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Author: Dr. Jennifer Blank
National Aeronautics and Space Administration (NASA), Ames Research Center /Blue Marble Space Institute of Science, United States

A RATIONALE AND MISSION CONCEPT FOR FUTURE SUBSURFACE EXPLORATION OF THE RED PLANET

Abstract

Today's surface of Mars, the planet in our Solar System most similar to Earth, is cold and dry. Its regolith appears to be void of significant amounts of organic material, but remote imagery reveals features to support the hypothesis that once there were oceans and an atmosphere that could have supported life as we know it. In recent years, consensus has grown to support the theory that the martian subsurface may be the best place to search for signs of extraterrestrial, microbial life. The subsurface may harbor extant life, and/or it may preserve a chemical signature of life that has not been degraded by the harsh environmental conditions at the surface. The most straightforward access to the martian subsurface could be offered by the planet's numerous lava tubes, formed from ancient basaltic flows and appearing to offer many access points to their interiors. Elysium Planitia, the second largest volcanic region on Mars, provides an ideal target for the first mission to a Martian cave. This region is distant to Tharsis Montes, the broad, elevated expanse that dominates the western hemisphere of Mars and includes the largest shield volcanoes and majority of lava flow features where putative cave entrances have been identified. Concerns for forward contamination of a designated "special region" on Mars would not be as complex. Elysium Planitia also sits at lower elevation, proximal to landing sites below the current technology threshold for entry-descent-landing (EDL) considerations. Several candidate cave entrances in the vicinity of Elysium Planitia have been imaged using the highest resolution camera, HiRISE, on the Mars Reconnaissance Orbiter, and multiple images of one of these sites enables the creation of a digital terrain model for further characterization of the site's ingress geometry. A volcanic cave is an attractive target for human habitation on Mars, not only because of the protection it offers from exposed surface conditions but because of the potential to provide a relatively constant, temperate environment. The biggest unknown is the void space itself, and thus any mission to a martian cave would require multiple phases – one to explore (and map) the void space, and another to enter. These phased activities could involve multiple robotic mobilities and be part of a future, single landed mission. I will review several robotic technologies in development today and share a concept for scientific characterization of a martian cave environment using collaborative, autonomous robots equipped with heterogeneous payloads.