THE CANADIAN LUNAR ROVER: AN UPDATE. G. R. Osinski[1], P. Edmundson[2], E. A. Cloutis[3], M. Lemelin[4], C.-E. Morisset[5], M. Picard[5], T. Lamarche[5], B. T. Greenhagen[6], M. B. Smith[7], T. Harrison[8], J. Hackett[2], J. Newman[2], J. T. S. Cahill[6], T. Colaprete[9], A. Cunje[1], M. Daly[10], R. Flemming[1], C. Hardgrove[11], C. D. K. Herd[12], S. J. MacEwan[7], C. D. Neish[1], L. Preston[13], M. Siegler[14], A. Sirek[15], L. L. Tornabene[1], D. Williams[15] and the LRM team, [1]Dept. Earth Sciences, University of Western Ontario, ON, Canada (gosinski@uwo.ca), [2]Canadensys Aerospace Corporation, ON, Canada, [3]C-TAPE, University of Winnipeg, MB, Canada, [4]Département de géomatique appliquée, Université de Sherbrooke, QC, Canada, [5]Canadian Space Agency, Saint-Hubert, QC, Canada, [6]Johns Hopkins University Applied Physics Laboratory, MD, USA, [7]Bubble Technology Industries Inc., ON, Canada, [8]Earth and Planetary Institute of Canada, ON, Canada, [9]NASA Ames Research Center, CA, USA, [10]Dept. of Earth and Space Science and Engineering, York University, ON, Canada, [11]School of Earth and Space Exploration, Arizona State University, AZ, USA, [12]Dept. of Earth and Atmospheric Sciences, University of Alberta, AB, Canada, [13]Dept of Space and Climate Physics, University College London, UK, [14]Planetary Science Institute, AZ, USA, [15]Leap Biosystems, ON, Canada.

Introduction: The Canadian government has made substantial investments to lunar exploration in the past few years. Canada was one of the first countries to sign the Artemis Accords and to invest in the Lunar Gateway program. The Lunar Exploration Accelerator Program (LEAP), created in 2019, also seeks develop a portfolio of flight technology maturation, flight capability demonstration, and flight exploration mission contributions to near-term lunar exploration.

The flagship of the LEAP program is the Canadian Lunar Rover, which will be the first ever Canadian-led planetary exploration endeavour. Canadensys Aerospace Corporation (Canadensys) was selected in November 2022 as the prime contractor for this mission, which aims to land a 30 kg Canadian microrover in the south polar region of the Moon no earlier than 2026. It will carry Canadian and U.S. scientific payloads and it will fly as part of NASA's Commercial Lunar Payload Services (CLPS) program. 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. This contribution provides a summary overview of the main aspects of the LRM and an update on ongoing work.

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

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.

Along with the technology-demonstration focus of this mission, its science undertaking is driven by 3 overarching objectives:

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

These science objectives were determined based on the priorities of the Canadian lunar science community and 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. Given the early maturity of the small commercial landers still currently in development, the team had to work under the constraint that a high landing accuracy is unlikely.

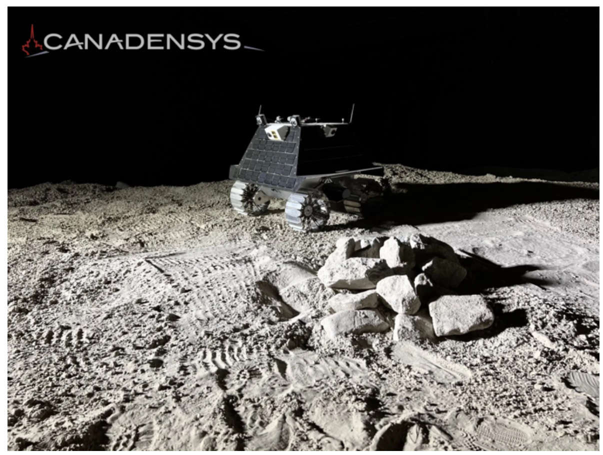

Fig. 1. A prototype of the Canadian lunar rover in a Moon yard at Canadensys.

Science Instruments: Multiple instruments will be carried by the rover (Fig. 1). This configuration has undergone some changes since the initial concept presented in 2023 [1].

Stereo cameras. There are two identical forward looking imagers, tilted downward, located at the top of the rover and separated by ~30 cm forming a stereo pair. Each imager has a Bayer colour sensor that can image a wide area, approximately 100º vertically and 140º horizontally. The central portion of the images are used to generate 3D information to assist with rover navigation and the wider image is used to help identify science targets. In addition, the stereo cameras will be calibrated and can provide science data in their own right by comparing the red, green and blue channels.

Multispectral Imager (MSI). The major payload for investigating the mineralogy of lunar surface materials is the MSI. This instrument uses 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 950 nm. The MSI points diagonally downward from horizontal and can image objects ranging from horizontal surfaces to vertical surfaces. It will be capable of characterizing the lunar regolith.

Lyman-Alpha Imager (LAI): This instrument will be able to identify the presence of water ice. It will measure lunar surface reflectance at 121.6 nm from faint sunlight in illuminated regions, and scattered sunlight along with the interplanetary medium and starlight in shadowed regions. At that wavelength, water ice has lower reflectivity than the lunar regolith.

Lunar Hydrogen Autonomous Neutron Spectrometer (LHANS). This is a combined neutron and gamma-ray instrument with the overall goal of detecting hydrogen as a proxy for water ice in the south polar region of the Moon. Hydrogen sensitivity comes predominantly from neutron spectroscopy. The instrument also has the capability to detect other elements (e.g., Ti, Fe, Ca, P, K, Th, and U) as a secondary goal, largely using gamma-ray spectroscopy. The LHANS will measure the thermal neutron signal using a thin scintillator crystal coupled to an array of photodetectors. The epi-thermal neutron, fast neutron, and gamma-ray data will be collected using a larger scintillator crystal with a smaller cross-sectional area, also coupled to a photodetector array. This payload is provided by Bubble Technology Industries from Chalk River, Canada.

Radiation Micro-Dosimeter. The goal of this instrument is to provide data on the radiation environment through time for the lunar south pole in order to increase our understanding of the effects of radiation on human crewmembers and lunar infrastructure. This commercially-available device is manufactured by Teledyne e2v HiRel Electronics.

LAFORGE. The Lunar Advanced Filter Observing Radiometer for Geologic Exploration (LAFORGE) instrument is being provided by the Johns Hopkins Applied Physics Laboratory through a partnership with NASA. LAFORGE will provide high-resolution 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 has been the subject of an intensive study over the past 30 months. The small size of this rover means that it will have a total travel distance on the order of a few km at best and will, thus, need to land in close proximity to the areas of scientific interest. Additional constraints include the requirement for <10º slopes, adequate illumination for power and Earth visibility for communications. In terms of scientific criteria, the primary initial focus was on identifying areas that would be promising for the detection of water ice.

A methodology for landing site selection has been developed and is covered in detail in Morisset et al. [2]. In summary, terrains were valued based on how suitable they were for lander operations, rover operations, and scientific investigation. A lander/landing factor is created by combining layers for slope, solar illumination, Earth visibility, and access to "safe havens". A traversal/rover factor is created by considering similar layers for slope, solar illumination, Earth visibility, and access to consecutive survivable nights, while evaluating the terrain area covering the extent of the potential rover traveling distance. A suitability layer is then calculated by combining the landing factor, the traversal factor, and variety of indicators for near-surface water ice in the vicinity of the lander (ice stability depth, surface ice detections, and hydrogen abundance). The result is a 60 m/px layer from 85 to 90º South. The values of the suitability layer were then analyzed, resulting in 36 discrete sites that were discussed at a meeting of the Landing Site Selection Working Group in March 2023.

Following this meeting, lander visibility (increased band-width during rover operations), hourly illumination (solar power), and CPR data from Mini-RF (proxy for small-scale surface roughness) were assessed for rover operations across the expected mission area. At a meeting held in April 2023, the number of potential sites was reduced to 13. This down-selection was driven to a large extent by a goal for Sun and Earth visibility for 300 hours in the first lunar day. It was also decided to omit sites in close proximity to the VIPER mission destination and focus exploration on other areas of the lunar South Pole. Following this, detailed geomorphological maps were created of the 13 sites. A workshop held in May 2023 resulted in the final down-selection of 6 sites, with two of these being a combination of 2 sites each. At the time of writing of this abstract, discussions are ongoing between the CSA, NASA, and other potential payloads on the CLPS flight to choose the ultimate destination for the Canadian Lunar Rover.

Acknowledgements: The authors would like to thank and acknowledge the entire LRM team, the Canadian Space Agency for funding past and future work related to this mission, and NASA for the great collaboration in making this endeavor a possibility.

References: [1] Osinski G. R. et al. (2023) *54th Lunar and Planetary Science Conference* (abstract #2487) [2] Morisset C.-E. et al. (2024) *55th Lunar and Planetary Science Conference* (abstract #2223).