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Melting and forefield reconnaissance technologies within TRIPLE - accessing subglacial water reservoirs for future missions to Ocean Worlds

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Recent measurements suggest the Jovian satellite Europa as one of the most promising places to host extraterrestrial life in the Solar System. In a global ocean, well hidden by a thick layer of ice, this moon supposedly contains more than twice as much liquid water than Earth. Many currently discussed space missions therefore aim to explore Europa's chemical composition or investigate its habitability and even search for biosignatures.
The TRIPLE Project, initiated by the DLR Space Administration, comprises the development of Technologies for Rapid Ice Penetration and subglacial Lake Exploration and consists of three distinct components: (i) a melting probe, that travels through the ice and carries (ii) an autonomous nano-scale underwater vehicle (nanoAUV) that explores the ocean and takes samples to be delivered to (iii) an astrobiological laboratory. The full system should be tested in a terrestrial analog scenario in Antarctica in approximately five years as a demonstration for a future space mission. For a successful test we need a retrievable melting probe capable of penetrating several kilometres of ice while avoiding obstacles and navigating around them. It has to be able to stop and dwell at the ice-water boundary, before returning back to the surface.

This contribution focuses on TRIPLE-IceCraft and TRIPLE-FRS in which key technologies of such a melting probe are developed.

The TRIPLE-IceCraft melting probe is designed as a modular transfer system to transport standardised payloads through ice sheets of several hundred meters of thickness and penetrate into a subglacial water reservoir. Possible payloads are e.g. the nanoAUV or in-situ analysis devices for water samples such as a fluorescence spectrometer. The melting probe will be demonstrated at the Ekström shelf ice in Antarctica at the end of the project.

The forefield reconnaissance system developed in TRIPLE-FRS combines radar and sonar techniques to benefit from both sensor principles inside ice. The radar antennas together with a specialized pulse amplifier as well as a piezoelectric acoustic transducer will directly be integrated into the melting head. To account for the respective propagation speed of electromagnetic waves, which is dependent on the surrounding ice structure, an in-situ permittivity sensor will additionally be developed. With this system, obstacles as well as the ice-water interface at the bottom of the icy layer could be detected. In order to prove the functionality and the performance of the system, several field tests on alpine glaciers will be performed during the project.

The successful demonstration of the described subsystems and key technologies represents a first milestone in the TRIPLE project line which will serve as a baseline design for the future development of space missions to Ocean Worlds as e.g. Europa.