Europa Clipper: Seven Months to Launch! R. Pappalardo[1], B. Buratti[1], H. Korth[2], D. Blaney[1], D.D. Blankenship[3], J. Burch[4], P. Christensen[5], S. Kempf[6], M. Kivelson[7,8], A. Luspay-Kuti[2], E. Mazarico[9], K. Retherford[4], E. Turtle[2], K. Craft[2], C. Glein[4], W. McKinnon[10], J.M. Moore[11], G.W. Patterson[2], C. Raymond[1], K. Soderlund[3], S. Trumbo[12], I. Daubar[1,13], S. Howell[1], R. Klima[2], E. Leonard[1], A. Matiella Novak[2], C. Phillips[1], B. Paczkowski[1], T. Ray[1], and the Europa Clipper Science Team. [1]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA (pappalardo@jpl.nasa.gov), [2]Johns Hopkins Univ. Applied Physics Laboratory, Laurel, MD, [3]UTIG, Austin, TX, [4]SWRI, San Antonio, TX, [5]SESE/Arizona State Univ., Tempe, AZ, [6]LASP/Univ. Colorado, Boulder, CO, [7]UCLA, Los Angeles, CA, [8]Univ. Michigan, Ann Arbor, MI, [9]NASA Goddard, Greenbelt, MD, [10]Washington Univ., Saint Louis, MO, [11]NASA Ames, Mountain View, CA, [12]Cornell Univ., Ithaca, NY, [13]Brown Univ., Providence, RI.

Introduction: Jupiter's satellite Europa almost certainly hides a global saltwater ocean beneath its icy surface. Chemistry at the ice surface and ocean–rock interface might provide the building blocks for life; thus, NASA's Europa Clipper mission was designed to assess Europa's habitability.

Mission and Payload: NASA's Europa Clipper spacecraft is set to launch in October 2024 and enter Jupiter orbit in April 2030. Beginning in March 2031, it will collect science data while flying past Europa 49 times over four years at closest approach distances as low as 25 km. The mission will characterize this moon's ice shell and ocean, study its composition, investigate its geology, and search for and characterize any current activity, including possible plumes.

The mission's objectives will be addressed using an advanced suite of complementary instruments. The remote sensing payload consists of the Europa Ultraviolet Spectrograph (Europa-UVS), Europa Imaging System (EIS), Mapping Imaging Spectrometer for Europa (MISE), Europa Thermal Imaging System (E-THEMIS), and Radar for Europa Assessment and Sounding: Ocean to Near-surface (REASON). The *in-situ* instruments are the Europa Clipper Magnetometer (ECM), Plasma Instrument for Magnetic Sounding (PIMS), SUrface Dust Analyzer (SUDA), and 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 for Radiation Monitoring (RadMon) will be collected by engineering sensors.

Exploration Context: The Galileo mission revealed the deformed and young surface of Europa, dominated by water ice and renewed through recent or active geologic activity. Galileo also discovered Europa's induced magnetic field, indicating 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 release internal water into space, indicating the potential for shallow water reservoirs beneath the icy surface that may or may not be connected to the ocean.

Geochemical constraints have led to questions about the viability of Europa to host life, notably whether appropriate reduction-oxidation (redox) potential exists within the ocean to power metabolism. Mixing between surface oxidants (produced by irradiation of surface ice and impurities) and ocean water (expected to be chemically reduced from water–rock interactions). Europa may have the basic ingredients that allow life to exist: liquid water, bioessential elements, chemical energy, and a stable environment through its ~4 Gyr lifetime.

Mission Science Goals and Objectives: The goal of the Europa Clipper mission is to explore Europa to investigate its habitability. This will be achieved through accomplishing three science objectives:

- Characterize the ice shell and any subsurface water, including their heterogeneity, ocean properties, and the nature of surface-ice-ocean 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.

Science Planning Process and Data: Europa Clipper draws on lessons from the Cassini mission to shape its science planning process. The Science System formulates a Science Strategic Planning Guide (SSPG), defining high-level strategies for each orbit. Developed before Jupiter Orbit Insertion (JOI), the SSPG integrates cross-disciplinary priorities, and the science team's Thematic Working Groups (TWGs) play a vital role in its development. SSPG updates may occur during Europa tour operations, accommodating new discoveries and lessons learned from data collection. The Tactical Science Group (TSG) engages in tactical decision-making during the Jovian tour, ensuring input from science, operations, and leadership representatives.

The Europa Clipper science team commits to freely sharing all scientific data products among team members, with a Mission Data Store serving as a central repository for geographically dispersed science operations. Collaborative data products aid team collaboration, with quick-look products available within two weeks. Data validation ensures data integrity before public release. Raw data will be archived for the sci-

ence community and public at the Planetary Data System (PDS) within six months, and derived data products will be archived by mission end. Standard data products and associated documentation form the core of the archives delivered to the PDS. These archives offer users online search and retrieval capabilities, supporting scientific analyses.

"One Team" Philosophy: To understand whether Europa is habitable, synthesis of phenomena and processes is key. In combining and assessing the details, limitations, and datasets from Europa Clipper's instruments, we can gain collective clarity into Europa's mysteries. We must work across instrument realms, to engage the expertise of the full Europa Clipper science team, and beyond. As is common in science, it is at the overlapping boundaries of sub-fields that the greatest insights and discoveries are derived; moreover, diverse and interdependent teams result in innovative and groundbreaking science.

Integrated science cannot be achieved as an afterthought. Instead, the synergies among instrumentation and investigators must be built into the organization and social fabric of the team. The Europa Clipper science team adopts a "one team" philosophy, promoting visibility and interdependence across the team. This requires understanding and sharing each other's processes, techniques, data sets, analyses, caveats, and results. Visibility and interdependence bring trust, promote partnerships, inspire group identity, and enhance interpersonal relationships, in turn promoting integrated science and holistic solutions to problems.

Efforts Toward Equity, Diversity, Inclusivity, and Accessibility: The Europa Clipper science team is dedicated to advancing equity, diversity, inclusion, and accessibility (EDIA). Acknowledging historical underrepresentation of women and underrecognized groups, the team aims to enhance its working environment and promote broad participation. A key aspect involves continuous evaluation and improvement of the team's EDIA practices.

The team boasts the first NASA planetary mission code of conduct, prioritizing a safe and equitable environment and underscoring respectful behavior and active efforts toward inclusivity. Science team meetings employ bystander intervention training, social science expert presentations, and practices to enhance communication and accessibility. EDIA efforts extend to grassroots team initiatives, fostering group discussions including those focused on social science literature and early-career perspectives.

Leadership opportunities rotate within the science team, offering diverse experiences and supporting career growth. Since 2009, the project has worked with a mission sociologist, who provides valuable perspectives on human factors affecting teams informed by embedded ethnographic studies. These efforts underscore Europa Clipper's commitment to foster an inclusive, diverse, and equitable team environment.

Coordination with Earth-Based Telescopes: Ground-based and space-based telescopes play a valuable role in augmenting Europa Clipper's mission by offering extended temporal coverage and additional wavelengths. Telescopic observations enhance scientific value through ground-based observing teams, and historical data mining. Historical observations hinted at Europa plume activity even before Hubble Space Telescope detections. Coordination with ground-based telescopes, particularly during the James Webb Space Telescope era, can significantly enrich the Europa Clipper mission's scientific return, especially if telescopic observations confirm ongoing activity at Europa.

Mission Status and Timeline: The mission is currently in its assembly, test, and launch operations phase. All science instruments have been successfully delivered; moreover, all are installed on the spacecraft with the planned exception of the REASON antennas. Flight system integration and system-level environmental testing has been completed at the Jet Propulsion Laboratory. The flight system will be shipped to Kennedy Space Center, Florida, in May 2024, where the solar arrays and REASON antennas will be integrated for final pre-launch testing.

Launch is planned within the window of 10–31 October 2024, close to 11 a.m. EDT. Europa Clipper will cruise to the Jupiter system with gravity assists at Mars (28 February 2025) followed by Earth (2 December 2026). The spacecraft is planned to enter Jupiter orbit on 11 April 2030 and have a first close encounter with Europa (E1) on 7 March 2031.

The Europa Clipper team is documenting the mission, science plans, and instruments in a topical collection of the journal *Space Science Reviews*. The team has begun science observation planning for the selected tour to sketch out the SSPG. ESA's JUpiter ICy moons Explorer (JUICE) spacecraft is expected to be in the Jovian system at the same time, so the two science teams have begun informal collaborations to consider synergistic science opportunities.

U.S. Poet Laureate Ada Limón has written a poem, *In Praise of Mystery: A Poem for Europa*, now signed by more than 2.5 million people worldwide. A spacecraft vault plate includes an engraving of the poem and other symbology relevant to Europa exploration.

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