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LunarLeaper - Unlocking a Subsurface World

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LunarLeaper is a mission concept designed to robotically explore subsurface lava tubes on the Moon. Lunar pits, steep-walled collapse features, are thought to be connected to such lava tube systems and more than 300 have been identified through remote sensing. These

natural subsurface structures hold immense value for exploration and scientific investigations, because they offer protection from radiation, micrometeorites, and harsh temperature fluctuations on the lunar surface

and as such, they have been proposed for possible future human habitation. In addition, the extent, nature and duration of lunar volcanism is poorly understood and the uniquely exposed stratigraphy along the pit walls might hold crucial information on the volcanic history of the Moon.

However, current orbital imaging lacks sufficient resolution to confirm these connections, making ground-truth exploration essential. LunarLeaper aims to address these knowledge gaps by deploying a lightweight (<15 kg) legged robot capable of autonomously traversing challenging terrains, including steep slopes and boulder fields, that hinder traditional wheeled rovers. The mission will investigate four primary objectives:

- (1) Subsurface Lava Tubes—confirming the presence and extent of lava tubes;
- (2) Suitability for Human Habitation—assessing the accessibility/stability of pits;
- (3) Geological Processes—analyzing the exposed stratigraphy along pit walls to study volcanic evolution, the number and timing of lava flows, and the compositional evolution of the lunar interior;
- (4) Regolith Assessment—exploring the lateral and vertical extent of regolith, which holds vital information about the Moon's geological and impact history.

The legged robot will land close to a lunar pit, equipped with ground-penetrating radar (GPR) and a gravimeter to map subsurface structures and detect lava tubes. It will also capture high-resolution images and compositional data from the pit walls travelling a total of approximately 1 km within one lunar day (approximately 12 Earth days). LunarLeaper not only advances lunar exploration by providing access to previously unreachable terrains but also demonstrates the potential of legged robotic systems in space. It will serve as a key technology demonstration, contributing to the development of future robotic exploration systems and laying the groundwork for future human missions to the Moon.