EUROPA CLIPPER: MISSION STATUS AND UPDATE. Robert Pappalardo[1], Samuel Howell[1], Haje Korth[2], Kate Craft[2], Ingrid Daubar[1], Hamish Hay[1], Rachel Klima[2], Erin Leonard[1], Alexandra Matiella Novak[2], Divya Persaud[1], Cynthia Phillips[1], and the Europa Clipper Science Team. [1]NASA Jet Propulsion Laboratory, California Institute of Technology; [2]The Johns Hopkins University Applied Physics Laboratory

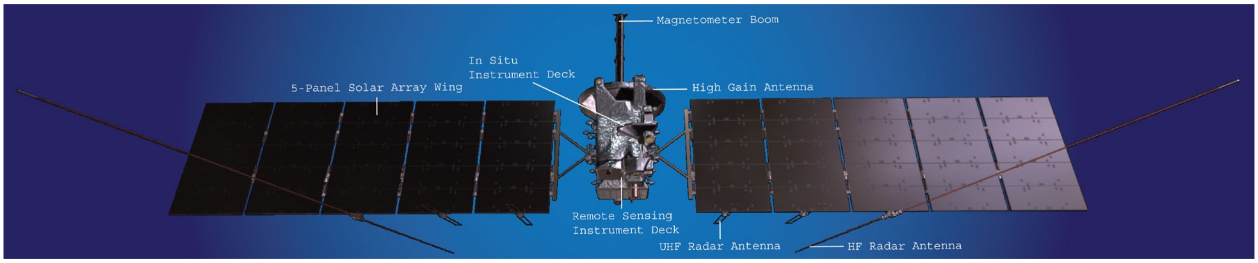

Figure 1 | ***Spacecraft illustration with labels showing various components and instruments.***

Introduction: With a launch readiness date of late 2024, NASA's Europa Clipper will set out on a journey to explore the habitability of Jupiter's moon Europa. At the beginning of the next decade, the spacecraft will orbit Jupiter, flying by Europa more than 40 times over a 4-year period to observe this moon's ice shell and ocean, study its composition, investigate its geology, and search for and characterize any current activity. The mission's science objectives will be accomplished using a highly capable suite of remote-sensing and in-situ instruments (**Fig. 1**).

The remote sensing payload consists of the Europa Ultraviolet Spectrograph (Europa-UVS), the Europa Imaging System (EIS), the Mapping Imaging Spectrometer for Europa (MISE), the Europa Thermal Imaging System (E-THEMIS), and the Radar for Europa Assessment and Sounding: Ocean to Near-surface (REASON). The in-situ instruments comprise the Europa Clipper Magnetometer (ECM), the Plasma Instrument for Magnetic Sounding (PIMS), the SUrface Dust Analyzer (SUDA), and the MAss Spectrometer for Planetary Exploration (MASPEX). Gravity and Radio Science (G/RS) will be achieved using the spacecraft's telecommunication system, and valuable scientific data will be acquired by the spacecraft's radiation monitoring system.

Mission Context: Jupiter's satellite Europa almost certainly hides a global saltwater ocean beneath the icy surface. Chemistry at the ice surface and ocean-rock interface might provide the building blocks for life, and NASA's Europa Clipper mission will assess Europa's potential habitability.

The Voyager and Galileo missions first revealed a deformed surface at Europa with an average surface age younger than Earth's, dominated by water ice and renewed through recent or active geologic activity. The Galileo mission discovered Europa's induced magnetic field, which indicates the presence of a global, electrically conductive fluid layer beneath the surface, most likely a saltwater ocean. Recent observations also suggest the presence of plumes that may spew internal water into space, indicating the potential for additional shallow water reservoirs beneath Europa's icy surface.

Figure 2 | ***Spacecraft flight hardware.*** *Top: Engineers and technicians in a clean room at NASA's Jet Propulsion Laboratory display the thick-walled aluminum vault they helped build for the Europa Clipper spacecraft. The vault will protect the spacecraft's electronics from Jupiter's intense radiation. In the background is a duplicate vault. Credit: NASA/JPL-Caltech. Bottom: Engineers at NASA's Goddard Space Flight Center in Greenbelt, Maryland, prepare for a propellant tank to be inserted into the cylinder in the background at left. The cylinder is one of two that make up Europa Clipper's propulsion module. Credit: NASA/GSFC Denny Henry.*

Geochemical constraints have led to open questions about the viability of Europa to host life. Intense radiation from Jupiter at Europa's surface forms water and impurities into oxidants, chemical reagents capable of carrying out oxidation. Active geologic cycling of seawater through rocky material on the Europan seafloor is expected to be chemically reducing. If mixing between the surface oxidants and the reduced ocean water occurs, there is an opportunity in Europa's ocean or ice shell to produce a reduction-oxidation (redox) potential. All known life on Earth relies on such redox potentials to extract chemical energy from the environment in exchange for heat energy and entropy, enabling cellular maintenance, metabolism and reproduction. Europa thus has the ingredients that may allow life to emerge: liquid water, bioessential elements, chemical energy, and a stable environment through time.

Science Goals and Objectives: The Overarching Goal of the Europa Clipper mission is to explore Europa to investigate its habitability. This will be achieved through the accomplishment of three Science Objectives:

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

Status and Advancement Toward Launch: As the mission moves forward towards launch, elements of both the spacecraft and the payload are under construction in preparation for assembly, testing, and launch operations (ATLO) beginning in March 2022 (**Figs. 2,3**).

Major milestones from the past year include selection of a launch vehicle and launch readiness date by NASA, evaluation of candidate tours by the science team, and preparations for the cruise and operational phases of the mission. The project, flight system, and payload have completed their Critical Design Reviews, and the mission has recently completed its System Integration Review. Meanwhile, the science team is preparing a set of manuscripts describing the mission science and the instruments that enable these investigations for publication in the journal Space Science Reviews.

One Team Philosophy: Our "One Team" philosophy prioritizes synergistic science by bridging across the individual instrument-based investigations, while promoting collaborations among members of the Europa Clipper science team. Each of the Europa Clipper individual instruments will be used to investigate Europa and its environs, finding critical clues about how Europa works as a planetary body. In combining and assessing the datasets from each instrument's experiments, we can collectively gain clarity into Europa's mysteries. As is commonly true in science, it is at the overlapping boundaries of our subfields that the greatest insights and discoveries will be made. Integrated science celebrates our individual expertise, challenges our assumptions, breaks through our limitations, and expands our intellectual boundaries. Associated visibility brings trust, promotes partnerships, and enhances personal relationships. These aspirations are the inherent basis for functioning as one science team.

Acknowledgments: Portions of this work were performed at the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration. This work was supported by NASA through the Europa Clipper project.

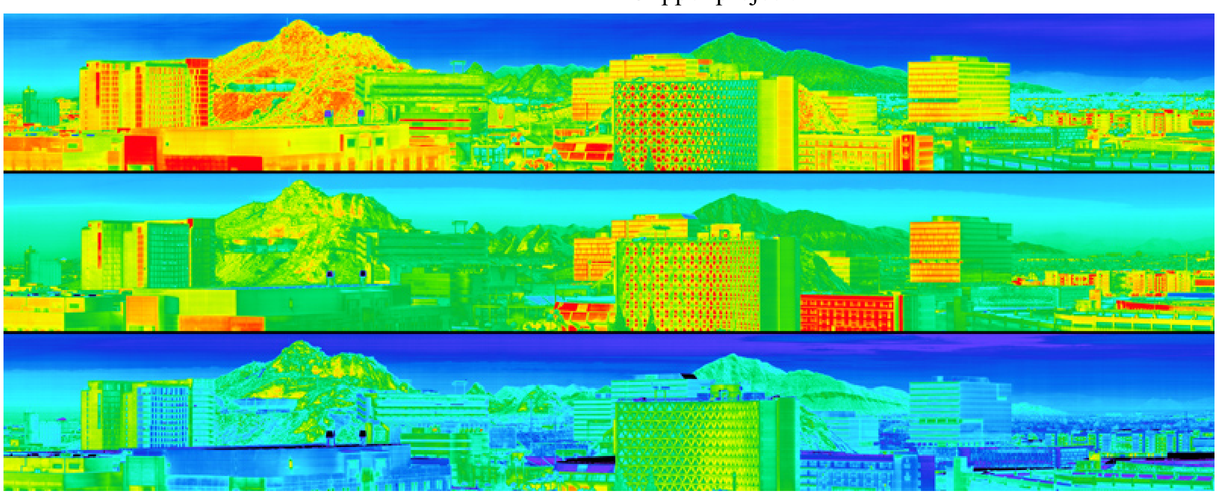

Figure 3 | *E-THEMIS "first light."* *Diurnal temperature color images taken from the rooftop of the Interdisciplinary Science and Technology Building 4 on the Tempe Campus of Arizona State University (ASU). The top image was acquired at 12:40 PM, the middle at 4:40 PM, and the bottom image at 6:20 PM (after sunset). Warm colors represent warmer temperatures, and cool colors represent colder temperatures. Credit: NASA/JPL-Caltech/ASU.*