THE CANADIAN LUNAR ROVER MISSION (LRM): A MICRO-ROVER MISSION TO THE SOUTH POLE OF THE MOON. G. R. Osinski[1], P. Edmundson[2], J. Hackett[2], J. Newman[2], P. Visscher[2], E. A. Cloutis[3], M. Lemelin[4], C.-E. Morisset[5], M. Picard[5], B. T. Greenhagen[6], J. T. S. Cahill[6], S. J. MacEwan[7], M. B. Smith[7] and the LRM team[8], [1]Dept. Earth Sciences, University of Western Ontario, London, ON, Canada (gosinski@uwo.ca), [2]Canadensys Aerospace Corporation, Bolton, ON, Canada, [3]C-TAPE, University of Winnipeg, Winnipeg, MB, Canada, [4]Département de géomatique appliquée, Université de Sherbrooke, Sherbrooke, QC, Canada, [5]Canadian Space Agency, Saint-Hubert, QC, Canada, [6]Johns Hopkins University Applied Physics Laboratory, Laurel, MD, USA, [7]Bubble Technology Industries Inc., Chalk River, ON, Canada, [8]See acknowledgements.

Introduction: The Canadian academic and industrial community has long been interested in lunar surface exploration. Canada's interest can be traced back to the 2004 U.S. Vision for Space Exploration – which eventually became the Constellation program. This catalysed discussions of Canada's next post-International Space Station (ISS) contributions to lunar exploration. In the subsequent decade, the Canadian Space Agency (CSA) funded over 30 concept studies, technology developments, prototypes, and analogue mission projects. Fast forward to 2019 and CSA not only became the first partner to join with NASA on its Lunar Gateway program, but it also crucially received both a mandate and funding to assemble a portfolio of flight technology maturation, flight capability demonstration, and flight exploration mission contributions to near-term lunar exploration with the Lunar Exploration Accelerator Program (LEAP). Canada was also one of the first countries to sign the Artemis Accords.

The flagship of the LEAP program is the Lunar Rover Mission (LRM), which will be the first ever Canadian-led planetary rover mission. This contribution provides a summary overview of the main aspects of the LRM and ongoing work.

Lunar Rover Mission Overview: This mission aims to land a 30 kg Canadian rover in the south polar region of the Moon by late 2026 (Fig. 1). It will carry 6 scientific payloads – 5 Canadian and 1 U.S. – and it will fly as part of NASA's Commercial Lunar Payload Services (CLPS) initiative. Canadensys Aerospace Corporation (Canadensys) was selected in November 2022 as the prime contractor for this mission. The goal is that the rover will be able to operate inside of permanently shadowed regions (PSRs) for up to one hour and survive multiple lunar days/nights.

Mission Objectives: There are 3 high-level objectives for the Lunar Rover Mission:

1. Demonstrate and characterize Canadian technology on the surface of the Moon;
2. Perform meaningful science; and
3. Increase the Canadian Space Sector's readiness for future lunar missions.

The 3 arising overall science objectives are:

1. Lunar polar geology and mineral resources;
2. Lunar polar shadow, cold-traps, and volatiles;
3. Environmental monitoring for engineering to ensure the future presence astronaut(s) health.

These broad science objectives were determined based on the priorities of the Canadian lunar science community and given the constraints on the mission, including the fact that a landing site would only be chosen following the selection of the mission and its instruments, and given the likelihood that a high landing accuracy is unlikely given the early maturity of the small commercial landers still currently in development.

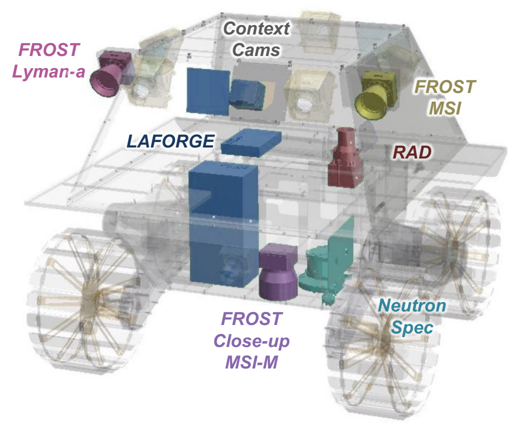

Fig. 1. The LRM rover with 6 science instruments and an additional 6 rover navigation/context cameras.

Science Instruments: In order to address the science objectives, the following instruments will be carried by the rover (Fig. 1):

Lunar Hydrogen Autonomous Neutron Spectrometer (LHANS). This is a combined neutron and gamma-ray instrument with the goal of detecting hydrogen as a proxy for water ice in lunar PSRs. It will also have the capacity to detect other elements as a secondary goal. Hydrogen sensitivity comes from neutron spectroscopy, while elements such as Ti, Fe, Ca, P, K, Th, and U are largely investigated using gamma-ray spectroscopy. LHANS will measure the thermal neutron signal using a thin neutron-sensitive scintillator material coupled to a photodetector. The epi-thermal neutron, fast neutron, and gamma-ray data will be collected using a larger crystal with a smaller cross-sectional area, also coupled to a photodetector. This payload is provided by Bubble Technology Industries from Chalk River, Canada.

Frozen Regolith Observation and Science Tools (FROST) suite. This is a suite of 3 instruments provided by Canadensys. It features two multispectral imagers with the goal of investigating the mineralogy of lunar surface materials. Both instruments use a set of carefully chosen LEDs to illuminate the scene one wavelength at a time, and the broad spectral response optics and detector acquire images sequentially at each wavelength as the LEDs cycle through illumination of a given target. The wavelength range covered is from 365 to 995 nm. The Multi-Spectral Imager (MSI) points diagonally downward from horizontal and can image objects ranging from horizontal surfaces to vertical surfaces. The MSI-Macro (MSI-M) will work in the same manner as the MSI but will enable the collection of data at a much higher resolution. It is pointed downward to view the lunar regolith and rocks beneath the rover in fine detail. The final instrument in the FROST suite is the Lyman-Alpha Imager that will measure lunar surface reflectance 121.6 nm from faint sunlight in illuminated regions, and the interplanetary medium and starlight in shadowed regions. At that wavelength, water ice has lower reflectivity than the lunar soil.

Radiation Micro-Dosimeter. The goal of this instrument is to provide data on the radiation environment through time for the lunar south pole with the goal of better determining how much radiation human crewmembers and lunar infrastructure will be exposed to. This instrument is being supplied from This instrument is being supplied by Teledyne e2v HiRel Electronics.

LAFORGE. The U.S. payload funded by NASA is the Lunar Advanced Filter Observing Radiometer for Geologic Exploration (LAFORGE) instrument will be provided by the Johns Hopkins Applied Physics Laboratory. The goal of LAFORGE is to provide high quality thermal imaging with an ability to obtain highly accurate temperature measurements across the full range of thermal environments present on the Moon. These data will be used to study the thermal environment, thermophysical properties such as porosity and thermal inertia, silicate and oxide composition and soil maturity. It will accomplish this by pairing raster-scanning narrow field-of-view reflective optics with an advanced thermal infrared detector provided by the Jet Propulsion Laboratory and state-of-the-art infrared filters provided by the University of Oxford.

Landing Site Analysis: The identification of potential landing sites for the LRM is ongoing and will be subject of an intensive study over the next 6 months in preparation for discussions with NASA and other partners. Criteria being used to identify potential landing sites include the requirement for <10º slopes, adequate illumination for power and Earth visibility for communications. In terms of scientific criteria, the primary focus has been on identifying areas that would be promising for potential hydrogen detection that could be attributed to the presence of water ice with the rover mounted neutron spectrometer. Various spacecraft datasets and previous studies are being used to frame this landing site study. This includes hydrogen abundance from the Lunar Prospector Neutron Spectrometer (LPNS) [1], maps of potential surface ice and/or frost locations derived from the Lyman-Alpha Mapping Project (LAMP) instrument [2], models for ice stability depth [3], and reflectance spectra from the M3 instrument to identify near-infrared absorption features diagnostic of water ice [4].

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References: [1] Feldman, W.C. et al. (2001) *Journal of Geophysical Research: Planets*, *106*, E10, 23231–23251. [2] Hayne, P.O. et al. (2015) *Icarus*, *255*, 58–69. [3] Paige, D.A. et al. (2010) *Science*, *330*, 6003, 479–482. [4] Li, S. et al. (2018) *Proceedings of the National Academy of Sciences*, *115*, 36, 8907 LP – 8912.