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Exploring Europa's Habitability: The Europa Clipper on the Path to Critical Design

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Abstract

By investigating the potential habitability of Jupiter's moon Europa, the Europa Clipper mission will aid understanding of habitability across the solar system. With passing of the Preliminary Design Review, the mission is on the path to enter full implementation. Here we present the mission's science objectives and an updated view of the scientific payload and mission design moving toward the final design and fabrication phase.

1. Mission Goal and Objectives

The overarching science goal of the Europa mission is to explore Europa to investigate its habitability. Following from this goal are three Mission Objectives: (1) characterize the ice shell and any subsurface water, including their heterogeneity, ocean properties, and the nature of surface-ice-ocean exchange; (2) understand the habitability of Europa's ocean through composition and chemistry; and (3) understand the formation of surface features, including sites of recent or current activity, and characterize high science interest localities. Folded into these three objectives is the desire to search for and characterize any current activity, notably plumes and thermal anomalies.

2. Exploring Europa Through Synergistic Investigations

To address the science questions of the Europa mission, NASA selected a scientific payload comprised of five remote-sensing instruments, which observe in the wavelength range from the ultraviolet through radio (radar), and four *in situ* instruments, which measure fields and particles. The capability of the science payload includes the following investigations: The *Europa Ultraviolet Spectrograph (Europa-UVS)* will measure the composition, chemistry, structure, and variability of Europa's tenuous atmosphere. In addition, it will characterize the plasma environment and search for and characterize any active plumes to constrain surface composition and microphysics and relationships to endogenic and exogenic processes. The *Europa Imaging System (EIS)* will map Europa globally at 100 m resolution and image almost any point on the surface at better than 20 m resolution to provide constraints on the formation of surface features and insight into small-scale regolith processes, search for active plumes, and characterize the ice shell through modeling of the limb shape. The *Mapping Imaging Spectrometer for Europa (MISE)* will observe the distribution of surface compounds to identify and map the distributions of organics, salts, acid hydrates, water ice phases, altered silicates, radiolytic compounds, and warm thermal anomalies. The *Europa Thermal Imaging System (E-THEMIS)* will detect and characterize thermal anomalies that may indicate current or recent activity and provide information on thermal inertia to characterize regolith particle size, block abundance, and subsurface layering. The *Radar for Europa Assessment and Sounding: Ocean to Near-surface (REASON)* will map Europa's vertical crustal structure and search for shallow subsurface water and the deeper ice-ocean interface to provide insight into material exchange among the ocean, ice shell, surface, and atmosphere, and constrain the amplitude and phase of the tides. The *Interior Characterization of Europa using Magnetometry (ICEMAG)* investigation will measure magnetic fields generated by currents induced in Europa's subsurface ocean, ionized material ejected from any plumes, and electromagnetic coupling of the moon to Jupiter. The *Plasma Instrument for Magnetic Sounding (PIMS)* will measure ions and electrons in Europa's atmosphere to infer the contributions to the magnetic field from plasma currents and to understand the interaction and coupling of the plasma with the

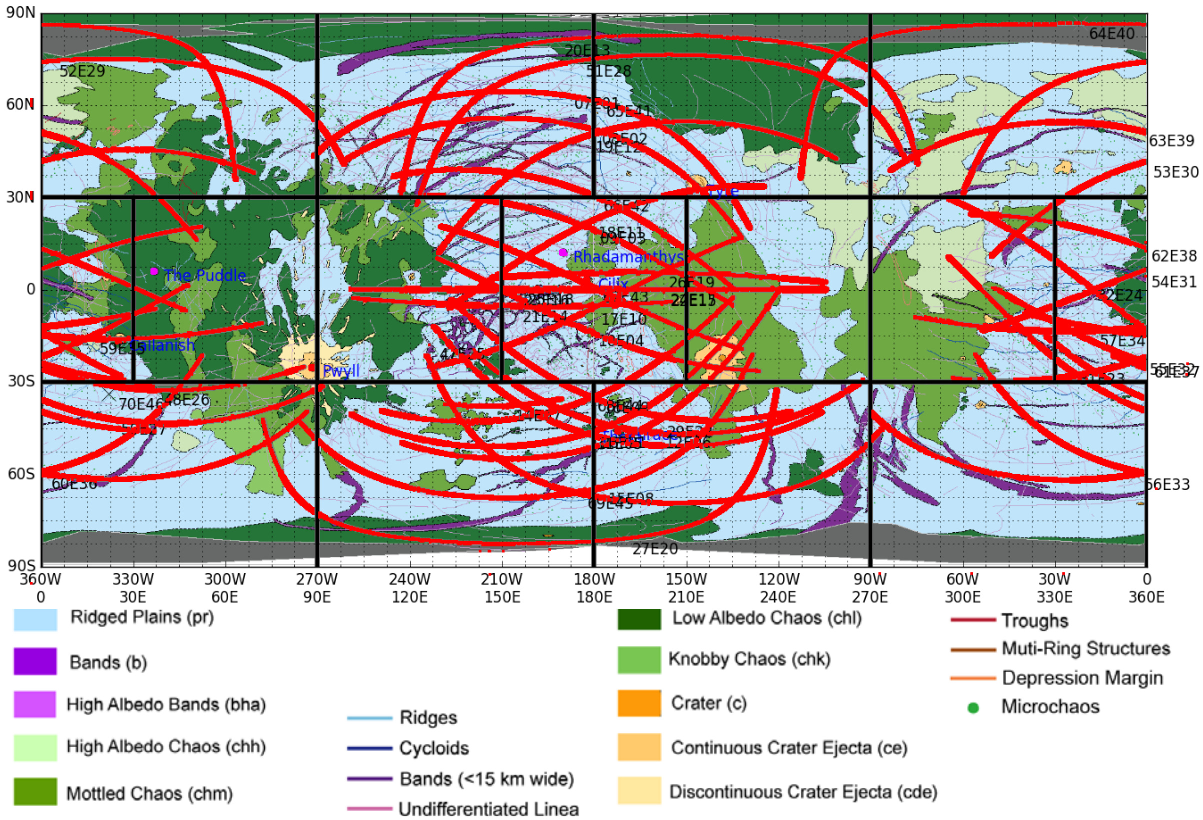

Figure 1: Planned Europa Clipper close approach ground tracks below 1000 km altitude (red) overlaid on the geologic map of Europa [1]. Blue areas are dominated by ridges. Purple areas are bands. Orange and yellow colors are associated with impact features. Chaos, pits, domes, and dark plains are most strongly concentrated in the green areas, but small examples are also found outside these regions.

moon's surface and with Jupiter. *The MAss Spectrometer for Planetary Exploration (MASPEX)* will measure trace neutral species to determine the composition in Europa's sputter-produced exosphere and potential plumes. Finally, the *SUrface Dust Analyzer (SUDA)* will map the chemical composition of particles ejected from Europa's surface and identify the makeup of potential plumes by directly sampling microscopic particles originating from the surface, entrained in the plumes, or delivered from elsewhere within or outside the Jovian system. In addition, the spacecraft's telecommunication system in combination with radar altimetry will enable geodesy, and the spacecraft's radiation monitoring system will provide information on Europa's energetic particle environment.

The current tour consists of 46 Europa flybys below 1000 km numbered E01 through E46, shown in Figure 1 superposed on the geologic map of Europa [1]. The altitudes of closest approach typically range from 25 km to 100 km. The tour is divided into two principal campaigns, visiting first the anti-Jovian hemisphere followed by observations of the sub-Jovian hemisphere. As seen in Figure 1, flybys occur over a rich variety of terrains, including ridges, bands, impact features, chaos, domes, pits, and plains.

Working together, the Europa mission's robust investigation suite can be used to test hypotheses and enable discoveries relevant to the interior, composition, and geology of Europa, thereby addressing the potential habitability of this intriguing ocean world.

References

[1] Leonard et al., Updating the global geologic map of Europa, Lunar and Planetary Science Conference 48, #2357, 2017.