MISSION OPTIONS FOR EXPLORING EUROPA'S HABITABILITY. R. T. Pappalardo[1], F. Bagenal[2], A. C. Barr[3], B. G. Bills[1], D. L. Blaney[1], D. D. Blankenship[4], W. Brinckerhoff[5], J. E. P. Connerney[5], K. Hand[1], T. Hoehler[6], W. Kurth[7], M. McGrath[8], M. Mellon[9], J. M. Moore[6], L. M. Prockter[10], D. A. Senske[1], E. Shock[11], D. E. Smith[12], T. Gavin[1], G. Garner[1], T. Magner[10], B. C. Cooke[1], R. Crum[1], V. Mallder[10], L. Adams[10], K. Klaasen[1], G. W. Patterson[10], and S. D. Vance[1]; [1]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, [2]University of Colorado, Boulder, CO, [3]Brown University, Providence, RI, [4]University of Texas Institute for Geophysics, Austin, TX, [5]NASA Goddard Space Flight Center, Greenbelt, MD, [6]NASA Ames Research Center, Mountain View, CA, [7]University of Iowa, Iowa City, IA, [8]NASA Marshall Space Flight Center, Huntsville, AL, [9]Southwest Research Institute, Boulder, CO, [10]Johns Hopkins University Applied Physics Laboratory, Laurel, MD, [11]Arizona State University, Tempe, AZ, [12]Massachusetts Institute of Technology, Cambridge, MA.

Introduction: Assessment of Europa's habitability requires understanding whether the satellite possesses the three "ingredients" for life: water, chemistry, and energy. The National Research Council's Planetary Decadal Survey [1] placed an extremely high priority on Europa science but noted that the budget profile for the Jupiter Europa Orbiter (JEO) mission concept [2] is incompatible with NASA's projected planetary science budget. Thus, in April 2011, NASA enlisted a small Europa Science Definition Team (ESDT) to consider Europa mission options that might be more feasible over the next decade from a programmatic perspective.

The ESDT has studied three Europa mission concepts: a Europa orbiter, a Europa multiple-flyby mission, and a Europa lander. These share an overarching goal: *Explore Europa to investigate its habitability*. Each of the three mission options would address this goal in different and complementary ways, and each has high science value of its own, independent of the others.

Europa Orbiter: An envisioned Europa orbiter mission concept would address two key objectives for Europa:

- *Ocean:* Characterize the extent of the ocean and its relation to the deeper interior;
- *Geology:* Understand the formation of surface features, including sites of recent and current activity.

These objectives trace to geophysical and geological investigations that are best addressed through near-continuous global data sets that are obtained under relative uniform conditions. As such, these are best suited to be collected from a spacecraft that is in orbit around Europa. The example measurements developed by the ESDT suggest a model payload consisting of: radio subsystem, laser altimeter, magnetometer, Langmuir probe, and mapping camera. This mission architecture would provide for radiation-shielded instruments that are all relatively low mass, power, and data rate. Such a payload would require limited spacecraft resources, and could be delivered into Europa orbit by a modest spacecraft.

Europa Flyby: An envisioned Europa flyby mission concept would address three key objectives for Europa:

- *Ice Shell:* Characterize the ice shell and any subsurface water, including their heterogeneity, and the nature of surface-ice-ocean exchange;
- *Composition:* Understand the habitability of Europa's ocean through composition and chemistry;
- *Geology:* Understand the formation of surface features, including sites of recent or current activity, and characterize high science interest localities.

These objectives trace to remote sensing investigations that could be well-addressed by multiple flybys of Europa from a spacecraft in Jupiter orbit. The example measurements developed by the ESDT suggest a model payload consisting of: radar sounder, stereo imager, infrared spectrometer, and ion and neutral mass spectrometer. This mission architecture would provide for radiation-shielded instruments that are all relatively high mass, power, and data rate. The architecture of a multiple flyby mission with a modest spacecraft is well-suited to the requirements of such a relatively resource-intensive instrument payload.

Europa Lander: An envisioned Europa lander mission concept would address three key objectives for Europa:

- *Composition:* Understand the habitability of Europa's ocean through composition and chemistry;

- *Ocean and Ice Shell:* Characterize the local thickness, heterogeneity, and dynamics of any ice and water layers;
- *Geology:* Characterize one or more localities of high scientific interest to understand the formation and evolution of the surface at local scales.

As of this writing, the ESDT is actively investigating the appropriate investigations and example measurements to best achieve these objectives. A preliminary minimum model payload to achieve these aims would consist of: mass spectrometer, magnetometer, seismometer, and site and nadir imagers. The significant radiation processing that occurs on Europa's surface requires a sampling system to best understand Europa's intrinsic composition. A Europa lander could take advantage of the complex radiation environment of the satellite, landing in regions where modelling suggests that radiation is about an order of magnitude less intense than in other regions [3].

References: [1] Space Studies Board, 2011. *Vision and Voyages for Planetary Science in the Decade 2013–2022*. The National Academies Press, Washington, DC. [2] Greeley, R., et al., 2010. *Joint Jupiter Science Definition Team Report to NASA*. JPL D-67959. [3] Patterson, G., et al., 2012. Characterizing electron bombardment of Europa's surface by location and depth. *Icarus*, in revision.