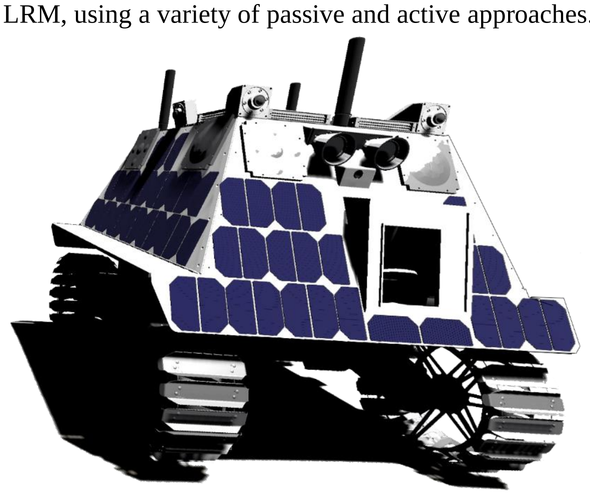
THE CANADIAN LUNAR ROVER MISSION. P. Visscher[1], P. Edmundson[1], J. Newman[1], , L. Stras[1], J. Russell[1], and M. Picard[2], T. Lamarche[2], F. Moroso.[2] [1]Canadensys Aerospace Corporation (10 Parr Blvd, Bolton ON, PVisscher@Canadensys.com), [2]Canadian Space Agency (6767 Route de l'Aeroport, Longueil, Quebec, Martin.Picard@asc-csa.gc.ca).

Introduction: In 2019, the Government of Canada announced that they would conduct a Canadian Lunar Rover Mission (LRM) to explore a polar region of the Moon within the next five years under the Lunar Exploration Accelerator Program (LEAP). Two Canadian companies, MDA and Canadensys Aerospace Corporation were awarded Phase A contracts to develop concepts for the rover and its instrument suite. In 2022, following a downselection process, the CSA selected Canadensys to be awarded a contract to design, fabricate, and assemble a rover that would carry six scientific instruments, five Canadian and one American.

Mission Overview: The CSA's Lunar Rover Mission will fly as part of NASA's Commercial Lunar Payload Services (CLPS) initiative. With a total mass of 30 kg, LRM will travel to the lunar south polar region as soon as late 2026. In addition to demonstrating key technologies, the rover will perform opportunistic science such as characterizing shadowed regions, searching for volatiles, analyzing the lunar geology, and assessing the radiation environment.

The rover is expected to survive multiple lunar nights, the objective being to survive at least 354 hrs of continuous darkness, greatly increasing the total data return for this mission and demonstrating a capability that will be extended to larger platforms. Canadensys has nearly a decade of experience developing and prototyping approaches to lunar night survival which it is leveraging to manifest lunar night-qualified avionics and sensors on several upcoming missions, including LRM, using a variety of passive and active approaches.



Rover Design: The rover is a 30 kg (including 6 kg of payloads) 4-wheel skid-steer vehicle whose design is based on extensive lunar rover mission and system concept design and technology development projects funded and/or supported by a combination of CSA and industry investments in the areas of mobility, thermal management, imaging & sensors, avionics, science instruments, GN&C and ConOps over the past 10+ years.

Technology Development: Over the past decade, numerous technical aspects of the rover have been prototyped and tested in an effort to raise the TRL.

Wheels: Starting from the ground and moving upwards, the wheels on LRM are the result of more than a decade of development. The flexible wheel allows the rover to generate more tractive effort and flotation, thereby reducing the likelihood of getting stuck in soft regolith. Previous generations of this wheel were tested for up to 2,000 km in a regolith simulant.

Mobility: Like the wheels, the drivetrain and suspension have been in development for over a decade. A 30 kg prototype has been in operation since 2020 in an indoor analogue terrain. Previous iterations of the drivetrain have been tested in a dirty TVAC chamber at lunar-like temperatures and pressure. In 2019, a 600 km durability test in lunar regolith simulant was completed on a scaled version of the drivetrain.

Electrical/Avionics: Small rovers require optimized, high-performance avionics. PSR operations require high power throughput (~200 W), while night survival requires extreme efficiency. Similarly, high-performance computers are needed for navigation, operations, and payload data handling. Radiation-tolerant avionics, capable of surviving the lunar night, have been developed and tested, and have been integrated into breadboard and engineering prototypes, and software has been developed to tie all of these subsystems together.

Night Survival/Thermal: Multiple prototype thermal control systems have been built and TVAC tested, demonstrating the viability of lunar night survival at this scale using a combination of low-temperature (<90 K) survival component qualification, and isolation of sensitive components in a thermally regulated enclosure.

Communications: The requirements of a lunar mission with up to 3 separate possible radio links requires a low SWaP but highly flexible and (re)configurable high performance communication system. An SDR and Phased array antenna system at K/Ka band are being developed and tested to meet the rigours of the lunar environment including radiation, vacuum and cryogenic temperatures. Breadboards and simulations are consistent with goals and prototypes are in design. SDR programming must be able to support 3 different links and protocols and integrate into overall mission software and data busses.

GNC: The LRM rover will be tele-operated from Earth under a Range and Waypoint Drive commanding scheme, which remains simple but robust to the expected communication delays. On-board localization and hazard detection will mainly rely on the fusion of wheel odometry, IMU, and stereo camera-based visual odometry. Wide angle cameras will provide all-around situational awareness to the operators.

Science Instruments: The rover will carry the following payloads:

LAFORGE: Designed and built by Johns Hopkins University Applied Physics Laboratory (APL), Lunar Advanced Filter Observing Radiometer for Geologic Exploration (LAFORGE) is a NASA-funded instrument that utilizes an imager with the ability to obtain highly accurate temperature measurements across the full range of thermal environments present on the Moon.

LHANS: Designed and built by Bubble Technology Industries in Chalk River, Ontario, Canada, the Lunar Hydrogen Autonomous Neutron Spectrometer will detect and quantify hydrogen down to 1 m below the lunar surface, used as a likely indicator of water ice.

FROST: The Frozen Regolith Observation & Science Tools imaging suite consists of three instruments including a Lyman Alpha Imager, a Multispectral imager and a Multispectral Imager-Macro.

Lyman-Alpha Imager (LAI) operates by imaging faint sunlight (or starlight) at 121.6 nm that is reflected from the lunar surface. A bandpass filter blocks appreciable levels of all other wavelengths. This Far-UV light is imaged using a magnesium fluoride lens exhibiting good transmission at this wavelength, striking a phosphor coating that is deposited directly on the CMOS sensor surface. The phosphor converts the Far-UV light into the visible band which can readily be detected by the CMOS sensor (this is a common Far-UV imaging technique). Lunar regolith has a higher reflectivity than ice in the 121.6 nm band, and hence regolith shows up as bright regions in a darker image – the opposite of a visible band image. The LAI Far-UV image is combined with a visible image and a “ratio image” is generated.

Multispectral Imager (MSI): will help identify the mineralogy present in the lunar soil. The lens of the MSI is surrounded by LEDs of different wavelengths that will allow scientists to learn the reflectance of the lunar soil.

MSI-Macro (MSI-M): will work in the same manner as the MSI but will offer the collected data at a much higher resolution and will be used to image close-up objects.

Micro-Dosimeter: In conjunction with the LHANS instrument, measurements from these two instruments will be analysed jointly in order to measure the radiation fluence due to neutrons, gamma-rays, electrons, protons and high-Z charged particles. This will provide previously-unavailable data on the radiation environment versus time at the Moon’s south polar region, and will provide a basis for estimating radiation doses to which human crew members will be exposed during later Artemis missions to the Moon’s surface in that region.

References:

[1]https://www.asc-csa.gc.ca/eng/funding-programs/programs/leap/about.asp

[2] C-E. Morisset, M. Picard, and F. Moroso, (2022) *The Canadian Lunar Exploration Accelerator Program (LEAP) Rover Mission (LRM): Rove, Gather, Overcome, and Inspire.*

Additional Information: Canadensys is partnering with numerous industrial and academic partners on the Lunar Rover Mission.

Industry
Bubble Technology Industries – Chalk River, Ontario
Leap Biosystems – Halifax, Nova Scotia
Maya HTT – Montreal, Quebec
NGC Aerospace – Sherbrooke, Quebec
Resonance Ltd. – Barrie, Ontario
Waves in Space Corporation – Cambridge, Ontario
RF Collins Consulting Incorporated – Toronto, Ontario

Academia
Simon Fraser University – Burnaby, British Columbia
University of Alberta – Edmonton, Alberta
Université de Sherbrooke – Sherbrooke, Quebec
University of Winnipeg – Winnipeg, Manitoba
Western University – London, Ontario

International partners
John Hopkins U. APL – Baltimore, Maryland (USA)
Arizona State University – Tempe, Arizona (USA)
NASA Ames Research Center – Mountain View, CA (USA)
Planetary Science Institute – Tucson, Arizona (USA)