Europa Clipper Update to OPAG

Bob Pappalardo, Europa Clipper Project Scientist
Jet Propulsion Laboratory, California Institute of Technology
and the Europa Clipper Science Team
February 21, 2018
Europa Clipper Project-Level Lifecycle Schedule

Key Project Reviews

- Propulsion Subsystem PDR 6/27-29/17 (GSFC)
- Propulsion Module PDR 7/24-27/17 (APL)
- Flight System PDR 10/17-20/17 (JPL)
- Europa-UVS PDR 11/16-17/17 (SWRI)
- PIMS PDR 12/6-7/17 (APL)
- EIS PDR 1/9-11/18 (APL)
- Solar Array Requirements Review 1/22/17 (JPL)
- Power PDR 1/23-24/18 (JPL)
- SUDA PDR 1/30-31/18 (CU)
- Guidance, Navigation & Control PDR 2/7-9/18 (JPL)
- Mechanical PDR 2/20-22/18 (JPL)
- Thermal PDR 2/27-28/18 (JPL)
- Radio Frequency Module / Telecom PDR 3/14-15/18 (APL)

- REASON PDR 3/26-27/18 (JPL)
- Magnetometer Boom PDR 4/9-10/18 (JPL)
- ICEMAG PDR 4/11-12/18 (JPL)
- Radiation Monitor System PDR 4/17/18 (APL)
- E-THEMIS PDR 4/19-20/18 (ASU)
- MISE PDR 4/24-25/18 (JPL)
- Avionics PDR 5/7-10/18 (JPL)
- MASPPEX PDR 5/15-16/18 (SWRI)
- Fault Management PDR 5/21-22/18 (JPL)
- Mission System PDR 6/19-21/18 (JPL)
- Propulsion Subsystem CDR 6/26-28/18 (GSFC)
- Solar Array PDR 7/10-11/18 (Airbus)
- Project PDR 8/20-24/18 (JPL)
Europa Ultraviolet Spectrograph (Europa-UVS)
PI: Kurt Retherford (SWRI, San Antonio)

- Europa-UVS has identified 464 opportunities for occultation observations of 106 UV-bright stars, with 198 scheduled, in the latest trajectory
- Europa-UVS EM electronics boards have been fabricated and are proceeding through board level testing
Europa Imaging System (EIS)
PI: Elizabeth Turtle (JHU/APL)

- Demonstrated a preliminary design and operations plan that meets all science requirements
- EIS-NAC gimbal enables near-global coverage (100 m/pixel) and local-scale imaging (1 m/pixel) with stereo topography
Mapping Imaging Spectrometer for Europa (MISE)
PI: Diana Blaney (JPL/Caltech)

- The instrument changed from an Offner to a Dyson design, improving S/N and reducing energy needs (single cryo-cooler)
- MISE cryo-cooler completed radiation testing
- MISE Data Processing Prototype boards fabricated and are being tested
Europa Thermal Imaging System (E-THEMIS)
PI: Phil Christensen (SESE, Arizona State Univ.)

- E-THEMIS microbolometer array successfully passed radiation testing
- Refining methodology using overlapping day-night observations to quickly identify endogenic hot spots with small (0–4 K) deviations from Standard Model prediction, distinguished from thermal inertia or albedo effects
Radar for Europa Assessment and Sounding: Ocean to Near-surface (REASON)
PI: Don Blankenship (Univ. Texas Institute for Geophysics)

- Performed numerical simulations to assess the potential for estimating $h_2$ using altimetric measurements with a combination of radar altimetry and stereo imaging data (Steinbrügge et al., EPSL, 2018)
  - Love number $h_2$ accuracy sufficient to unambiguously confirm (or reject) global ocean hypothesis
  - Love number $k_2$ accuracy sufficient to constrain Europa’s ice shell thickness to $\pm 15$ km

- Ensuring appropriate requirements for solar array, given the intimate association of the REASON VHF antennas which are mounted on the array (being built by Airbus)
Plasma Instrument for Magnetic Sounding (PIMS)
PI: Joe Westlake (JHU/APL)

- PIMS prototype instrument has been fabricated, assembled, and successfully completed testing (vibration, ion/electron beam, etc.)
- Progressing to Engineering Model
- Developed a multi-fluid full 3-D magnetohydrodynamic interaction model, to derive moon-plasma interaction magnetic field from simulated Europa Clipper trajectory through the model
Simulation of Europa’s Dipole Field Induced at 11-hr Synodic Period

June 1–3, 2017; Δt = 5 min

Simulations by Corey Cochrane
Interior Characterization of Europa using Magnetometry (ICEMAG)
PI: Carol Raymond (JPL/Caltech)

- Visualization of a simulation of Europa’s induced magnetic field including 11 and 85 hr periods using the VIP4 model of Jupiter’s magnetic field, to help in tour evaluation
- Testing low-temperature performance of sensors and optical fiber to minimize thermal energy requirements
SUrface Dust Analyzer (SUDA)
PI: Sascha Kempf (LASP, Univ. Colorado)

- Ion Detector: 2 flight-like prototypes fully developed and successfully tested
  - Reached TRL 6
- Target: 4 flight-like prototypes developed and successfully tested
  - Ir-coated Ti substrate
- Successfully measured mass spectra of dust particles up to 30 km/s
• MASPEX Engineering Model (EM) has been constructed, and completed vibration testing
• Ambient analytes that fall below the radiation noise line or that require integration in excess of a single flyby can be measured by cryotrapping
Gravity Science
Subject Matter Expert: Jean-Luc Margot (UCLA)

- Analysis of Gravity Science capabilities (Verma and Margot, 2017)
  - Two-way Doppler data can confirm presence or absence of ocean
  - Determination of hydrostatic equilibrium is possible, pending sufficient crossover range accuracy
  - Arraying DSN stations or use of 70-m antenna can provide additional resilience on tracking requirements
Identified ways that the Europa Clipper might better constrain habitability of Europa’s ocean using data returned from already-planned measurements:

- Temperature
- Pressure
- pH
- Oxidation state
- Major ions & salinity
- Physical and chemical sources of energy
- Compositional gradients (surface to ocean), mass transfer
- Concentrations of nutrients
- Speciation (if amino acid)
- Ocean vs. rock reservoirs, including salinity
- Composition vs. presence of organics
- Amount of chemical disequilibrium
- Energy fluxes
Plume Focus Group
Co-Chairs: Matt Hedman (Univ. Idaho) & Carly Howett (SWRI, Boulder)

- Identified targets of opportunity to search for current activity prior to first Europa flyby:
  - EIS: Plume search
    - Terminator; High phase limb; Europa eclipse
  - Europa-UVS: Plume search & atm. variability
    - Europa scans; Europa transits; Stellar occultations,
  - E-THEMIS: Surface temperatures
  - EIS: Surface color changes
  - MASPEX: Europa torus
  - SUDA: Escaped grains
  - Europa-UVS: Neutral cloud & torus stare
• Settled on key priorities in evaluating potential tours, including ensuring acceptable remote sensing and \textit{in situ} observations of:
  • Landform variety
  • “Young” landforms
  • Leading & trailing hemispheres

• Key focuses have been laboratory data and Europa's radiation environment:
  • Plans to hold a community workshop to discuss the current state of laboratories and laboratory data, and what will be needed to best interpret the multi-instrument Europa Clipper data
  • The formation of the Radiation Focus Group (next slide)
Radiation Focus Group
Co-Chairs: Roger Clark (PSI) & Abi Rymer (JHU/APL)

• To focus on understanding both the Europa radiation environment and its effects on the surface, and to advise the Project on trades relevant to radiation science

• Briefed on status of the Radiation Monitoring System
  • Charge monitor stack: Three plates of selected thickness provide crude energy spectra
  • Dosimeters: ~8 distributed around the spacecraft, plus hosted in science instruments, each returning integrated radiation flux above an energy determined by local shielding
Geology Working Group
Co-Chairs: Geoff Collins (Wheaton Coll.) & Julie Rathbun (PSI)

- Planned nadir ground tracks (red) overfly diverse landforms
- More distant remote sensing can observe other features

Leonard et al. (2018)
Several occultation opportunities exist for the Europa Clipper trajectory, using existing telecom system

- LGAs & fanbeam antennas (X-band)
- Two-way: Uplink radio signal from Earth, receive at spacecraft, and retransmit back to Earth

Would provide vertical profiles of electron density in ionosphere, and useful for Europa position and shape

Not yet baselined, but seems achievable and valuable
Project Science Team Bystander Intervention Training

- Europa Clipper Project Science team (which includes Investigation Scientists) retreat featured Bystander Intervention Training by Moses Milazzo (USGS)

- “Bystander intervention is an evidence-based framework intended to reduce victims’ burden of protecting themselves from harassment and shift the burden to the community” (Milazzo et al., LPSC, 2018)

- Given extremely positive feedback, the entire Europa Clipper Science Team will be strongly encouraged to participate in future training opportunities, including at Europa PSG meetings.
Upcoming Science Events (Programmatic)

- Mini- Project Science Group Meeting
  - March 23, The Woodlands, Texas

- Project Science Group meeting #6
  - June 11 – 15, JPL

- JUICE – Europa Clipper collaborative science workshop
  - July 22, Caltech
**JUICE – Europa Clipper Collaborative Science Discussions**

Members of the JUICE and Europa Clipper science teams will discuss potential scientific synergies between the Europa Clipper and JUICE missions

- **Investigations if both missions are in the Jupiter system at the same time:**
  - Multi-point measurements of the characteristics of the Jovian magnetodisc, with each spacecraft providing far-field context for the other

- **Investigations if both spacecraft are not in the Jupiter system at the same time:**
  - Opportunities for observations that are spatially or otherwise complementary, e.g.
    - Complementary coverage in spatial, spectral, energy, and geometric domains
  - Observations providing long temporal baselines, e.g.
    - Time-variability of the Jovian magnetodisc
    - Europa’s atmosphere and potential plume activity

- **Combined data sets will offer a more complete view of the Europa, Ganymede and the Jupiter system, while enabling in-depth comparative studies of the ocean worlds Ganymede and Europa.**
Europa Clipper Science Team
PIs, Co-Is, Project Science (Currently 119 total)

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