INVESTIGATING ICY WORLD HABITABILITY THROUGH THE EUROPA CLIPPER MISSION CONCEPT.
D. A. Senske[1], R. T. Pappalardo[1], L. Prockter[2], S. Vance[1], W. Patterson[2], and the Europa Study Team, [1]Jet Propulsion Laboratory/California Institute of Technology, Pasadena, CA 91109, [2]Johns Hopkins Applied Physics Laboratory, Laurel, MD, 20723.

Introduction: Understanding the processes that lead to potential habitability across the solar system is a cornerstone of the Planetary Decadal Survey, "*Visions and Voyages*" [1]. Fundamental to this is understanding the astrobiological significance of the icy outer planet satellites. It is in this context that Europa has been placed at the forefront of outer planet exploration targets [1].

Understanding Europa's habitability is directly tied to understanding the three "ingredients" for life: water, chemistry, and energy. Our understanding of Europa suggests that it may have all three of these ingredients in the form of: (1) an extensive saltwater ocean beneath an ice shell that is geodynamically active and relatively thin (several kilometers to several tens of kilometers thick); (2) essential chemical elements derived from the primordial chondritic composition of the Jovian protoplanetary disk, plus delivery by asteroids and comets over time; and (3) a rich source of chemical energy for life created by the combination of irradiation of its surface and tidal heating of its interior. However, the processes that shape Europa's ice shell, and the exchange processes between the surface and ocean, remain poorly understood. Even the existence of a subsurface ocean, while generally accepted, is not proven.

A Europa Science Definition Team (SDT) has stated the goal for future Europa exploration as: Explore Europa to investigate its habitability. The SDT considered the objectives for a multiple-flyby mission to Europa based on current hypotheses regarding the satellite's potential for being habitable:
(1) *Ocean and Ice Shell*: Characterize the ice shell and any subsurface water, including their heterogeneity, and the nature of surface-ice-ocean exchange and the properties of the ocean;
(2) *Composition*: Understand the habitability of Europa's ocean through composition and chemistry;
(3) *Geology*: Understand the formation of surface features, including sites of recent or current activity, and characterize high science interest localities.

The Clipper Mission: Based on the SDT defined science drivers, a JPL-APL Europa technical team has devised a flight system and mission design that can accommodate a capable science payload to achieve these science objectives. The notional set of science instruments are: an Ice Penetrating Radar (IPR), Topographic Imager (TI), Shortwave Infrared Spectrometer (SWIRS), Neutral Mass Spectrometer (NMS), Magnetometer (MAG), Langmuir Probe (LP), and the spacecraft Radio Sub-system (RS) to enable gravity measurements. A mission design that incorporates 45 close flybys of Europa has been developed to achieve globally distributed regional surface coverage. The overall mission architecture is optimized for the mass, power, and data rate expectations of the model payload.

Reconnaissance: Science achieved by the Europa Clipper would provide global and regional characterization of the satellite. It is anticipated that a next logical step to address scientific questions regarding the habitability and composition of this icy world's subcrustal ocean would be to land a spacecraft capable of *in situ* sampling and analysis. From a recent study of a lander concept [2], it became clear that additional information is needed regarding surface characteristics and properties to robustly architect a low-risk lander concept. To maximize success of a potential future landed mission, ensuring both safe landing and access to surface material of high scientific value, surface reconnaissance is essential.

The objectives of reconnaissance are two-fold:
(1) *Site Safety*: Assess the distribution of surface hazards, the load-bearing capacity of the surface, the structure of the subsurface, and the regolith thickness;
(2) *Science Value*: Assess the composition of surface materials, the geologic context of the surface, the potential for geological activity, the proximity of near surface water, and the potential for active upwelling of ocean material.

To achieve these reconnaissance objectives, two additional notional payload elements are a Reconnaissance Camera (RC) and a Thermal Imager (ThI).

Conclusions: A Jupiter-orbiting spacecraft that makes many flybys of Europa would provide an excellent platform from which to conduct measurements to investigate Europa's ocean and ice shell, composition, and geology, and thus the potential ingredients for life. Most of the required measurements could be achieved through remote sensing techniques that tend to be resource-intensive, in terms of data volume and data rate drivers. Such needs would be readily accommodated through implementation of the Europa Clipper concept.

References: [1] Space Studies Board, (2011) The National Academies Press, Washington, DC. [2] Europa Study Team, (2012) JPL Internal Document D-71990.