

**Science Goals, Objectives, and Investigations of the 2016 Europa Lander Science Definition Team Report.** K. P. Hand<sup>1</sup> (khand@jpl.nasa.gov), A. E. Murray<sup>2</sup>, J. Garvin<sup>3</sup>, S. Horst<sup>4</sup>, W. Brinkerhoff<sup>3</sup>, K. Edgett<sup>5</sup>, T. Hoehler<sup>6</sup>, M. Russell<sup>1</sup>, A. Rhoden<sup>7</sup>, R.A. Yingst<sup>8</sup>, C. German<sup>9</sup>, B. Schmidt<sup>10</sup>, C. Paranicas<sup>11</sup>, D. Smith<sup>12</sup>, P. Willis<sup>1</sup>, A. Hayes<sup>13</sup>, B. Ehlmann<sup>1,14</sup>, J. Lunine<sup>13</sup>, A. Templeton<sup>15</sup>, K. Nealon<sup>16</sup>, B. Christner<sup>17</sup>, M. Cable<sup>1</sup>, K. Craft<sup>11</sup>, R. Pappalardo<sup>1</sup>, A. Hofmann<sup>1</sup>, T. Nordheim<sup>1</sup>, C. Phillips<sup>1</sup>, <sup>1</sup>Jet Propulsion Laboratory, Caltech (khand@jpl.nasa.gov), <sup>2</sup>Desert Research Institute & University of NV, Reno, <sup>3</sup>Goddard Space Flight Center, <sup>4</sup>Johns Hopkins University, <sup>5</sup>Malin Space Science Systems, <sup>6</sup>NASA Ames Research Center, <sup>7</sup>Arizona State University, <sup>8</sup>Planetary Science Institute, <sup>9</sup>Woods Hole Oceanographic Institution, <sup>10</sup>Georgia Tech., <sup>11</sup>Applied Physics Laboratory, Johns Hopkins, <sup>12</sup>Massachusetts Institute of Technology, <sup>13</sup>Cornell University, <sup>14</sup>Caltech, <sup>15</sup>CU Boulder, <sup>16</sup>University of Southern California, <sup>17</sup>University of Florida.

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 NASA HQ Charter **goals**, in priority order, are as follows:

1. Search for evidence of life on Europa.
2. Assess the habitability of Europa via in situ techniques uniquely available to a lander mission.
3. Characterize surface and subsurface properties at the scale of the lander to support future exploration of Europa.

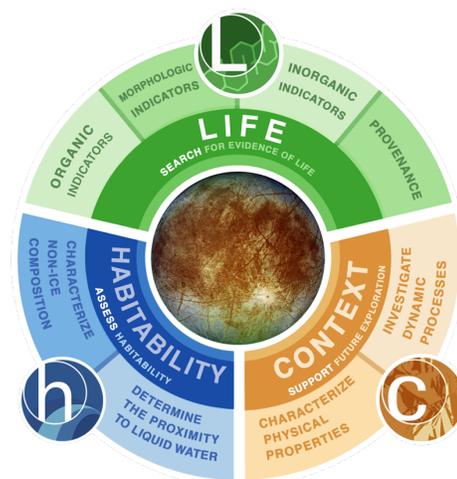
Within Goal 1, four Objectives were developed for seeking signs of life. These include the need to: a) detect and characterize any organic indicators of past or present life, b) identify and characterize morphological, textural, and other indicators of life, c) detect and characterize any inorganic indicators of past or present life, and d) determine the provenance of Lander-sampled material. Within Goal 1 investigations and measurement requirements there are more than seven distinct and complimentary approaches for detecting potential biosignatures within material sampled from Europa's surface and near-subsurface.

Goal 2 focuses on Europa's habitability and ensures that even in the absence of the detection of any potential biosignatures, significant ocean world science is still achieved. The objectives within Goal 2 are to: a) characterize the non-ice composition of Europa's near-surface material and determine whether there are indicators of chemical disequilibria, and b) determine the proximity to liquid water and recently erupted materials at the lander's location.

Goal 3 ensures that the landing site region is quantitatively characterized in the context needed for Goals 1 and 2, and that key measurements about Europa's ice shell are made to enable future exploration. The objectives for Goal 3 include the need to: a) observe the properties of surface materials and sub-meter-scale landing hazards at the landing site, including the sampled area (connecting local properties with those seen from precursor Europa flyby remote sensing), and b)

characterize dynamic processes of Europa's surface and ice shell over the mission duration to understand exogenous and endogenous effects on the physiochemical properties of surface and shallow sub-surface materials.

The high-level goals and objectives of the Europa Lander mission concept are shown in **Figure 1** as a circle of inter-connected science investigations, each of which plays an important role in the scientific success of the mission. Critically, scientific success cannot be, and should never be, contingent on finding signs of life – such criteria would be levying requirements on how the universe works. Rather, scientific success is defined here as achieving a suite of measurements such that if convincing signs of life are present on Europa's surface they could be detected at levels comparable to those found in benchmark environments on Earth, and, further, that even if no potential biosignatures are detected, the science return of the mission will significantly advance our fundamental understanding of Europa's chemistry, geology, geophysics, and habitability.



**Figure 1.** Science goals and objectives of the Europa Lander mission concept. Within each Goal are the high level Objectives, represented as a “fan” across each Goal (i.e., a circular STM).