Europa Clipper Update to OPAG

Bob Pappalardo, Europa Clipper Project Scientist
Barry Goldstein, Europa Clipper Project Manager
Jet Propulsion Laboratory, California Institute of Technology
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Europa Clipper Science Overview

- **Mission Goal:** Explore Europa to investigate its habitability

- **Level-1 Science Objectives:**
  - **ICE SHELL & OCEAN:** Characterize the ice shell and any subsurface water, including their heterogeneity, ocean properties, and the nature of surface-ice-ocean exchange
  - **COMPOSITION:** Understand the habitability of Europa's ocean through composition and chemistry
  - **GEOLOGY:** Understand the formation of surface features, including sites of recent or current activity, and characterize high science interest localities*
  - **CURRENT ACTIVITY:** Search for and characterize any current activity, notably plumes and thermal anomalies

* "Reconnaissance” for a potential future lander is folded into the Geology objective."
NASA-Selected Europa Clipper Investigations

**Europa-UVS**
UV Spectrograph
- surface & plume/atmosphere composition

**MASPEX**
Mass Spectrometer
- sniffing atmospheric composition

**SUDA**
Dust Analyzer
- surface & plume composition

**ICEMAG**
Magnetometer
- sensing ocean properties

**PIMS**
Faraday Cups
- plasma environment

**EIS**
Narrow-Angle Camera + Wide-Angle Camera
- mapping alien landscape in 3D & color

**MISE**
IR Spectrometer
- surface chemical fingerprints

**E-THEMIS**
Thermal Imager
- searching for hot spots

**REASON**
Ice-Penetrating Radar
- plumbing the ice shell

**Phase A Radiation Science Working Group**
- radiation environment

**Phase A Gravity Science Working Group**
- confirming an ocean

**Remote Sensing**
- green

**In Situ**
- red
Europa Clipper Project-Level Lifecycle Schedule

### Key Project Reviews

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#### PDR Season
- **Spacecraft**
  - 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 1/9-11/17 (APL)
  - Solar Array Requirements Review 1/22/18 (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)

- **Payload**
  - 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)
  - MASPEX PDR 5/15-16/18 (SWRI)
  - Fault Management PDR 5/21-22/18 (JPL)
  - ICEMAG PDR 5/23-24/18 (JPL)
  - Mag Boom PDR 5/30 - 6/1/18 (JPL)
  - Mission System PDR 6/19-21/18 (JPL)
  - Propulsion Subsystem CDR 6/26-28/18 (GSFC)
  - Project PDR 8/20-24/18 (JPL)
  - Solar Array PDR 9/4-5/18 (Airbus, Leiden)
  - Integrated Wing Review 1/14-16/2018 (JPL)
Europa Clipper Flight System Configuration

**Flight System = Spacecraft + Payload**

- **Cruise Configuration**
  - 2670 kg FS Dry mass (CBE)
  - 336 Ah Battery (EOM)
  - 102 m² Solar Array area
  - 5.3 TB Downlink capability

**Launch Configuration**
Europa Clipper Flight System Highlights

**Power**
- 102 m² Solar array, 339 Ahr Li-Ion batteries,
- Power regulation, switching & distribution

**Avionics**
- RAD-750 Processor, 512 Gbit non-volatile NAND memory storage,
- Remote electronics unit, 1553 bus, Spacewire i/Fs, flight software

**Guidance & Control**
- 3-axis control, pointing and slewing for science,
- JOI, maneuvers, RW and RCS control using redundant SRUs, IMUs, & sun sensors, SA control

**Propulsion**
- Bi-prop system, tanks, lines, 24 engines,

**Thermal**
- Heat Reclamation System (pumps, lines), radiator, louvers, blankets, heaters,

**Science Instruments**
- 10 remote sensing and in-situ science instruments hosted & accommodated

**Radmon**
- Engineering radiation monitor

**Telecom**
- RF module, antennas, TWTAs, radios
- 2-way X band, Ka-band downlink

**Mechanical**
- Structures, magboom, sensor deck, vault
Flight System Instrument Accommodation

Deployed spacecraft view

Standard close approach:

vault and sensor deck view
Europa Clipper Instrument Accommodation

• REASON and ICEMAG accommodation details have been ongoing and challenging, with each now converging on excellent solutions:
  – REASON: converging on solutions for ground plane mesh and coax cable configuration consistent with solar array constraints
  – ICEMAG: for scalar vector helium (SVH) sensors, fiber optic cable solution identified to operate at cryogenic temperatures in radiation environment
**Key Europa Clipper Mission Scenarios**

**Launch and Deployment**
- 21 day launch period
- Short coast
- Minimize communication gap
- Autonomous detumble, Sun search, solar array deployment
- Nominal completion in < 2 hours

**Jupiter Orbit Insertion (JOI)**
- Centered at 12.05 Rj Perijove
- 6.5 hour burn, ~860 m/s
- RCS control, JOI attitude achieved @ JOI start – 9 hrs
- X-band, Fanbeam, Tones, 70-m coverage, Dual-Complex
- Solar array fixed

**Tour Encounters**
- Europa Flyby Period: +/-2 days around closest approach, contains 3 sub-phases:  
  - Approach Sub-phase
  - Nadir Sub-phase
  - Departure Sub-phase
- Collect ~80 Gbits data per flyby
- Playback Period: starting at 2 days after C/A to 2 days before the subsequent C/A
Europa Clipper Mission Concept

ETHEMIS
[Day/Night Coverage]

Europa-UVS
[Total Daytime Coverage]

MISE
[Global Daytime Coverage]

Trajectory

EIS
[WAC + NAC, Framing Pan Mono]
"One Team" Philosophy

- The Europa Clipper Science Team is one science team
- Fostering integrated science promotes insights and discovery
- The suite of instruments are our common hardware tools
  - Investigation teams are the acknowledged instrument experts
- Shared tools, planning, and data ensure mutual awareness and visibility
- Multi-investigation analyses coordinated via Thematic Working Groups
- Meetings of the whole science team promote visibility and integration
- Participating scientists are planned for one year before Jupiter arrival
• Built recommendations for the strategic and tactical science planning processes
  – What is the process by which the PSG will generate a strategic plan?
  – What is the process for tactical (encounter-based) planning?

• Discussed circumstances that might suggest deviation from the strategic plan, to help ensure the planning process is robust
  – What is the process by which the strategic plan might be altered, i.e. when new discoveries are made or in response to operations opportunities or challenges?

• Included presentations on other mission examples:
  – MESSENGER: Carolyn Ernst
  – Juno: Candy Hansen
  – Cassini: Bill Kurth
  – MER: Jeff Moore
  – New Horizons: John Spencer
Reconnaissance Focus Group
Co-Chairs: Alfred McEwen (Europa Clipper) & Cynthia Phillips (Europa Lander Study)

- Joint between Europa Clipper science team and Europa Lander study team
  - A co-chair from each group
- First meeting was Sept. 10 (yesterday):
  - Goal: Consider strategies for characterization of areas of interest for a potential lander, concentrating on engineering considerations
  - ~40 in-person attendees from Europa Clipper and Europa Lander Study teams, plus ~15 more on-line
  - All presentation materials and a meeting summary is planned to be posted to a publicly-accessible site, with link will be shared with OPAG