DEPLOYABLE ROBOTIC HOPPER FOR EXPLORING CHALLENGING TERRAINS. M. Atwell[1], T. Martin[1], M.S. Robinson[2], [1]Intuitive Machines (3700 Bay Area Blvd, Suite 600, Houston, TX 77058, matwell@intuitivemachines.com), [2]Arizona State University.

Introduction: A deployable robotic hopper enables exploration of challenging terrains: such as permanently shadowed regions, rough or blocky targets, and steep slopes. The µNova hopper [**1**], developed by Intuitive Machines, was specifically designed to meet such exploration challenges. The µNova will deploy from a small or mid-sized CLPS lander such as the Intuitive Machines Nova-C lander. The same platform can be optimized and configured for maximum range or payload mass, depending on the mission objectives and the required payload suite. This platform can achieve targeted surface access for a relatively low cost. The second fully-funded Intuitive Machines CLPS mission (IM-2) will deploy the first µNova hopper in 2023 on a demonstration mission, and it will target a small (<200 m diameter) permanently shadowed region near the south pole. This first hopper will return color images of the PSR interior (cm scale) and measure the temperature using a radiometer.

System Description: The demonstration mission µNova hopper is 70-cm tall and has a total system mass of 30-kg. The vehicle can be stretched to a 60-kg configuration using the same structure with a larger propellant tank, enabling 5-kg of payload. A flight profile optimized for distance can achieve a maximum range of over 30 km (one-way). Alternatively, this configuration could allow the hopper to descend into a four km deep crater, land at the bottom, and fly back out to the rim. The hopper is a fully independent spacecraft with propulsion, avionics, power, flight controls, and communication systems. The hopper utilizes a precision landing and hazard avoidance (PLHA) system that images the surface and autonomously guides the vehicle to a safe landing site. Landing on slopes up to 10° can be achieved, along with landing in low-light environments such as permanently shadowed regions (PSRs) or pits. All subsystem elements are currently at TRL 6 or higher.

Mission Examples: The µNova hopper enables many lunar science and exploration missions. **A)** Lunar pit reconnaissance can be conducted to determine the extent and utility of sublunarean voids for engineering and scientific purposes [**2**]. The hopper could slowly descend into the pit, taking high-resolution stereo (2 cm pixels scale) images and measuring the wall profile with a laser rangefinder. An optical pyrometer and MEMS magnetometer would provide additional environmental assessment. After assessing the interior of the pit, the hopper could then ascend, characterizing another section of the wall returning valuable observations of flow thickness and test for the existence of intercalated regolith. **B)** A series of hops at varying altitudes and locations could map magnetic field strength, polarity and orientation at lunar magnetic anomalies providing definitive tests of formation hypotheses. **C)** Irregular Mare Patches (IMPs) are an enigmatic lunar landform thought to have formed as a result of basaltic volcanic processes in the last 100-my. The overarching scientific goal is to test the age of Ina to understand the duration of lunar volcanism and its implications for the thermal evolution of the Moon. The µNova science objectives [**3**] are 1) to determine the physical properties of the two main units (smooth materials (sm) and uneven materials (um)), 2) to delimit and characterize primary volcanic landforms at a 2-cm scale, 3) to document the morphology and topology of impact craters down to diameters of 1 m, and 4) monitor the environment for signs of geologically recent activity (heat flow and gas release). Objectives 1-3 characterize landforms predicted from the competing origin hypotheses. Objective 4 tests if Ina has increased heat flow relative to the global average (tests recent volcanism hypothesis) and the idea of recent gas release hypothesis.

The hopper also provides significant utility within the context of human exploration for prospecting potential ISRU production sites. The hopper can quickly travel to multiple dispersed sites, measure the regolith with an active neutron detector to determine suitability, and then report back to mission planners. Another key human exploration support mission would be the emplacement of a repeater on high ground to serve as a communication relay supporting astronaut excursions away from the lander.

References

[1] Atwell et al. (2020) LSSW, Abstract #6011. [2] Martin et al., European Lunar Symp. pp. 137-138 (2022). [2] Robinson et al., LSSW 2021 #8034, (2021).