The Europa Multiple Flyby Mission: Synergistic Science to Investigate Habitability

*Elizabeth P Turtle[1], Robert T Pappalardo[2], Haje Korth[1], David A Senske[2]

1. Johns Hopkins University Applied Physics Laboratory, 2. Jet Propulsion Laboratory

Europa is a complex geophysical and geochemical system, illustrating a wide range of processes relevant to understanding ocean worlds, including: tectonics; tidal deformation and heating; impact cratering; mass wasting; surface-plasma, exospheric, and magnetospheric interactions; solid state convection; and cryovolcanism, possibly including plumes. It is a key target for astrobiological exploration, potentially hosting the ingredients for life: liquid water, bioessential elements, and chemical energy.

The overarching science goal of the planned Europa Multiple Flyby Mission is to explore Europa to investigate its habitability, with Objectives (roman numerals) and Investigations (numbered, with applicable investigations), including the searching for any current activity, e.g., plumes, thermal anomalies:
I. Ice Shell & Ocean: Characterize the ice shell and any subsurface water, including their heterogeneity, ocean properties, and the nature of surface-ice-ocean exchange
1. Characterize the distribution of any shallow subsurface water and the structure of the icy shell *(EIS, REASON)*
2. Determine ocean salinity and thickness *(ICEMAG, MISE, PIMS, SUDA)*
3. Constrain the regional and global thickness, heat-flow, and dynamics of the ice shell *(E-THEMIS, EIS, Gravity, ICEMAG, PIMS, REASON)*
4. Investigate processes governing material exchange among the ocean, ice shell, surface, and atmosphere *(EIS, ICEMAG, MASPEX, MISE, REASON, SUDA)*

II. Composition: Understand the habitability of Europa's ocean through composition and chemistry
1. Characterize the composition and chemistry of endogenic materials on the surface and in the atmosphere, including potential plumes *(EIS, Europa-UVS, ICEMAG, MASPEX, MISE, PIMS, REASON, SUDA)*
2. Determine the role of the radiation and plasma environment in creating and processing the atmosphere and surface materials *(EIS, Europa-UVS, MASPEX, MISE, PIMS, Radiation, REASON, SUDA)*
3. Characterize the chemical and compositional pathways in the ocean *(EIS, ICEMAG, MASPEX, MISE, SUDA)*

III. Geology: Understand the formation of surface features, including sites of recent or current activity, and characterize high science interest localities
1. Determine sites of most recent geological activity, including potential plumes, and characterize localities of high science interest and potential future landing sites *(E-THEMIS, EIS, Europa-UVS, MASPEX, MISE, PIMS, Radiation, REASON, SUDA)*
2. Determine the formation and three-dimensional characteristics of magmatic, tectonic, and impact landforms *(EIS, REASON)*
3. Investigate processes of erosion and deposition and their effects on the physical properties of the surface *(E-THEMIS, EIS, Europa-UVS, PIMS, Radiation, REASON, SUDA)*

To address Europa science objectives, NASA selected a suite of instruments, including remote-sensing

covering wavelengths from ultraviolet through radar:
- *Europa Ultraviolet Spectrograph (Europa-UVS)*
- *Europa Imaging System (EIS)*
- *Mapping Imaging Spectrometer for Europa (MISE)*
- *Europa Thermal Imaging System (E-THEMIS)*
- *Radar for Europa Assessment and Sounding: Ocean to Near-surface (REASON)*

and *in situ* instruments that measure fields and particles:
- *Interior Characterization of Europa using Magnetometry (ICEMAG)*
- *Plasma Instrument for Magnetic Sounding (PIMS)*
- *MAss Spectrometer for Planetary Exploration (MASPEX)*
- *SUrface Dust Analyzer (SUDA)*

Gravity science can be achieved via the spacecraft telecom system in combination with REASON altimetry, and a planned radiation monitoring system will provide valuable scientific data. Together, these investigations will test hypotheses relevant to the interior, composition, and geology of Europa and to provide a synergistic framework to address the potential habitability of this intriguing moon.

An overview of planned Europa mission science will be presented along with the EIS camera suite, designed to provide global decameter-scale coverage, topographic and color mapping, unprecedented sub-meter-scale imaging, and plume searches.

Keywords: Europa, Habitability, Europa Multiple Flyby Mission

