ABSTRACT

Determining the amount and depth of near-surface water ice on Mars and in permanently shadowed regions on the Moon is of primary interest to NASA. Such deposits are essential to provide life support and fuel for future human missions to Mars and the Moon. Similarly, lava tubes or other underground cavities on both bodies could provide a shielded habitat for humans. Aside from human exploration, near-surface water ice is key to understanding recent climate change on Mars. Although neutron and thermal spectrometer data indicate that shallow water ice exists broadly above 40° latitude on Mars, orbital radar detection of non-polar, non-glacial buried ice has been limited to a few areas, potentially due to mineralogical attenuation that is also a concern for ground-penetrating radar systems that may be deployed at the surface. Not subject to the same concerns, active-source seismic systems present a unique and promising means to find near-surface water ice and other shallow geologic features. Our goal is to design, build, and test an Autonomous Roving Exploration System (ARES) through a series of grants, culminating in a future landed mission to the Moon and/or Mars. We propose to enable imaging of buried water ice and underground cavities from the surface of the Moon and Mars by developing mobile robotic active-source seismic exploration techniques and instrumentation. ARES will nominally consist of a seismic source station and one or more receiving stations, all mounted on mobile robotic platforms. The key aspect of our proposed technique is its adaptability, as all instruments are detached from one-another, thus maximizing the ability to (re)configure the system based on the terrain and acquired data, while minimizing operational risk. This concept is enabled by recent advances in seismic acquisition using robust nodal systems that can acquire data autonomously for long durations. In the first phase of our program, we will investigate plausible scenarios for the ARES mission, produce conceptual designs for source and receiver stations, and conduct forward modeling of 3-D active-source seismic surveys. At the same time, we intend to conduct field studies with existing wireless geophones and portable accelerated weight-drop sources to test the proposed methodology over planetary analog sites with lava tubes and buried ice.