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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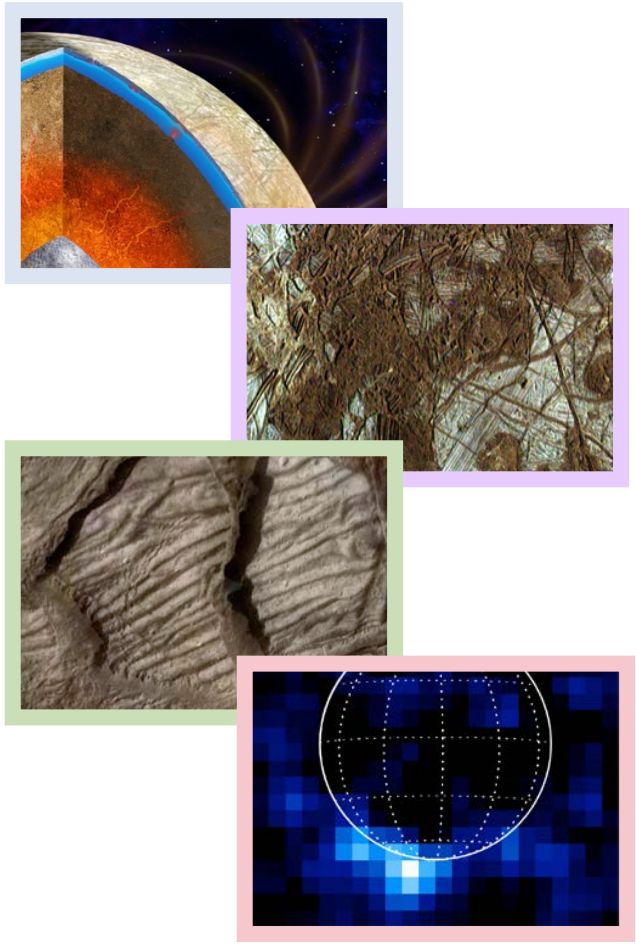
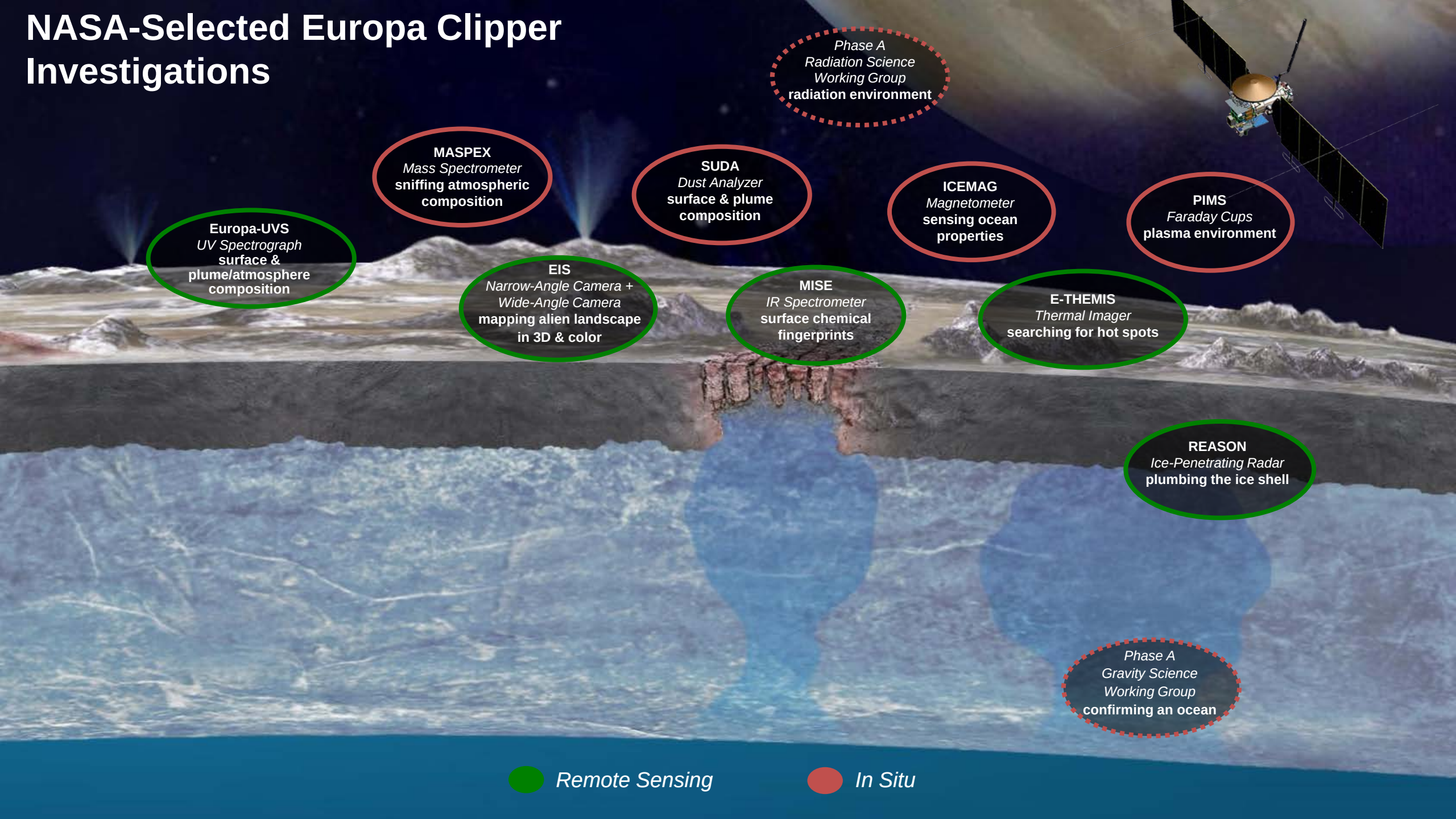
Europa Clipper Science Overview

- *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



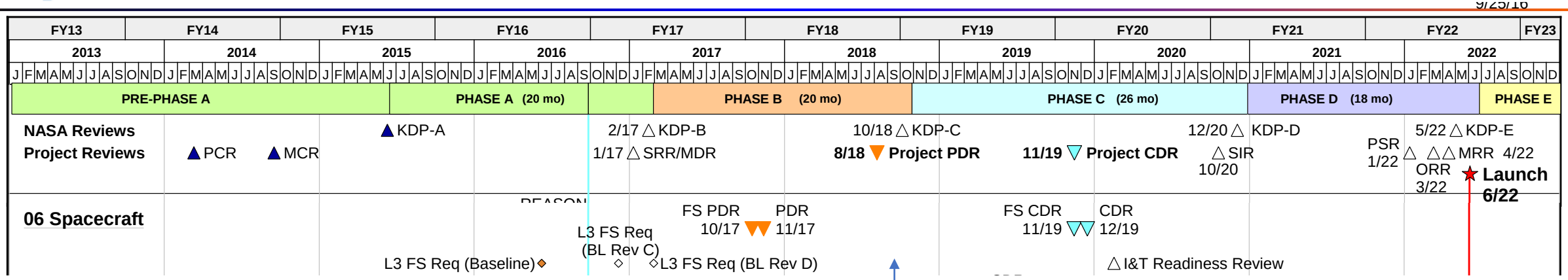
** "Reconnaissance" for a potential future lander is folded into the Geology objective.*

NASA-Selected Europa Clipper Investigations



Europa 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** 1/22/18 (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)

PDR Season

Spacecraft

Payload

Mission System

Project

We are here

- **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)

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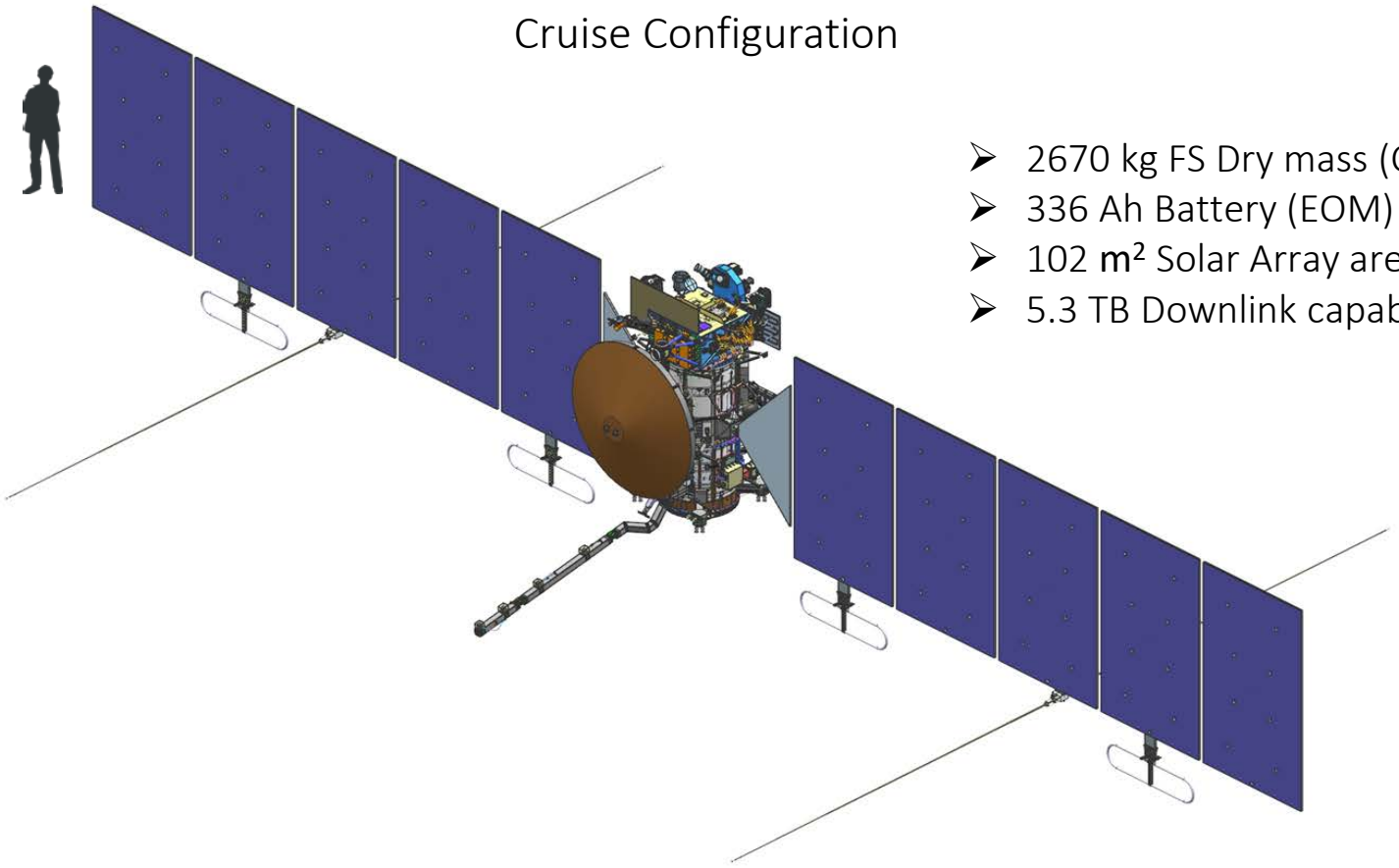
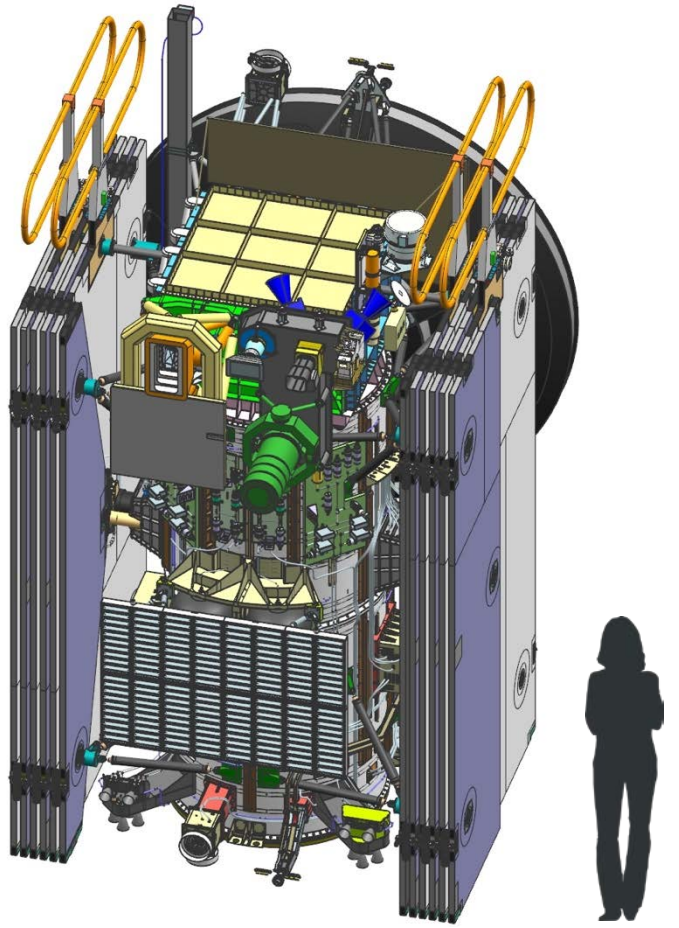
Europa Clipper Flight System Configuration

Cruise Configuration



- 2670 kg FS Dry mass (CBE)
- 336 Ah Battery (EOM)
- 102 m^2 Solar Array area
- 5.3 TB Downlink capability



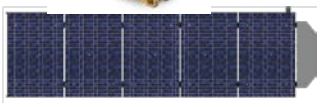
Launch Configuration

Flight System = Spacecraft + Payload

Europa Clipper Flight System Highlights

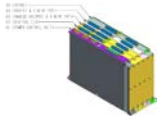
Power





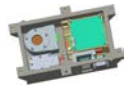

102 m^2 Solar array, 339 Ahr Li-Ion batteries, Power regulation, switching & distribution

Avionics

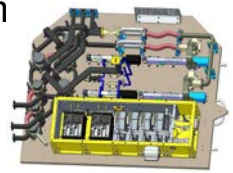
RAD-750 Processor, 512 Gbit non-volatile NAND memory storage, Remote electronics unit, 1553 bus, Spacewire i/Fs, flight software

Radmon



Engineering radiation monitor

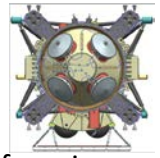
Telecom

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

Guidance & Control

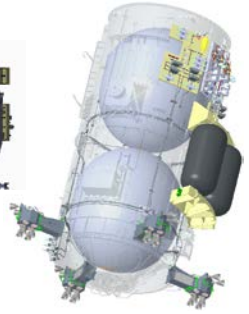


3-axis control, pointing and slewing for science, JOI, maneuvers, RW and RCS control using redundant SRUs, IMUs, & sun sensors, SA control

Propulsion





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

Thermal

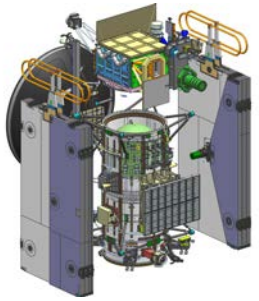
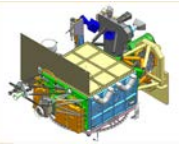



Heat Reclamation System (pumps, lines), radiator, louvers, blankets, heaters,

Science Instruments

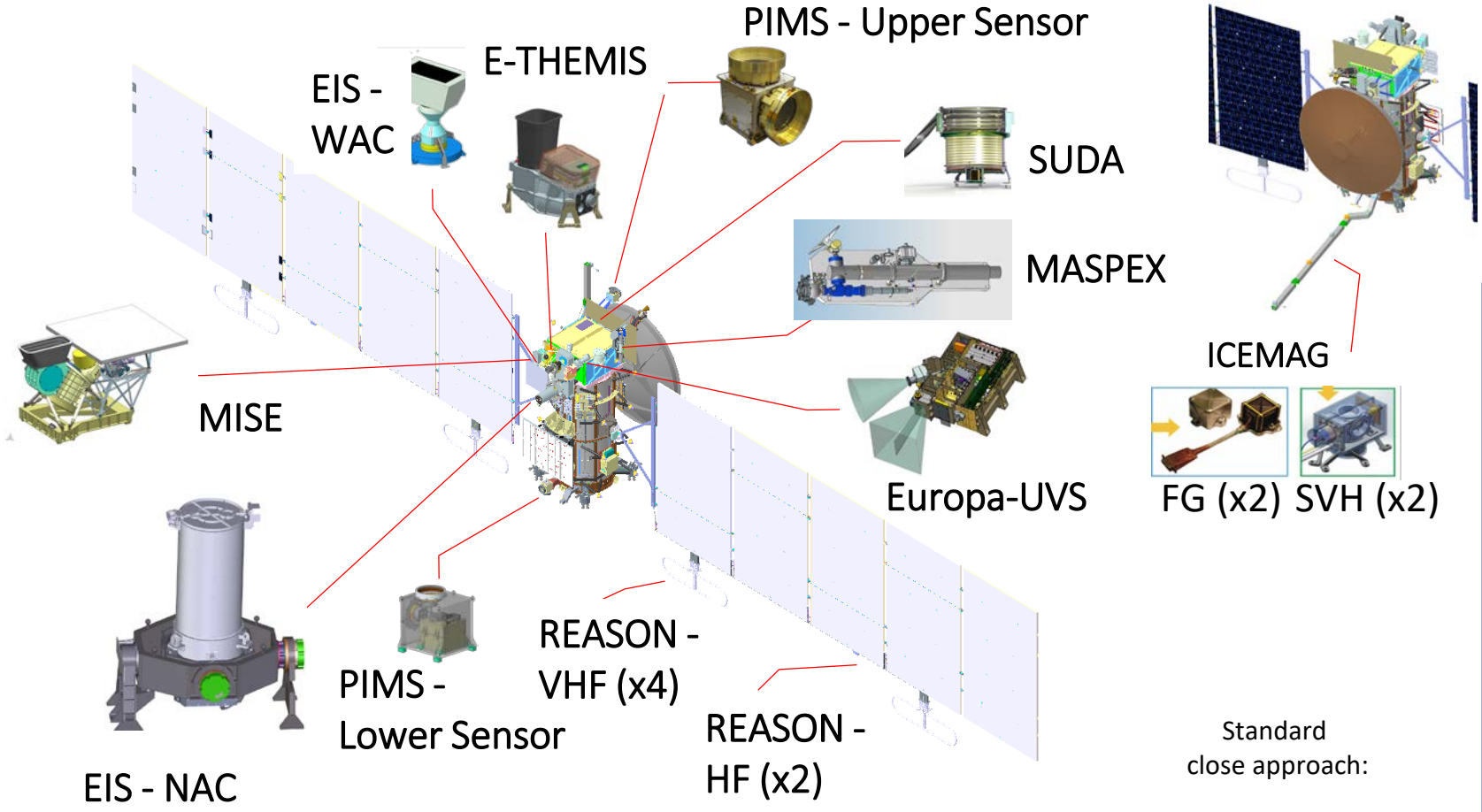
10 remote sensing and in-situ science instruments hosted & accommodated

Mechanical

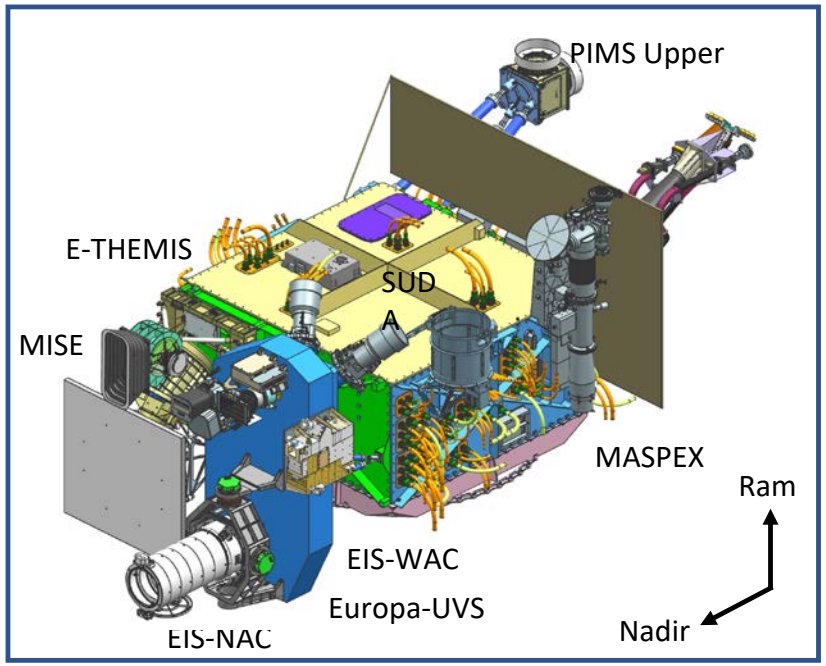
Structures, magboom, sensor deck, vault

Flight System Instrument Accommodation



Deployed spacecraft view

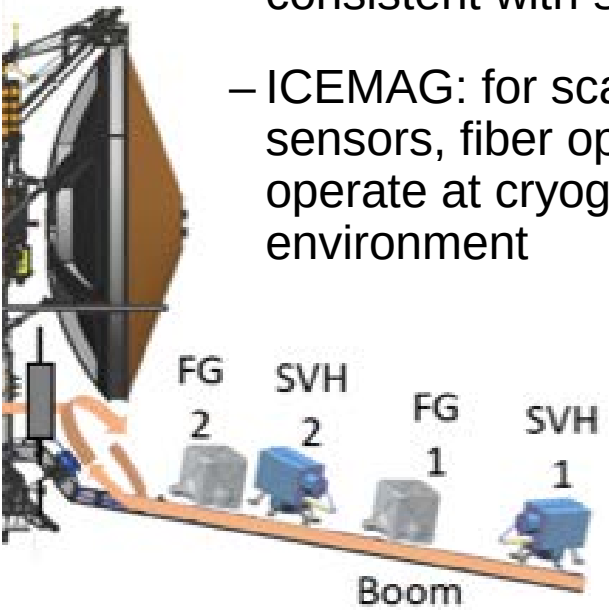
Standard close approach:

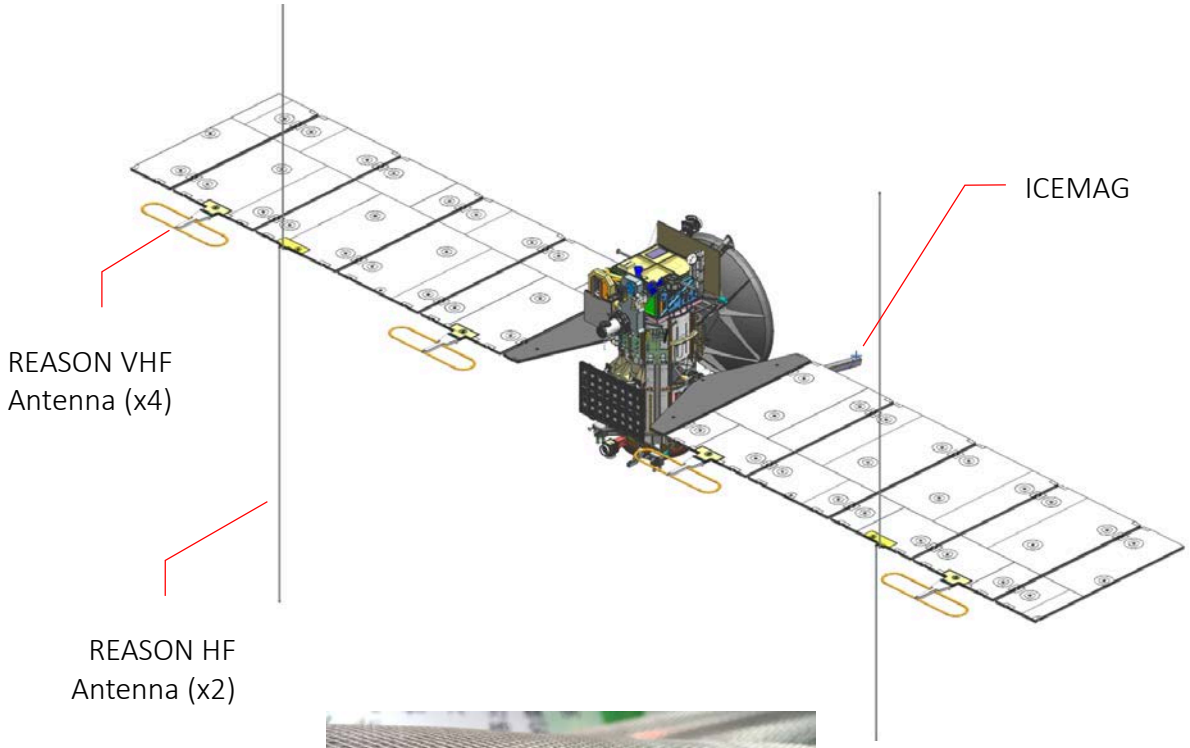


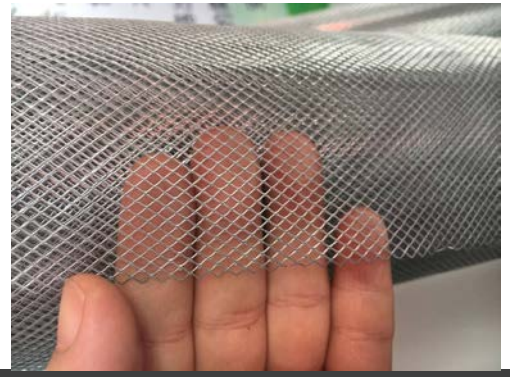
vault and sensor deck view

Europa Clipper Instrument Accommodation

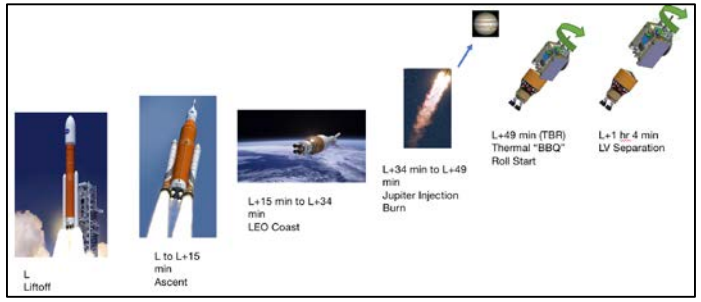
- REASON and ICEMAG accommodation details have been ongoing and challenging, with each now converging on excellent solutions:
  - REASON: converging on solutions for ground plane mesh and coax cable configuration consistent with solar array constraints
  - ICEMAG: for scalar vector helium (SVH) sensors,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

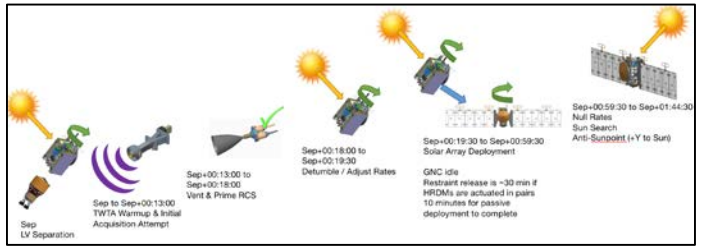


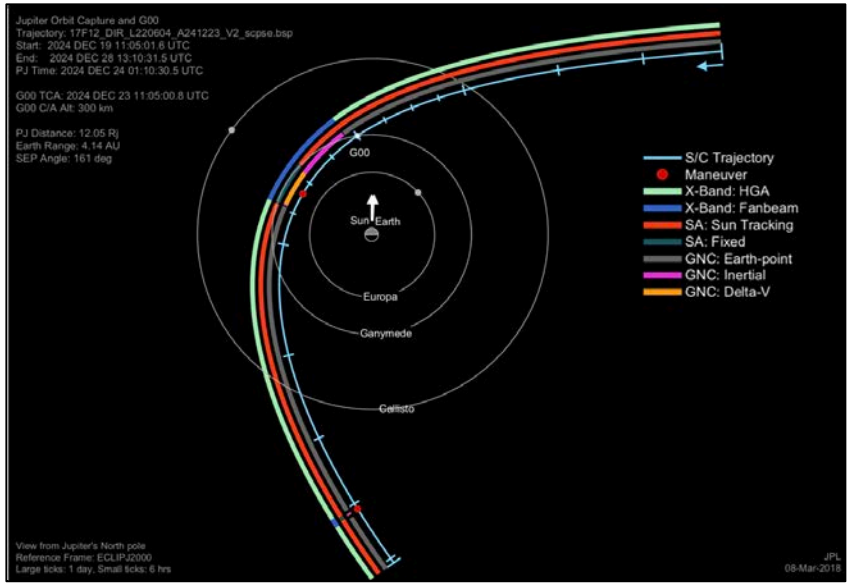


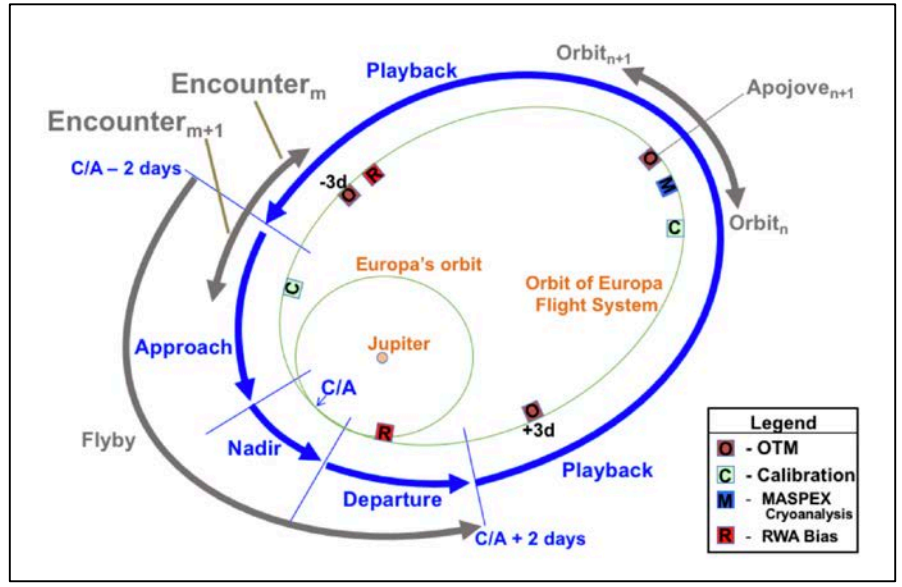


Key Europa Clipper Mission Scenarios









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)

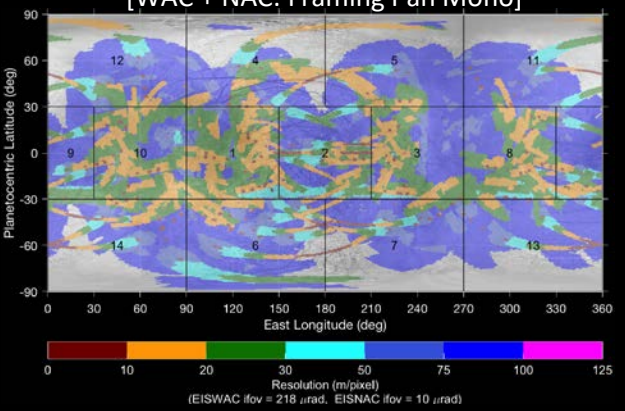
- Centered at 12.05 Rj Perijove
- 6.5 hour burn, ~860 m/s
- RCS control, JOI attitude achieved @ JOI start – 9 hrs
- X-band, Fanbeam, Tones, 70-m coverage, Dual-Complex
- Solar array fixed

Tour Encounters

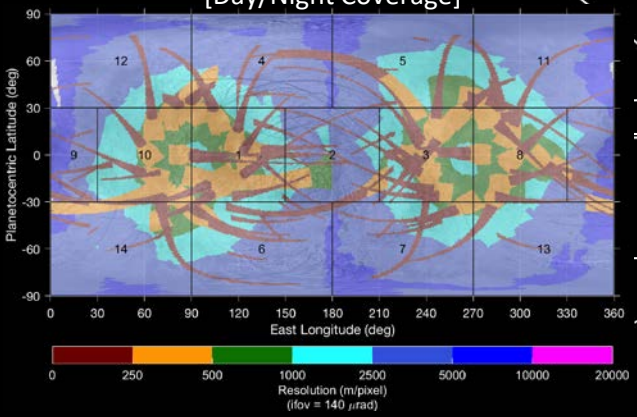
- Europa Flyby Period: +/-2 days around closest approach, contains 3 sub-phases:
  - Approach Sub-phase
  - Nadir Sub-phase
  - Departure Sub-phase
- Collect ~80 Gbits data per flyby
- Playback Period: starting at 2 days after C/A to 2 days before the subsequent C/A

Europa Clipper Mission Concept

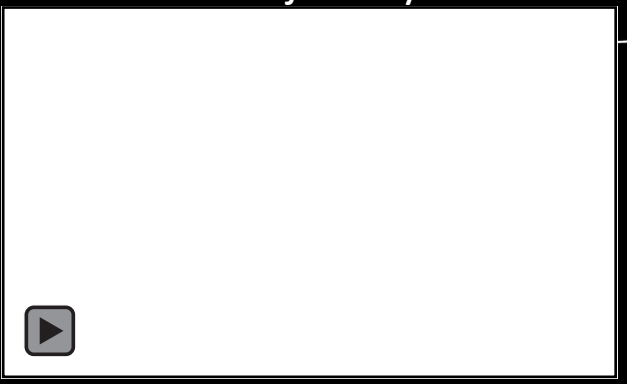
EIS
[WAC + NAC: Framing Pan Mono]

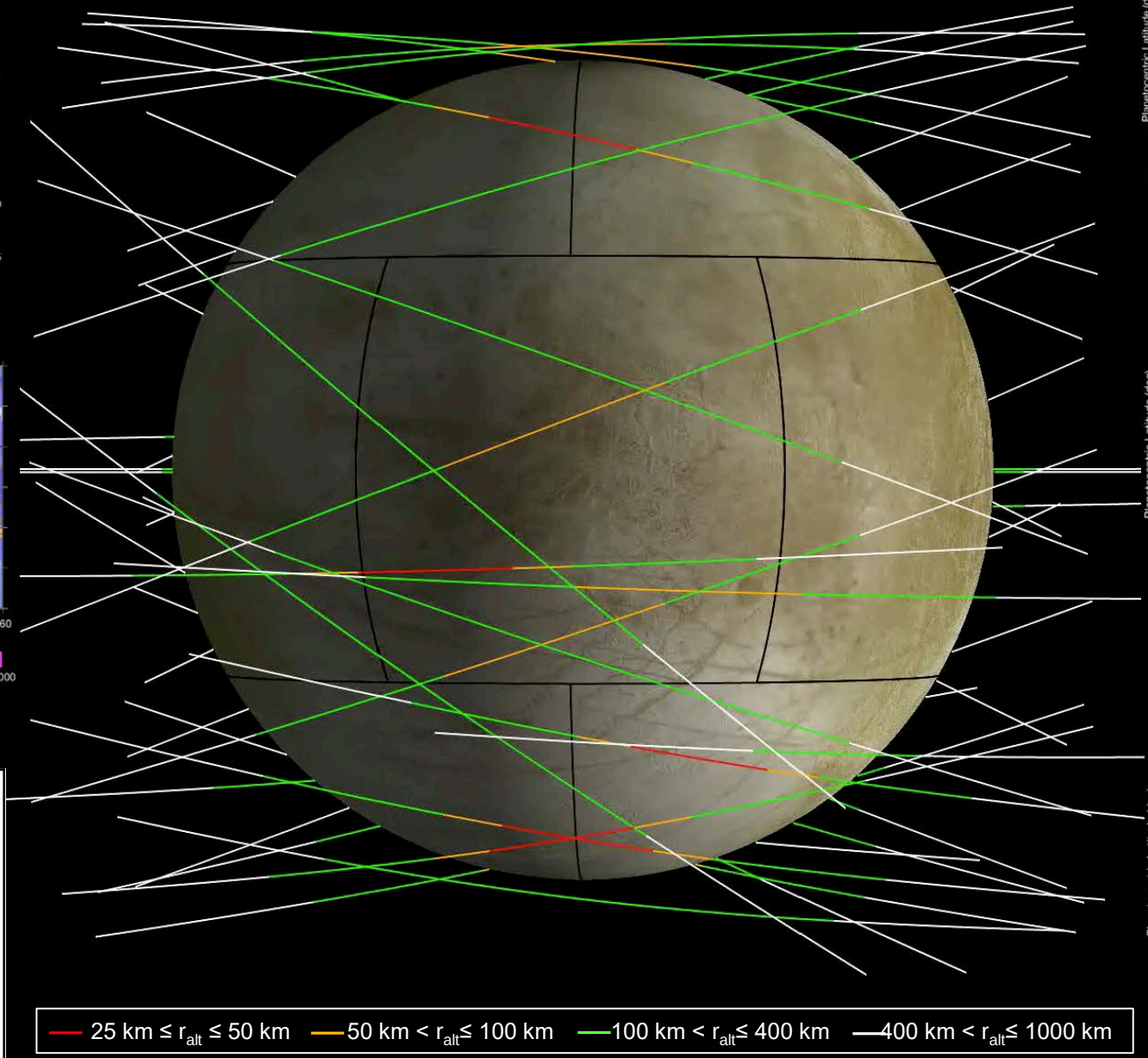


ETHEMIS
[Day/Night Coverage]

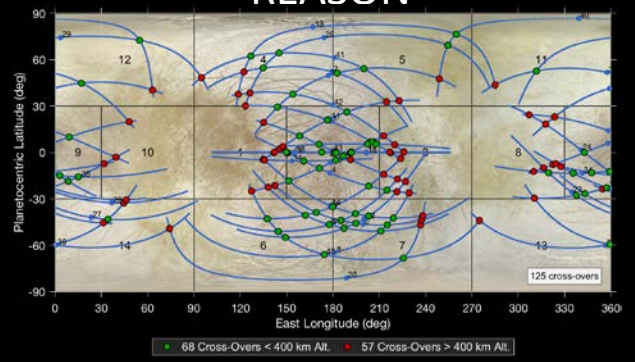


Trajectory

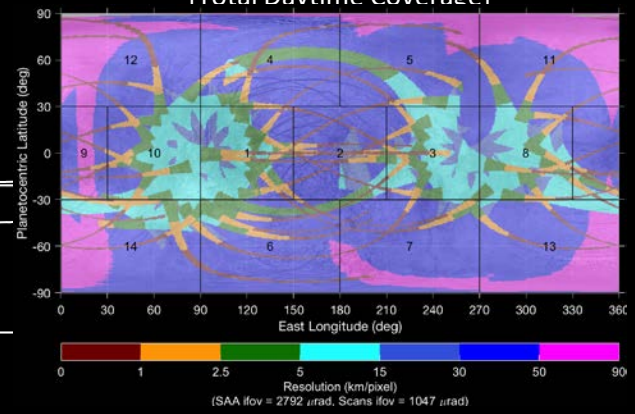




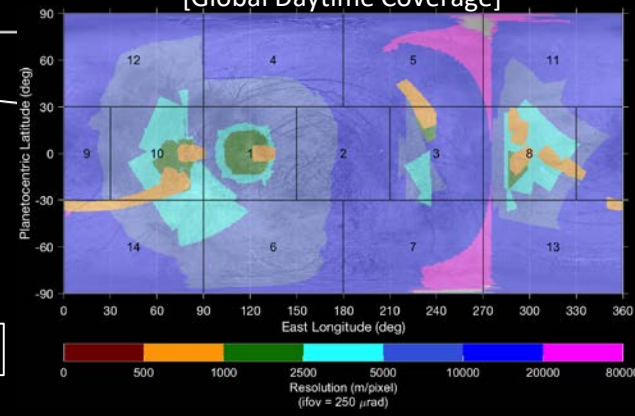
REASON



Europa-UVS
[Total Daytime Coverage]

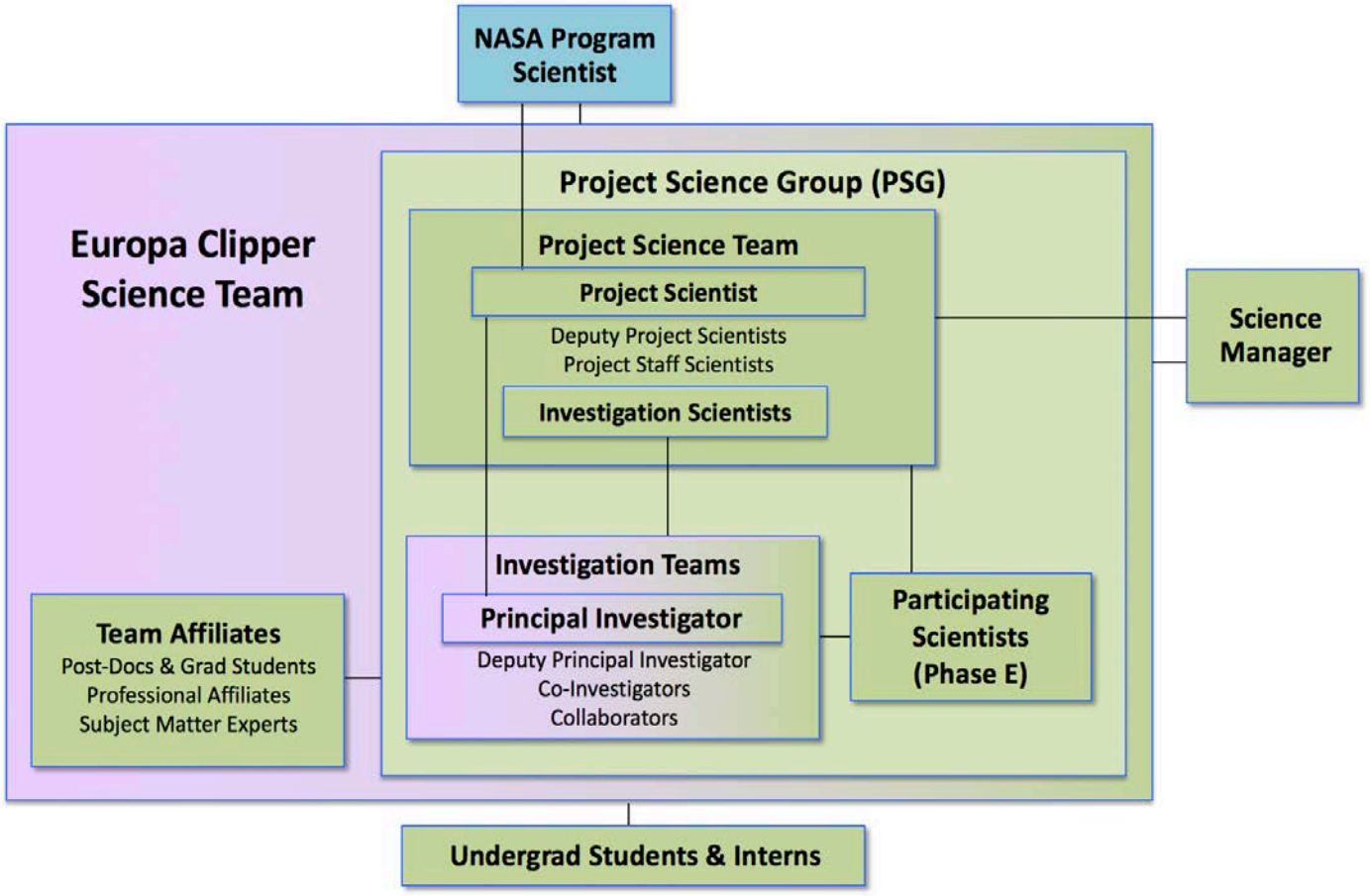


MISE
[Global Daytime Coverage]



“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



Project Science Group Meeting #6

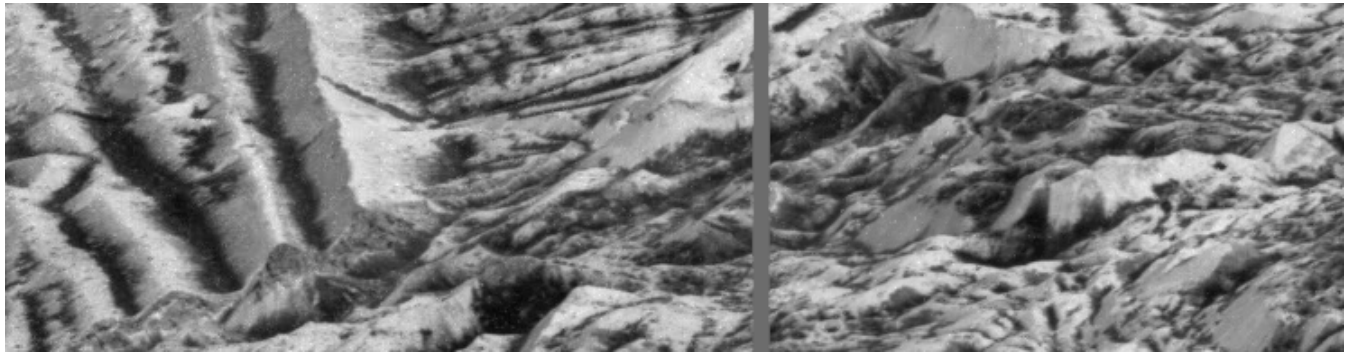
JPL, June 12-14, 2018

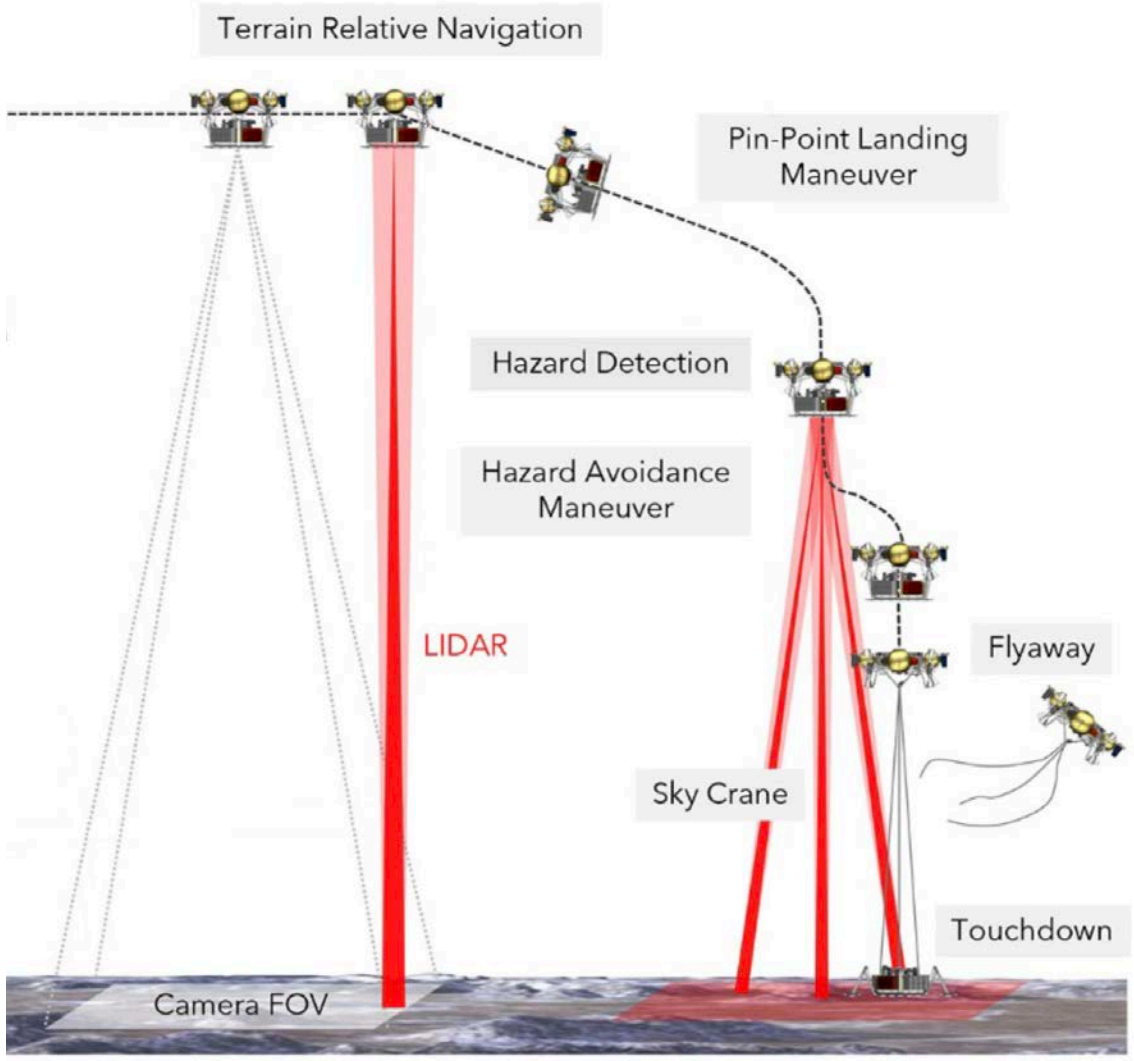
- Built recommendations for the strategic and tactical science planning processes
  - What is the process by which the PSG will generate a strategic plan?
  - What is the process for tactical (encounter-based) planning?
- Discussed circumstances that might suggest deviation from the strategic plan, to 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





https://europa.nasa.gov