Paper ID: 73136
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IAF SPACE SYSTEMS SYMPOSIUM (D1)
Innovative and Visionary Space Systems (1)

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MOON DIVER: EXPLORING A PIT'S EXPOSED STRATA TO UNDERSTAND LUNAR VOLCANISM

Abstract

The discovery of natural pits on the Moon, potential entrances to lava tubes, expose a deep cross-section of the lunar maria, enabling the direct investigation of the formation and evolution of the Moon's secondary crust. With this goal, the Moon Diver mission seeks to explore the Mare Tranquillitatis pit with its 70 m of exposed wall of regolith and bedrock. The mission is enabled by two innovative capabilities: pinpoint landing near the pit and robotic access to its near-vertical wall with an instrument package to examine the chemistry, mineralogy, and morphology of these bedrock layers. Pinpoint landing uses closed-loop guidance with terrain-relative navigation (TRN), which was advanced by Perseverance landing on Mars, to deliver the lander within a 100 m ellipse. The Axel robotic explorer, which remains tethered to the lander, would egress onto the lunar surface and traverse the relatively flat terrain to the pit's funnel entrance. The lander, which is the data link to Earth, also serves as an anchor and provides power and communication to the rover through its tether. The rover is a novel two-wheeled platform with a trailing boom and a spool that pays out the tether as the rover traverses toward the pit. The 300 m long tether is well margined for the rover to scale the pit wall. The rover carries a surface preparation tool and three additional instrument types: (a) three high-resolution cameras for acquiring context images of the near and far walls with the near-wall pair in a stereoscopic configuration, (b) an alpha-particle-X-ray spectrometer (APXS) for elemental composition, and (c) a multi-spectral microscopic imager (MMI) that uses controlled lighting for minerology. The surface-preparation tool removes dust and patina from rock wall by grinding a small area. This tool, the MMI and the APXS would be deployed from an instrument bay inside the wheel wells. The rover would independently point each instrument at the same target on the wall with millimeter repeatability. Landing shortly after sunrise, the surface mission timeline is just shy of a lunar day (14 Earth days). Beyond the primary mission, the rover would be capable of descending across the overhang and peer into the void that may open to a large cave or lava tube. Lunar pits provide an exciting new target for exploration using innovative robotic capabilities that have been tested with integrated science instruments at multiple terrestrial analog sites including a basaltic pit in Arizona.