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# ENCELADUS EXPLORER - A MANEUVERABLE SUBSURFACE PROBE FOR AUTONOMOUS NAVIGATION THROUGH DEEP ICE

**Abstract**

Extensive water ice bodies exist on Mars, Europa, Enceladus, and other moons in the outer solar system. Although their subsurface environments are scientifically extremely interesting, they are also extremely difficult to access. Europa is probably most interesting from the astrobiological perspective, but access to subsurface material is easier on Enceladus. Recent analyses of Cassini measurements imply a subsurface salt-water reservoir on Enceladus, where ice grains containing organic compounds escape via cryvolcanism from "warm" fractures in the ice, known as "Tiger Stripes". Because landing in close vicinity to such a fructure is too risky, we propose to land at a safe distance and to use a maneuverable subsurface ice probe to navigate to such a water-bearing fracture at a depth of 200m below the surface. Once there, the subsurface ice probe can sample and analyze the materials in the fracture. The required technology is currently developed and tested at FH Aachen University of Applied Sciences' Astronautical Laboratory. "IceMole" is a novel maneuverable subsurface ice melting probe for clean sampling of ice and subglacial liquids and for clean in-situ measurements. A first prototype was successfully tested on the Swiss Morteratsch glacier in September 2010 and demonstrated successful horizontal, upward and downward melting capabilities for distances up to 5m. A driving curve with a 10-m radius and the penetration of a 4-cm dirt layer was also achieved. Funded by the German Space Administration (DLR), a university consortium, led by FH Aachen, currently develops a much more advanced IceMole probe, which includes a sophisticated system for obstacle avoidance, target detection, and navigation in ice. The main technical objective of this project, which is termed "Enceladus Explorer" (or "EnEx"), is to develop and test the technology that is required for navigation in deep ice, in preparation of the IceMole and the associated navigation technology for Enceladus and other potential extraterrestrial targets. The EnEx-probe will also feature a clean mechanism for the sampling of subglacial brine from a crevasse. To validate the technology, we intend to use the EnEx-probe for clean access into a unique subglacial aquatic environment and an extraterrestrial analog in the McMurdo Dry Valleys, Antarctica, known as Blood Falls; with subsequent sample return from this subglacial brine for chemical and microbiological analysis. In our conference contribution, we describe the IceMole design and the Enceladus Explorer mission concept, including the developed probe and navigation solution.