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Science from the Europa Clipper Mission Concept: Exploring the Habitability of Europa

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Abstract

The Europa Clipper mission concept concentrates on remote sensing science that can be accomplished through multiple close flybys of Europa. This includes exploring Europa's ice shell for evidence of liquid water within or beneath it, in order to understand the thickness of the ice shell and potential material pathways from the ocean to the surface and from the surface to the ocean, and includes confirming the existence of an ocean and characterizing that ocean through geophysical measurements of Europa's gravitational tides and magnetic induction response. The mission concept also includes exploration of the surface and atmospheric composition of Europa, to address ocean composition and habitability. Detailed morphologic and topographic characterization of Europa's surface are included as well. In this presentation, we discuss the science that could be achieved by the Europa Clipper concept, a spacecraft in orbit around Jupiter that would make observations over the course of 32 flybys of Europa.

1. Science Objectives

Understanding Europa's habitability is intimately tied to understanding the three "ingredients" for life: water, chemistry, and energy. Our current understanding of Europa suggests that it may have all three ingredients for life: Europa likely contains an extensive saltwater ocean beneath an ice shell that is geodynamically active and relatively thin (several kilometers to several tens of kilometers thick); essential chemical elements derived from the primordial chondritic composition of the satellites, plus delivery by asteroids and comets over time are present; and the combination of irradiation of its surface and tidal heating of its interior could make Europa a rich source of chemical energy for life. However, the processes that shape Europa's ice shell, and the exchange processes between the surface and ocean, remain poorly understood. Indeed, even the existence of a subsurface ocean, while generally accepted, is not yet proven.

With this foundation, the Europa Clipper science objectives are:

(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.

2. Reconnaissance Objectives

To address fundamental scientific questions regarding the habitability and composition of Europa's sub-ice ocean, a landed spacecraft capable of in situ sampling and analysis represents a likely future step. To maximize success of such a landed mission, ensuring both safe landing and access to surface material of highest scientific value, some level of reconnaissance is necessary on any preceding mission. Including a reconnaissance remote-sensing package on the enhanced Clipper spacecraft mission presents a cost effective way of obtaining this necessary data. 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.

3. Model Payload

Notional instruments are provided as a proof of concept to demonstrate that the science and reconnaissance objectives could be realistically addressed. The Europa Clipper model payload contains a Radio Subsystem for gravity science, Magnetometer, Langmuir Probes, an Ice-Penetrating Radar, Shortwave Infrared Spectrometer, Neutral Mass Spectrometer, and Topographical Imager. Two additional instruments are envisioned to support mission engineering, design, and site selection through analysis of landing site hazards related to obstacles and topography: a high-resolution stereo Reconnaissance Camera and a Thermal Imager. These are not meant to be exclusive of other measurements and instruments that might be able to meet the science and reconnaissance objectives in other ways. It is anticipated that NASA would ultimately select the payload through a formal Announcement of Opportunity (AO).

4. Mission Design

It is envisioned that the Clipper mission would be launched in the 2022 timeframe on an Atlas V 551 that places it on a 6.5 year VEEGA interplanetary trajectory before performing a Jupiter Orbit Insertion (JOI) burn. After JOI at Ganymede, the spacecraft would perform four additional Ganymede gravity assists over 11 months to lower its orbital energy with respect to Jupiter and set up the correct flyby conditions (lighting and relative velocity) at Europa; these flybys are solely to shape the orbit and are not driving science priorities.

The spacecraft would then embark on an 18 month Europa science campaign. The Europa flyby campaign is composed of four segments each designed to provide good coverage of a wide region on Europa with consistent lighting conditions. The unique multiple-flyby mission design allows for building up over time a regionally distributed network of flyby locations across Europa's entire globe. Remote-sensing instruments are able to observe Europa with flyby coverage similar to orbiting the body.

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