EUROPA Calling – A comprehensive technical concept for exploring ocean worlds.

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Introduction: Ocean worlds on planetary moons like EUROPA, TITAN, and ENCELADUS are gaining strong attention because of their potential to harbor life forms that might be of similar origin as on Earth or could provide insight into how life can develop along different pathways. In astrobiology, the concept of habitability of an extraterrestrial subglacial water ocean assumes besides the existence of water in its liquid phase two further preconditions: *i)* the ocean must be in direct contact with a rocky lithosphere at its bottom, and *ii)* hydrothermal activity must be given. For the three different moons mentioned above it is likely that these requirements are fulfilled and, thus, they are within the focus of space exploration [2]. For EUROPA and ENCELADUS it means that a robotic probe has to penetrate the thick surface ice layer of ~10 - 25 km thickness and subsequently deploy an ocean going probe, i.e. an autonomous underwater vehicle, into the ocean.

Technological Challenges: A space mission to explore such an subglacial ocean world is a very complex endeavor that necessitates a thorough systems engineering design approach: The complete system would obviously consist of an orbiter and a lander. The lander either has to be capable to penetrate the ice sheet itself to access the ocean beneath, or has to be carrying an ice penetrating probe as a third technological component. The latter option is favored because the lander could act as a communication relay on the surface and hold contact with the departing penetration probe. Once the ice/water interface is reached by the probe, it would be best to fix the penetration vessel at the interface. A basic exploration of the ocean water could follow. If a more sophisticated exploration strategy is foreseen, the penetration probe should carry a wireless and autonomously operating underwater vehicle (AUV). The different phases of that mission - landing, ice mobility penetration of the ice surface, ocean access and mobility exploration of the ocean – have been discussed within previous paper studies [3] and technical demonstrations addressing specific technical issues have been already carried out successfully. However, the design of individual phases of the mission as well as the transition between them have to be coordinated to minimize overall risk to mission success due to component failure. The consequence of that is that the design process has to be controlled by an overarching mechanism that integrates individual functionalities of subcomponents into a concurrent engineering model.

One particular aspect that had not been fully explored up to now is the ocean access and mobility phase. It is well known that the limited communication and navigation capabilities underwater set massive constraints on every conceivable approach. As a consequence a mobile agent deployed in an extraterrestrial ocean has to be tasked with a robust search strategy that allows the AUV to effectively sense, classify, and identify regions that are of highest interest for astrobiologic analysis. Due to the limited available space and energy the needed sensor systems for navigation, i.e. sonar systems, and existing vehicle mobility concepts have to be rethought completely and in consequence most likely to be redesigned and tested.

During a recently workshop organized by the German Aerospace Center (DLR) a design process has started that builds up on previous and currently running projects (EurEx, EnEx). The activities are aiming for the design, development and testing of a fit-for-purpose Autonomous Underwater Vehicle (nanoAUV) that can be integrated in and deployed by an Ice-Diver-like fast melting probe [1]. The system of a shuttle melting probe and the nanoAUV shall be tested in a terrestrial analog scenario in Antarctica.

The ongoing deliberation is focusing on exploring technical concepts that can cope with the challenges of

- localizing a mobile object within a subglacial lake making use of a dedicated sonar system design
- tailoring the search strategy by integration of crucial sensors like for methane to target for detecting organic material
- exploring the virtual design space to accommodate the minimum set of functionalities

Next Steps: A cooperative approach towards achieving the design goals is anticipated. Ideally support provided by different nations through for instance DLR, ESA, and NASA could provide a solid base to make a future exploration mission highly probable. At the moment the authors are pursuing a phased approach where the near term goal is to design an earth analog field test to be carried out in Antarctica. The system shall be capable to demonstrate the feasibility of this approach for future space exploration missions as well as being utilized for contamination free exploration of different subglacial lakes with sample returns.

References:

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