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Science Goals and Drivers for Future Exoplanet, Space Astronomy, Physics, and Outer Solar System Science Missions (2)

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ASSESSMENT OF MISSION ARCHITECTURES AND KEY TECHNOLOGIES FOR THE ASTROBIOLOGICAL EXPLORATION OF EUROPA AND ENCELADUS

Abstract

Ocean worlds in the solar system are prime candidates for life. In particular, Europa and Enceladus are considered as most likely to satisfy the requirements for habitability: the availability of liquid water, available energy, and nutrients for a sufficiently large amount of time.

Indicators of life (either extant or extinct) such as products of metabolism and cellular structures can be detectable by the appropriate instrumentation. Places to look for such evidence are where any geological and other processes (e.g. plumes) have transferred material from the putative oceanic habitats to where they would be accessible to investigation by spacecraft.

There are astrobiologically relevant missions being planned to the icy moons by both ESA and NASA. Currently planned missions such as ESA's JUpiter ICy moons Explorer (JUICE) and NASA's Europa Multiple Flyby Mission (EMFM) mainly aim to characterize the habitability of these icy moons, in particular of Europa. NASA has also been investigating a mission concept for a lander that would follow EMFM and conduct an in-situ search for evidence of life. There are no missions currently planned to explore Enceladus. A recent meeting of the Outer Planets Assessment Group (OPAG) established by NASA decided to form a Roadmap to Ocean Worlds (ROW) group, to identify future steps in the astrobiological exploration of ocean worlds in the solar system. For the explicit goal of the search for life, various concepts have been proposed for the two moons, either by remote sensing, in-situ probing, or sample-return to Earth.

In this paper we plan to explore and classify high level mission architectures to detect and characterize life on the two icy moons. We will do this by applying a modified version of the Rapid Mission Architecture (RMA) method, a novel approach developed by NASA JPL to generate new mission architectures, explore broad trade space options, and conduct architecture-level analyses.

Following this method, we will first present a science traceability matrix, listing the necessary instruments to detect and characterize life on Europa and Enceladus. We will then generate a broad spectrum of mission architectures to deliver sets of these instruments to their relevant target environment. We will then evaluate each of the generated architectures based on their science return, cost, risk, and mass. Based on these combined results we will identify promising mission concepts and key technologies, and propose a framework for defining a roadmap for astrobiological exploration missions and relevant technology development.