**UPDATE ON THE EUROPA LANDER MISSION CONCEPT.** Cynthia B. Phillips[1], Kevin P. Hand[1], Morgan L. Cable[1], Amy E. Hofmann[1], Kate L. Craft[2] and Europa Project Science and Engineering Teams.
[1]NASA Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA.
Cynthia.b.phillips@jpl.nasa.gov, [2]Johns Hopkins Applied Physics Laboratory, Laurel, MD.

**Introduction:** In June of 2016, NASA convened a 21-person team of scientists to establish the science goals, objectives, investigations, measurement requirements, and model payload of a Europa lander mission concept. The Europa Lander Science Definition Team (SDT) then worked with engineers to refine these requirements into a viable Europa Lander mission concept, and published the Europa Lander Study 2016 report [1]. Since completion of the report, the Europa Lander mission concept team at JPL has refined the mission through a Mission Concept Review (MCR) and subsequently through the advice and oversight of an external advisory board that met during the Summer and Fall of 2017 [2]. A final report of the board's recommendations was presented to NASA HQ in late Fall of 2017, and a delta MCR was held in late Fall of 2018, which presented updates to the mission concept's cost and mission architecture [3].

The science of the Europa Lander mission concept remains largely constant with respect to the 2016 SDT Report, with one important rescope that changes the first goal of the mission to 1) Searching for biosignatures on Europa, rather than a direct search for evidence of life. This rescope enables maximum science while minimizing complexity. The other SDT goals remain unchanged, and are: 2) Assessing the habitability of Europa via in situ techniques uniquely available to a landed mission; and 3) Characterizing the surface and subsurface properties at the scale of the lander to support future exploration of Europa. The Europa Lander mission concept, with its model payload, would be capable of achieving a suite of measurements such that if potential biosignatures are present on Europa's surface they could be detected at levels comparable to those found in benchmark environments on Earth. Importantly, even if no potential biosignatures are detected, the science return of the mission would significantly advance our fundamental understanding of Europa's chemistry, geology, geophysics, and habitability.

**Europa Lander Science Definition Team Report:** The NASA HQ Charter goals for the initial Europa Lander Science Definition Team, in priority order, were as follows: 1) Search for biosignatures on Europa, 2) Assess the habitability of Europa via in situ techniques uniquely available to a lander mission; and 3) Characterize surface and subsurface properties at the scale of the lander to support future exploration of Europa.

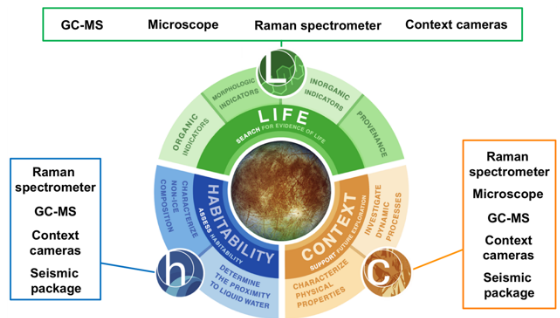


**Figure 1: Europa Lander Science Goals and model instruments.**

The Science Definition Team generated Objectives, Investigations, Measurement Requirements, and a Model Payload to address the high-level goals, and worked with the Project Engineering team to generate a mission concept that would achieve the measurement requirements. Figure 1 shows the abbreviated science traceability matrix with the model payload instruments that would address each goal.

**Goal 1: Biosignatures**

Objectives for seeking signs of life:

a) Detect and characterize any organic indicators of past or present life

b) Identify and characterize morphological, textural, and other indicators of life

c) Detect and characterize any inorganic indicators of past or present life

d) Determine the provenance of lander-sampled material.

The proposed measurements for biosignature analyses leverage many of the lessons learned from the Viking missions and all subsequent missions that have sought to detect complex organics and other signs of life on distant worlds. The model payload provides a robust, redundant, and complementary suite of measurements that would ensure high-science-value geological, geochemical, and geophysical measurements along with the search for biosignatures. These measurements can provide indications of ocean-surface exchange and activity.

**Goal 2: Habitability**

Goal 2 ensures that, even in the absence of the detection of any potential biosignatures, significant ocean world science that is uniquely possible from a landed mission still would be achieved. The identification and thorough interrogation of key salts, organics, inorganics, and volatiles from both the surface and subsurface would help constrain the endogenous and exogenous chemistry of the non-ice material, thereby helping to determine Europa's ocean chemistry, pH, redox state, and ultimately its habitability.

The characterization of the non-ice composition via in situ techniques provides orders-of-magnitude improvements in sensitivity and detection limits, relative to remote sensing capabilities. Seismic investigations serve to help determine the proximity of the lander to subsurface liquid water reservoirs, which could serve as potentially habitable environments, and perhaps to conduits or fractures that could enable transport and mixing of surface – subsurface material.

**Goal 3: Geological and Geophysical Context**

The overarching objectives of Goal 3 are to physically contextualize the sample measurements and to provide geophysical data that would, over the duration of the mission, enable characterization of the physical structure of Europa's ice shell as well as of the dynamic processes — both exogenous and endogenous — that modify Europa's surface. Key measurements include characterizing the local topography; determining the thickness of the ice shell, ocean, and structural layers of Europa's interior; searching for proximal subsurface water bodies and cryovolcanic conduits as well as for evidence of interactions between liquid water and the icy surface; and documenting any observable plume activity. Such measurements could in turn enable further exploration of Europa.

**Mission Concept:** In the proposed Europa Lander mission concept, the spacecraft would travel to Europa on a carrier, which would transfer the lander to Jupiter orbit (Figure 2). A descent orbital vehicle would bring the lander close to Europa's surface, where a skycrane vehicle would allow a safe, precise landing. The spacecraft would have a robotic sampling arm which would allow it to excavate to at least 10 cm below the surface, and to return samples to the on-board science payload instruments for analysis within a radiation-shielded vault. The nominal mission lifetime would be about a month.

**Current Status:** NASA recently issued a call, entitled ICEE-2: Instrument Concepts for Europa Exploration 2, for proposals to support in situ Europa exploration. ICEE-2 would allow the maturation of novel instrument approaches to meet the science goals and objectives of the Europa Lander concept, as illustrated in Figure 1. Any instrument concept teams selected under ICEE-2 would likely interact with a team of scientists and engineers at JPL to enable consideration of instrument accommodations and sample processing requirements by the Europa Lander pre-project team.

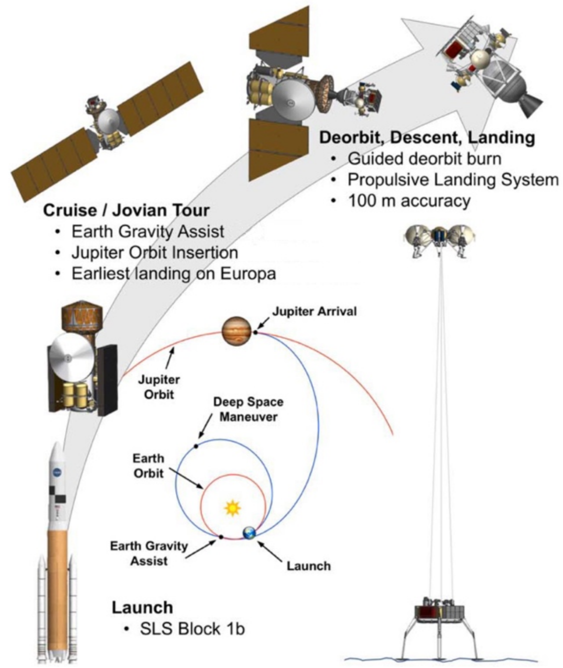


**Figure 2: Notional Europa Lander Mission Architecture**

The Europa Lander mission concept is a mature design that meets requirements for cost and complexity, and would push the boundaries of our search for signs of life in the Solar System.

The information presented about the Europa Lander is pre-decisional and is provided for planning and discussion purposes only.

**References:** [1] Europa Lander Study 2016 Report: Europa Lander Mission. JPL D-97667. https://solarsystem.nasa.gov/docs/Europa_Lander_SDT_Report_2016.pdf [2] Hand, K., et al. (2017) Europa Lander Update. Outer Planets Assessment Group (OPAG) Meeting, 6-7 Sept 2017. https://www.lpi.usra.edu/opag/meetings/sep2017/presentations/Hand.pdf [3] Braun, R. (2018) Europa Lander Pre-Phase A Study Report. OPAG Meeting, 11-12 Sept 2018. https://www.lpi.usra.edu/opag/meetings/sep2018/presentations/