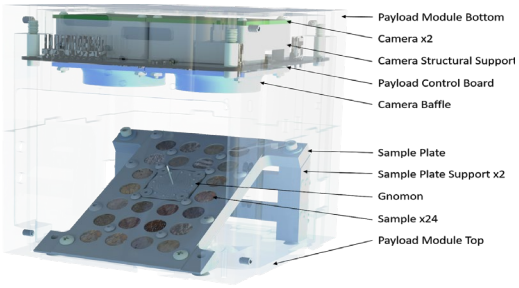

Figure 3. View of the Iris payload showing location of gnomon in center of the inclined payload plate.

In 2018, a group of students from multiple Winnipeg high schools were engaged to participate in all aspects of a high-fidelity rover-based exploration of a Mars analogue site, including targeting, sample triage, and field operations [7].

Project implementation: Over the two-year timeline of the current project we are developing and "beta-testing" a variety of educational materials and activities at a number of schools. The results of this beta testing will be used to evaluate the effectiveness in terms of engagement and uptake using multiple metrics. In the second year of this project, we will roll out the successful materials to additional schools, and further refine and evaluate. The goal is to have a robust series of educational activities and resources (such as a "garage" of field vehicles that can be made available to schools for field-based activities. A longer-term goal is to expand our reach across Canada and internationally.

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